

Original investigation

Tobacco Use, Quitting Behavior, and Health Characteristics Among Current Electronic Cigarette Users in a National Tri-Ethnic Adult Stable Smoker Sample

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Abstract

Introduction: The present study characterizes the tobacco use, quitting behaviors, and health characteristics of cigarette smokers who did not change their smoking pattern over the past 6 months and have used electronic cigarettes (ECs) in the past 30 days. This is an important subpopulation to characterize if EC dual use with cigarettes continues to grow.

Methods: Participants ($N = 2,376$) from a research survey panel completed an online cross-sectional survey between June and August 2012. Sampling was stratified to recruit equal numbers of cigarette smoking participants by race/ethnicity (Black, Hispanic, and Caucasian) and smoking frequency (nondaily and daily). All displayed a stable rate of smoking for the past 6 months and were not currently in treatment. Bivariate and multivariate analyses were used to examine correlates of current EC use (any use within the past 30 days).

Results: Current EC use was reported by 9.2% ($n = 219$) of the total sample. Of current EC users, 44% reported having used ECs as a quit method. Bivariate and multivariate analyses showed that current EC use was significantly associated with greater nicotine dependence, concurrent poly-tobacco use, more past-year quit attempts, past use of multiple cessation methods, and more depressive symptoms. No demographic variables were significantly associated with current EC use.

Conclusions: This study suggests that stable smokers who currently use ECs possess characteristics that are associated with difficulty in achieving smoking cessation. These characteristics should be considered when examining the effectiveness of ECs on cessation and in designing future cessation trials using ECs.

Introduction

Electronic cigarette (EC) use has risen dramatically in the United States is particularly notable among current smokers.^{1,2} The use of ECs by current smokers has framed a considerable debate about their role in smoking cessation. Many users adopt ECs to reduce their cigarette consumption or to quit smoking.³⁻⁹ Evidence of the efficacy of ECs for smoking cessation from uncontrolled studies is promising.^{8,10-12} Two randomized controlled trials to date also indicate the potential utility of ECs for smoking cessation.^{13,14}

The promise of ECs for smoking cessation, however, is equaled by concern that EC use could perpetuate the use of nicotine and tobacco products among smokers who might otherwise quit without EC use.^{4,15} This concern seems warranted in light of evidence that the use of other tobacco products does not replace traditional cigarettes among young adults¹⁶ and that EC use is a stable pattern of behavior.¹⁰ Marketing for ECs may promote dual use and thus potentially sustain nicotine addiction as products are advertised as a way to smoke in situations where one cannot smoke.¹⁷ In fact, many EC users report that ECs help them deal with situations where smoking is prohibited.³ However, recent research has shown that dual use leads to a reduction in smoking intake and so may have harm reduction potential.¹⁸

ECs are also receiving more consumer attention than FDA-approved nicotine replacement therapies (NRT) or cessation medications,¹⁹ and although ECs may possibly be beneficial for cessation or harm reduction, the research evidence remains scant on its efficacy toward complete smoking cessation. It is not yet known how long smokers who choose to use ECs, even for cessation or reduction purposes, will continue to use ECs. Thus, this subpopulation of dual cigarette and EC users has the potential to grow and maintain this smoking pattern.^{2,20,21} Research is needed to better understand factors associated with current EC use among smokers in order to inform the broader conversation in the field about the implications of current EC use by smokers.

Thus far, prior studies examining correlates of EC use have focused mainly on demographic characteristics or risk perceptions, typically finding that any EC use is associated with current smoking status and younger age, and the belief that ECs are less harmful than conventional cigarettes or that ECs can help in quitting.^{2,21-23} The literature is mixed on the association between other demographics (i.e., gender, ethnicity, education, income) and EC use across various studies.^{2,9,21-24} With regard to quitting behaviors, recent evidence suggests that EC use is associated with a greater number of past quit attempts, motivation to quit, quitting self-efficacy, and use of prior NRT.^{7,20,21,25,26} Among general populations of smokers (i.e., those not using ECs explicitly for cessation purposes), EC use has not been associated with cessation,^{7,9,27,28} however, failure to control for risk characteristics such as severity of nicotine dependence may confound outcomes.²⁸ Further, these outcomes do not account for those EC users who may have already successfully stopped smoking.²⁹ It is therefore important to broaden the knowledge base about characteristics of smokers who use ECs.

Additional identifying characteristics which distinguish smokers who currently use ECs from those who do not is needed to inform public health policy and practice regarding ECs, particularly if a subset of smokers are more likely to dually use ECs. In the current study, we investigate factors associated with smoking cessation outcomes in previous research, including poly-tobacco use, nicotine dependence, quitting behavior, medical illness history, depressive symptoms, and alcohol use.³⁰⁻³⁶ In addition, this study is stratified by ethnicity

(Black, Latino, and White) and smoking level (nondaily and daily), which will inform whether current EC use among smokers varies by these important demographic characteristics. This study is also unique in that it is the first to our knowledge that examines any current EC use among a sample of six-month long stable and currently non-treatment seeking smokers, a potentially different population from those who have been able to change their smoking rate in the past six months or who are actively pursuing treatment and who may want to quit relatively soon. Additionally, our sample of current EC users does not exclude smokers who had previously used ECs for cessation purposes, and may represent a sample of smokers who have previously failed or who have not yet benefitted from ECs for smoking cessation. This is a particularly important subpopulation of smokers since ever or past EC users may have already benefitted from EC use (i.e., cessation or reduction), or may have found ECs unappealing or unnecessary to warrant longer-term use. These current EC users, compared to those who do not currently use ECs, and who are not currently participating in cigarette cessation efforts have the potential for continued dual use and may represent a more committed or harder to treat smoking population with greater barriers to successfully quitting. We therefore hypothesize that our sample of current EC users who did not reduce or stop their cigarette use in the past six months, and includes those who have previously used EC as a quit method, will display higher levels of tobacco use and health risk characteristics including higher depressive symptoms, alcohol use, and medical illnesses, as well as higher levels of past quitting behaviors and use of cessation aids. We a priori explicitly classified our predictor variables into tobacco use, quitting behaviors, and health characteristics, as these variables were theoretically similar and most consistent with the tobacco literature.

Method

Participants

Participants completed a cross-sectional survey administered through an online panel survey service, Survey Sampling International (SSI), between July and August 2012. SSI is a commercial sample provider that is utilized for political polling, consumer research, and university research. SSI maintains access to an online panel of 1.5 million people in the United States, referred to as panelists, who have indicated that they are willing to participate in online surveys. Potential panelists are recruited through a variety of methods including websites, social media, and online communities, but to remain in the panel, panelists must complete a survey at least once every two months. Participants eligible for this study self-identified as Black, White, or Latino (of any race), were at least 25 years old, and were English-speaking. These participants were current smokers (i.e., smoked at least one cigarette in the past 30 days), had smoked at least 100 cigarettes in their lifetime, smoked for at least one year, smoked at their current rate (i.e., daily or nondaily) for at least 6 months, and had not participated in any smoking cessation treatment in the past 30 days. Women who were currently pregnant or breast-feeding were excluded from the study.

Equal samples of each of the three-race/ethnicity groups across smoking levels (nondaily and daily smoking) were enrolled through predetermined quotas. Quotas by smoking level were 1,200 for nondaily smokers, 600 for light daily smokers, and 600 for moderate to heavy daily smokers. Nondaily smokers smoked at least one cigarette on 4-24 days in the past 30 days; persons who smoked on fewer than four days in the past 30 days were ineligible.³⁷ Daily

smokers smoked 25–30 days in the past 30 days³⁸ and were further stratified into light daily smokers (≤ 10 cigarettes per day; CPD) and moderate to heavy daily smokers (>10 CPD).

Overall, 42,715 participants began the screener for this study, 13,775 did not meet the study criteria and were ineligible, 21,891 were ineligible because of full quotas (i.e., race/ethnicity, smoking level), and 4,581 discontinued before completing the survey (90% prior to starting the survey). The survey company completed a quality check that ensured no duplicate responses. Participants could discontinue at any time, but to progress through the survey, every question had to be answered. The final study sample consisted of 2,376 participants.

Procedures

All procedures were approved by the University of Minnesota Institutional Review Board. SSI used preliminary questions (e.g., smoking frequency) and existing participant information (e.g., race/ethnicity, age) to direct smokers to this study. Potential participants directed to the study were presented with the informed consent page. Once they provided consent, they were asked screening questions to determine eligibility. Eligible participants were then presented with the survey questions. Participants who completed the survey received SSI's standard incentives, which included entry into a quarterly drawing for \$25,000. In addition, SSI's incentive program includes individuals accumulating points that can be redeemed for cash.

Measures

Demographics

Demographic questions assessed participants' age, gender, race/ethnicity, education level, and monthly household income (dichotomized to $< \$1,800$, and $\geq \$1,800$).

Use of Electronic Cigarettes

Participants were asked whether they used any ECs in the past 30 days, the number of days used, and number of times used per day. Current EC users were defined as those reporting any past 30 day EC use.^{7,24,39}

Tobacco Use

Cigarette Use. Participants reported the number of days they smoked in the past month and average number of cigarettes smoked per day on the days smoked. Participants were asked to indicate the length of time they had been smoking cigarettes. We also assessed whether participants typically smoked mentholated or non-mentholated cigarettes.

Other Tobacco Use. Participants were asked whether they used any of the following forms of tobacco products in the past 30 days: cigars, cigarillos, little cigars, smokeless tobacco, pipes, hand rolled cigarettes, and hookah/waterpipe. For each form of tobacco affirmatively used in the past 30 days, participants were asked the number of days used in the past 30 days and the average amount used per day. Use of each of these alternative tobacco products was summed for a total number of other tobacco products currently used.

Nicotine Dependence. Nicotine dependence was assessed by the Brief Wisconsin Inventory of Smoking Dependence Motives (WISDM),⁴⁰ which is a 37-item measure consisting of 11 subscales.⁴⁰ The subscales can be used to calculate an overall smoking dependence score. In addition, two single-items were used to assess nicotine dependence. Time to first cigarette (TTFC) (dichotomized as: smoking

≤ 30 min after waking, and smoking >30 min), as smoking within 30 min of waking denotes nicotine dependence.^{41,42} Derived from the Cigarette Dependence Scale, participants were asked to report their level of perceived addiction to cigarettes on a scale of 0 "I am not addicted to cigarettes at all" to 100 "I am extremely addicted to cigarettes."⁴³

Quitting Intentions and Behavior

Cigarette Reduction. Participants were asked if they were "trying to cut down on the number of cigarettes smoked currently."⁴⁴

Readiness to Quit. Intention to quit was assessed using a single-item "What describes your intention to stop smoking completely, not even a puff? Would you say you...": "Never expect to quit," "May quit in the future, but not in the next 6 months," "Will quit in the next 6 months," "Will quit in the next 30 days."⁴⁵

Past Quit Attempts. Participants reported whether they had made a 24-hr quit attempt in the past year and the duration of the longest quit attempt in the past year. They also reported the number of quit attempts in the past year that lasted at least 24 hr.

Quitting Methods. Participants reported whether they had ever used any of the following methods to quit: NRT (including patches, gum, lozenges, nicotine inhaler or spray), bupropion/Zyban, varenicline/Chantix, talked to a doctor or nurse, talked to a counselor, attended a class or group program, telephone counseling, participated in an Internet or online program, started using smokeless tobacco such as snus, started using electronic cigarettes, or quit on their own.

Health Characteristics

Health Risk Perception. Perceptions of health risks from smoking were assessed with the following items, "If you continue to smoke, how likely do you think it is that you will develop...": (a) "lung cancer," (b) "other lung diseases," and (c) "heart disease."⁴⁶ Response options ranged from 1 "no chance" to 7 "certain to happen."

Medical History. Participants were asked if a doctor, nurse, or health professional ever told them that they had a heart attack, angina or coronary heart disease, stroke, cancer, asthma or emphysema (adapted from BRFSS, 2011).⁴⁷ A summary score was created to reflect total number of medical illnesses reported.

Perceived Health. Perceived health was assessed using a single item from the RAND 36-Item Short Form Health Survey (SF-36) developed for the Medical Outcome Survey: "In general, would you say your health is..." with response options of "Excellent," "Very Good," "Good," "Fair," and "Poor."⁴⁸

Depression. The two-item Patient Health Questionnaire was used to screen for depressed mood.⁴⁹

Alcohol use. The alcohol use disorders identification test is a three-item screening measure that assesses heaviness of alcohol use.⁵⁰

Data Analysis

Participant characteristics were summarized using descriptive statistics. Bivariate logistic regression was used to identify correlates of current EC use among smokers. Multivariable logistic regression was used to model predictors of current EC use among smokers in our three separate predictor models defined a priori (i.e., tobacco use, quitting behaviors, and health characteristics). These models would control for any significant demographic predictor variables if appropriate, and include significant variables at the bivariate level. Given our multiple comparisons at the bivariate level of analyses, we used a Bonferroni correction, setting the threshold of statistical significance at $p \leq .001$. Nagelkerke R^2 is the model statistic reported

in the multivariable analyses. Analyses were conducted using SPSS version 22.0. Models present the odds of being a current EC user (any past 30 day use) versus a non-EC user (reference group).

Results

Smoker Characteristics

On average participants were about 43 years in age ($SD = 12.44$) and 58.2% were female. Consistent with our recruitment, half of the sample were nondaily smokers, but smoked on average for 19.4 years ($SD = 16.0$). More than half (56.8%) smoked their first cigarette within 30 min of waking and smoked an average of 9.7 cigarettes per day on the days they smoked ($SD = 8.6$). Approximately half of the sample (51.3%) reported currently using other tobacco products, with the majority concurrently using cigars (30.0%). A full report of sample characteristics for all study variables is provided in the first column of [Tables 1–3](#).

Current EC Use and Patterns

Current EC use was endorsed by 9.2% ($n = 219$) of our total smoker sample. On average they used ECs 7.7 days out of the past 30 days ($SD = 8.6$, Range = 1–30 days), and number of EC days of use per month was not associated with days of cigarette use per month ($r = -.045$, $p = .506$). About 50% of current EC users used between 1 to 4 days out of the past 30 ($n = 111$), though 8.7% ($n = 19$) used ECs 30 out of 30 days. EC use (on the days used) averaged 5.8 times per day ($SD = 7.1$, Range = 1–50 use). There was a significant positive correlation between frequency of monthly and daily EC use ($r = .450$, $p < .001$), indicating that those who used ECs on more days per month tended to use EC more times per day.

Differences Among Current EC Users by Frequency of EC Use

Because there is limited research describing differences among smokers who use ECs less versus more frequently, we explored demographic, tobacco use, and quitting behavior differences between (a) those who used ECs between 1 to 4 days out of the past 30 days (median split) and those who used >4 days out of the past 30 days; and between (b) those who used ECs once in the past month, used a few days (2–5 days/month), used more often (6–24 days/month), and those who used most regularly (25–30 days/month) ([Supplementary Table](#)). In general, a greater proportion of those who used ECs more frequently in the past month endorsed having used ECs as a quit method previously [>4 days/month (56.5%) vs. 1–4 days/month (31.5%); $\chi^2 = 13.8(1)$, $p \leq .001$] and [1 day/month (28.1%) vs. 2–5 days/month (36.9%) vs. 6–24 days/month (50.9%) vs. >25 days/month (85.7%); $\chi^2 = 21.4(3)$, $p \leq .001$]. Conversely, a smaller proportion of those who endorsed greater monthly EC use endorsed having quit on their own previously [>4 days/month (6.5%) vs. 1–4 days/month (21.6%); $\chi^2 = 10.3(1)$, $p \leq .001$] and [1 day/month (28.1%) vs. 2–5 days/month (15.3%) vs. 6–24 days/month (9.1%) vs. >25 days/month (0%); $\chi^2 = 9.9(3)$, $p \leq .05$]. A greater proportion of those who used ECs more frequently (>4 days/month) reported at least one quit attempt in the past year compared to less frequent EC users (73.1% vs. 60.4%; $\chi^2 = 4.3(1)$, $p \leq .05$), and this appeared to be more concentrated among those who used ECs between 6–24 days/month (81.1%) compared to those who used >25 days/month (38.1%). With regard to other types of quitting methods used, more frequent EC users (>4 days/month) endorsed having used more quit

methods previously compared to less frequent EC users (1–4 days/month) [$\chi = 1.7(1.6)$ vs. 1.2(1.4); $t = -2.6(217)$, $p \leq .01$]. More frequent EC users also reported greater endorsement of having used Zyban [17.6% vs. 8.1%; $\chi^2 = 4.2(1)$, $p \leq .05$], and Chantix [16.7% vs. 7.2%; $\chi^2 = 4.7(1)$, $p \leq .05$] as a quit method in the past. Those who used ECs the most frequently (>25 days/month) also smoked the most cigarettes per day [$\chi = 16.3(13.3)$] compared to any other EC frequency group [$F = 2.8(3)$, $p \leq .05$]. They also smoked for the longest period of time [$\chi = 26.7(10.7)$ years], and this was significantly greater than among those who used ECs only once in the past month [$\chi = 18.1(10.5)$ years; $p \leq .05$]. Menthol smokers appeared to be evenly distributed across EC frequency categories, but were greatly represented among those using ECs 2–5 days/month (71.2%) [$\chi^2 = 12.5(3)$, $p \leq .01$].

Demographic Predictors of Current EC Use among Smokers

In unadjusted analysis, only education and specifically having a graduate degree was only marginally associated with current EC use ($OR = 3.43$ [1.16–10.09], $p < .05$). The overall model for ethnicity was also marginally significant ($R^2 = 0.01$, $p < .01$) with Latino smokers using EC at a higher rate (41.6%) than Whites (32.9%) and Blacks (25.6%), however pairwise tests did not reach significance. Overall, no demographic variables were significantly associated with current EC use among smokers in unadjusted analyses ([Table 1](#)), and thus they were not included in any multivariate models.

Tobacco Use Predictors of Current EC Use Among Smokers

Several tobacco use patterns distinguished smokers who currently used EC from those who did not in unadjusted bivariate analyses ([Table 1](#)). Higher nicotine dependence according to the WISDM was significantly associated with higher odds of using EC ($OR = 1.26$ [1.15 – 1.38], $p < .001$), though higher nicotine dependence on the other two dependence measures (e.g., TTFC and perceived addiction) were marginally associated ($p < .01$) with greater odds of EC use. Using any other form of tobacco, in addition to cigarettes and ECs, was associated with higher odds of current EC use ($OR = 1.49$ [1.38–1.62], $p < .001$), as did the use of every individual product assessed ([Table 1](#)). This effect was most pronounced for snuff or smokeless tobacco ($OR = 4.94$ [3.45–7.07], $p < .001$) and pipes ($OR = 4.72$ [3.22–6.93], $p < .001$). The greater number of other tobacco products concurrently used, the more likely smokers were to also use EC ($OR = 1.54$ [1.41–1.68], $p < .001$).

An adjusted multivariable logistic regression model ($R^2 = 0.11$) with only these significant tobacco use variables from bivariate analyses (excluding the continuous variable of total number of other tobacco products used due to multicollinearity) found that greater nicotine dependence (e.g., WISDM total scores) ($OR = 1.13$ [1.03–1.25], $p < .05$) and the concurrent use of little cigars, pipes, snuff or smokeless tobacco, or hand-rolled cigarettes ($ORs = 1.40$ – 3.04 ; $ps < .05$) were significantly associated with current EC use ([Table 1](#)).

Quitting Behavior Associated with Current EC Use Among Smokers

Bivariate analyses showed that having made at least one quit attempt in the last year ($OR = 2.39$ [1.79–3.22], $p < .001$), distinguished smokers who were currently using ECs. In addition, having used more methods to quit smoking was associated with EC use

Table 1. Demographic and Tobacco Use Characteristics and Bivariate/Multivariate Predictors of Adult Stable Smokers Who Used Electronic Cigarette (EC) in Past 30 Days

Demographics	All smokers (N = 2,376)		Non-EC users (N = 2,157)		EC users ^a (N = 219)		Unadjusted		Adjusted ^d	
	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	OR (95% CI)	p value	OR (95% CI)	p value	
Age	42.97 (12.44)	43.12 (12.49)	41.47 (11.92)		0.99 (.98–1.0)		.06			
Gender										
Female	58.2 (1,382)	58.4 (1,259)	56.2 (123)		Ref					
Male	41.8 (994)	41.6 (898)	43.8 (96)		1.09 (.83–1.45)		.53			
Education										
Not a high school graduate	3.4 (81)	3.6 (77)	1.8 (4)		Ref					
High school or General Education Diploma	23.1 (550)	23.6 (510)	18.3 (40)		1.51 (.53–4.34)		.44			
Some college or tech school	38.2 (907)	38.4 (829)	35.6 (78)		1.81 (.65–5.08)		.26			
College graduate	27.2 (646)	26.8 (578)	31.1 (68)		2.27 (.80–6.38)		.12			
Graduate degree	8.1 (192)	7.6 (163)	13.2 (29)		3.43 (1.16–10.09)		.03			
Ethnicity										
White	33.5 (796)	33.6 (724)	32.9 (72)		Ref					
Latino	33.1 (786)	32.2 (695)	41.6 (91)		1.32 (.95–1.82)		.10			
Black	33.4 (794)	34.2 (738)	25.6 (56)		0.76 (.53–1.10)		.15			
Income										
<\$1,800 per month	37.0 (841)	37.3 (771)	33.5 (70)		Ref					
≥\$1,800 per month	63.0 (1,433)	62.7 (1,294)	66.5 (139)		1.18 (.88–1.60)		.27			
Tobacco use characteristics										
All smokers (N = 2,376)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Unadjusted	OR (95% CI)	p value	Adjusted ^d	p value	
Smoker type										
Nondaily	50.5 (1,201)	50.3 (1,085)	53.0 (116)		Ref					
Daily light	24.3 (578)	24.6 (530)	21.9 (48)		0.85 (.60–1.21)		.36			
Daily moderate/heavy	25.1 (597)	25.1 (542)	25.1 (55)		0.95 (.68–1.33)		.76			
Cigarettes per day	9.71 (8.62)	9.60 (8.52)	10.79 (9.52)		1.02 (1.00–1.03)		.05			
Menthol smoker (Ref = No)	57.2 (1,360)	57.0 (1,229)	59.8 (131)		1.12 (.85–1.49)		.42			
Time to first cigarette (TTFC) ^a (Ref ≥ 30 min)										
Within 30 min	56.8 (1,349)	56.0 (1,207)	64.8 (142)		1.45(1.09–1.94)		.01			
Perceived addiction	57.43 (32.96)	56.9 (33.1)	62.88 (31.15)		1.01 (1.00–1.01)		.01			
WISDM ^b	3.93 (1.53)	3.88 (1.52)	4.41 (1.51)		1.26 (1.15–1.38)		<.001	1.13 (1.03–1.25)	.012	
Years smoked	19.47 (13.70)	19.67 (13.70)	18.48 (13.69)		0.99 (.98–1.00)		.26			
Current use of any other tobacco (Ref = No)	51.3 (1,220)	49.7 (1,073)	67.1 (147)		1.49 (1.38–1.62)		<.001	.826 (.526–1.30)	.406	
Number of other tobacco products used										
0	1.0 (1.30)	0.91 (1.18)	1.85 (1.97)		2.06 (1.54–2.77)		<.001			
1	48.7 (1,156)	50.3 (1,084)	32.9 (72)							
2	21.3 (507)	21.3 (459)	21.9 (48)							
3	14.7 (350)	15.1 (326)	11.0 (24)							
4	8.9 (212)	8.5 (184)	12.8 (28)							
5	3.5 (84)	3.3 (71)	5.9 (13)							
6	1.3 (31)	1.1 (23)	3.7 (8)							
7	0.6 (14)	0.3 (7)	3.2 (7)							
8	0.9 (22)	0.1 (3)	8.7 (19)							

Table 1. Continued

Demographics	All smokers (N = 2,376)		Non-EC users (N = 2,157)		EC users ^c (N = 219)		Unadjusted		Adjusted ^d	
	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	OR (95% CI)	p value	OR (95% CI)	p value		
Current use of other tobacco (Ref = No)										
Cigars	30.0 (712)	28.8 (621)	41.6 (91)	1.76 (1.32–2.34)	.805 (.530–1.22)	<.001			.308	
Cigarillos	21.7 (515)	20.2 (436)	36.1 (79)	2.23 (1.66–2.99)	1.40 (.942–2.09)	<.001			.096	
Little cigars	14.4 (341)	12.9 (279)	28.3 (62)	2.66 (1.93–3.66)	1.54 (1.03–2.30)	<.001			.036	
Pipes	6.4 (153)	5.1 (109)	20.1 (44)	4.72 (3.22–6.93)	2.31 (1.41–3.79)	<.001			≤.001	
Snuff or smokeless tobacco	7.6 (180)	5.9 (128)	23.7 (52)	4.94 (3.45–7.07)	3.04 (1.99–4.65)	<.001			<.001	
Hand rolled cigarettes	19.7 (469)	18.1 (391)	35.6 (78)	2.50 (1.86–3.36)	1.70 (1.16–2.48)	<.001			.006	
Hookah or waterpipe	8.5 (202)	7.5 (161)	18.7 (41)	2.86 (1.96–4.16)	1.35 (.842–2.17)	<.001			.212	

Note. ^aTime to first cigarette.

^bWisconsin inventory of smoking dependence motives, brief form.

^cAny past 30 day use.

^dAdjusted model includes significant bivariate associations adjusted for multiple comparisons ($p \leq .001$). Number of concurrent tobacco products used was excluded due to multicollinearity.

(OR = 1.47 [1.34–1.61], $p < .001$), as was the use of each individual quit method assessed with the exception of Chantix (Table 2). Those who were currently using ECs, compared to non-EC users, were much more likely to endorse having tried ECs as a method to quit in the past (OR = 14.5 [10.46–20.18], $p < .001$). Current EC users were less likely to have “quit on their own” in the past (OR = .31 [.21–.45], $p < .001$).

An adjusted multivariable logistic model ($R^2 = 0.26$) with these significant quitting behavior variables showed that having at least one quit attempt in the past year was associated with EC use (OR = 2.25 [1.61–3.15], $p < .001$). Several individual past quit methods were also significantly associated with current EC use: having attended a class or group program (OR = 2.26 [1.24–4.12], $p < .01$), having used smokeless tobacco (OR = 3.83 [2.05–7.17], $p < .001$), and having used ECs (OR = 10.76 [7.47–15.49], $p < .001$). Again, having quit on one’s own was less likely to be associated with EC use (OR = .553 [.347–.880], $p < .05$).

Because current EC use was associated with past quitting behaviors, we explored whether current EC users ($n = 219$) who endorsed having used ECs previously as a quit method ($n = 96$), versus those who did not ($n = 123$), differed in their current quitting behaviors. This exploratory analysis showed that current EC users who endorsed past use of EC as a quit method were more likely to report currently trying to reduce cigarette consumption (OR = 2.07 [1.07–4.01], $p < .05$) as well as greater intention to quit at some point (OR = 1.45 [1.02–2.06], $p < .05$).

Health Characteristics Associated with Current EC Use Among Smokers

As displayed in Table 3, several health characteristics distinguished smokers who used ECs from those who did not in unadjusted analyses. Greater number of medical illnesses (OR = 1.23 [1.10–1.37], $p < .001$), and the presence of several individual medical illnesses (e.g., Heart Attack, Stroke, and Cancer) (ORs = 2.18–2.56; $ps \leq .001$) were associated with higher odds of using EC. Higher depressive symptoms (OR = 1.14 [1.06–1.22], $p < .001$) was also associated with higher odds of EC use. An adjusted multivariable model with these significant variables ($R^2 = 0.02$) showed that only increased depression symptoms was associated with current EC use (OR = 1.12 [1.04–1.21], $p < .01$).

Discussion

This paper identifies tobacco use patterns, quitting behavior, and health characteristics, which distinguish stable, non-treatment seeking (no participation in any smoking cessation treatment in the past 30 days) smokers who currently use ECs (defined as within the past 30 days) from those who do not. Demographics and smoking status (nondaily vs. daily), however, did not distinguish current EC users. Overall, we found that 9.2% of stable smokers reported currently using ECs, which is higher than what has been reported in prior adult population surveys among smokers (ranging between 4.1% and 6.3% in 2010).^{2,21} Despite equivalent prevalence of current EC use across demographics and between nondaily and daily cigarette smokers, current EC use varied in past month frequency. About 50% of current EC users used between 1 to 4 days in the past 30, with 14.6% using ECs on only one day and 8.7% using ECs 30 out of 30 days. Exploratory analyses examining differences by frequency of monthly EC use showed that greater past month EC use was associated with having used ECs in the past as a cessation aid. This may

Table 2. Quitting Behavior and Bivariate Predictors of Adult Stable Smokers Who Used Electronic Cigarette (EC) in Past 30 Days

Quitting behavior	All smokers (N = 2,376)		Non-EC users (N = 2,157)		EC users ^a (N = 219)		Unadjusted		Adjusted ^b	
	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	OR (95% CI)	p value	OR (95% CI)	p value		
Currently trying to reduce(Ref = No)	70.7 (1,680)	70.1 (1,513)	76.3 (167)	1.37 (0.99–1.89)		.06				
Intention to quit					Ref					
Never	10.9 (259)	10.8 (234)	11.4 (25)							
Future	54.6 (1,298)	54.8 (1,183)	52.5 (115)			.68				
Within six months	26.6 (631)	26.4 (569)	28.3 (62)			.94				
Within 30 days	7.9 (188)	7.9 (171)	7.8 (17)			.83				
Duration longest quit attempt in past year (days)	77.25 (70.91)	75.07 (69.72)	91.72 (77.09)			.01				
Quit attempt (24 hr) in past year (Ref = No)	47.4 (1,127)	45.5 (981)	66.7 (146)			<.001	2.26 (1.62–3.17)	<.001		
Number of 24 hr quit attempts in past year	3.15 (8.38)	2.99 (8.09)	4.76 (10.69)			.004				
Number of quit methods used	0.73 (1.19)	0.66 (1.12)	1.42 (1.56)			<.001	.913 (.536–1.56)	.738		
Methods used to quit (Ref = No)										
Nicotine patch, gum, or lozenge	25.0 (594)	23.8 (514)	36.5 (80)			<.001	.890 (.462–1.71)	.727		
Nicotine inhaler or spray	3.2 (77)	2.8 (60)	7.8 (17)			<.001	1.81 (.740–4.42)	.193		
Zyban	7.3 (173)	6.7 (145)	12.8 (28)			<.001	.996 (.453–2.19)	.992		
Chantix	7.3 (174)	6.9 (148)	11.9 (26)			.01				
Talk to doctor or nurse	9.9 (236)	8.8 (189)	21.5 (47)			<.001	1.30 (.620–2.72)	.489		
Talk to counselor	6.3 (149)	5.6 (120)	13.2 (29)			<.001	1.23 (.573–2.62)	.600		
Attend class or group program	4.0 (95)	3.2 (70)	11.4 (25)			<.001	2.46 (1.12–5.42)	.026		
Telephone counseling	3.2 (77)	2.9 (62)	6.8 (15)			<.001	.894 (.346–2.32)	.818		
Internet or online program	4.1 (97)	3.6 (78)	8.7 (19)			<.001	1.15 (.494–2.68)	.746		
Smokeless tobacco (snus)	2.7 (64)	1.8 (39)	11.4 (25)			<.001	4.23 (1.80–9.92)	≤.001		
Start using EC	8.7 (206)	5.1 (110)	43.8 (96)			<.001	10.75 (7.46–15.47)	<.001		
Quit on own	33.1 (786)	35.0 (755)	14.2 (31)			<.001	.548 (.344–.875)	.012		

Note. ^aAny past 30 day use.

^bAdjusted model includes significant bivariate associations adjusted for multiple comparisons ($p \leq .001$).

Table 3. Health Characteristics and Bivariate Predictors of Adult Stable Smokers Who Used Electronic Cigarette (EC) in Past 30 Days

Health variables	All smokers (N = 2,376)		Non-EC users (N = 2,157)		EC users ^a (N = 219)		Unadjusted		Adjusted ^b	
	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	Mean (SD) or % (N)	OR (95% CI)	p value	OR (95% CI)	p value		
Perceived vulnerability to disease from smoking	4.53 (1.29)	4.51 (1.29)	4.77 (1.24)	1.17 (1.05–1.31)		.005				
Perceived health										
Poor	4.2 (100)	4.1 (89)	5.0 (11)	Ref		–				
Fair	21.0 (499)	20.7 (446)	24.2 (53)	0.96 (0.48–1.91)		.91				
Good	41.7 (990)	42.3 (912)	35.6 (78)	0.69 (0.36–1.35)		.28				
Very good	26.3 (624)	26.7 (576)	21.9 (48)	0.67 (0.34–1.35)		.26				
Excellent	6.9 (163)	6.2 (134)	13.2 (29)	1.75 (0.83–3.69)		.14				
Number of medical illnesses (Ref = No)	0.43 (1.05)	0.41 (0.10)	0.70 (1.44)	1.23 (1.10–1.37)		<.001	.916 (.679–1.24)	.567		
Presence of medical illness (Ref = No)										
Heart attack	7.1 (164)	6.2 (133)	14.2 (31)	2.56 (1.68–3.90)		<.001	1.60 (.666–3.86)	.293		
Coronary heart disease	5.9 (137)	5.4 (116)	9.6 (21)	1.88 (1.15–3.06)		.01				
Stroke	4.9 (113)	4.3 (93)	9.1 (20)	2.29 (1.38–3.80)		<.001	1.78 (.802–3.96)	.156		
Cancer	7.5 (173)	6.7 (144)	13.2 (29)	2.18 (1.42–3.34)		<.001	1.61 (.757–3.42)	.217		
Asthma	16.4 (380)	15.5 (334)	21.0 (46)	1.50 (1.06–2.12)		.02				
Emphysema	6.2 (144)	5.7 (124)	9.1 (20)	1.68 (1.02–2.75)		.04				
Depressive symptoms	1.98 (1.85)	1.94 (1.85)	2.40 (1.80)	1.14 (1.06–1.22)		<.001	1.12 (1.04–1.21)	.005		
Alcohol use	4.68 (2.85)	4.63 (2.83)	5.14 (3.02)	1.06 (1.01–1.12)		.02				

Note. ^aAny past 30 day use.

^bAdjusted model includes significant bivariate associations adjusted for multiple comparisons ($p \leq .001$).

suggest that as ECs continue in popularity, there may be distinct or evolving patterns of long-term EC use. Some may be on a trajectory to exclusively use ECs, while others may be or become established and committed dual cigarette and EC users. These differential patterns of use may also represent distinct subpopulations of current EC users. For example, we found that more frequent EC users have had difficulty quitting on their own and have used more varied cessation methods. Differences seen between our arbitrary groups of EC frequency users may suggest that there are multiple types of current EC users or patterns of EC use (e.g., social EC user vs. established EC user). Our arbitrary subgroups of EC users, however, were based only on the past month's behavior, and we were unable to ask additional questions that may help to define these types of current EC users and/or use trajectories. Future research should begin to establish definitions with appropriate survey questions (e.g., "How long have you been using ECs?" "Is it your intention to eventually exclusively use ECs?" and "What type of EC do you currently use—rechargeable vs. vaporizer?"), to define and examine any potential subgroups or trajectories of current EC users/use.

Nevertheless, our sample of smokers who currently were using ECs differed significantly from those who did not currently use ECs. Our sample of smokers who currently used ECs were more likely to have higher levels of poly-tobacco use, greater nicotine dependence, and more past quitting behaviors, as well as greater health risk characteristics including higher rates of lifetime medical illnesses and depressive symptoms than smokers who were not using ECs. When considering the implications of EC use by this specific group of current smokers, it is important to acknowledge that those who are currently using ECs but have not benefited or have not yet benefited from their use are more likely to possess characteristics that are associated with difficulty in achieving smoking cessation.^{30–36}

For example, while participants included in the current study are stable, non-treatment seeking smokers, those who use ECs had a marked history of smoking cessation efforts including more quit attempts in the past year and a lower likelihood of having quit previously on their own. They also were more likely to try specific cessation methods such as using smokeless tobacco and using ECs for cessation in the past (i.e., both possible substitution methods), as well as having attended a class or group program. This is consistent with previous research that showed that current EC use by smokers is related to quitting behavior, such as more past quit attempts⁹ and may demonstrate that the marketing approach of using ECs for cessation or harm reduction is appealing to those who have had much difficulty quitting in the past. Other research, however, has shown that greater quit attempts did not translate to successful attempts, and that smokers were less successful compared to those smokers who have not previously used ECs.⁹ The present study may provide insight into this finding by identifying potential barriers to cessation among smokers who still use ECs; these smokers have higher poly-tobacco use rates and greater nicotine dependence, both of which make quitting more difficult.^{34,36,51}

Poly tobacco use has been associated with lower intention to quit smoking,⁵² and less probability of quitting smoking.⁵³ In contrast, other studies have found that poly-tobacco use and intention to quit smoking are positively related, and that poly-tobacco use is linked with more previous quit attempts.⁵⁴ These seemingly conflicting results may be reconciled by the finding that dual users experience less cessation success despite greater quit attempts.⁵⁵ Given the risk associated with the use of other tobacco products by smokers, there is concern about trajectory toward dual or poly-tobacco use

that may stem from harm reduction via alternate product use as opposed to complete abstinence from smoking.⁷ It will be important for future research to prospectively follow smokers who use ECs, particularly those using additional tobacco products, to determine their quitting behavior and cessation outcomes.

Smokers who use ECs were distinct in their health status from those who do not use ECs. Importantly, smokers who currently use ECs reported more symptoms of depression, which is a risk factor for continued smoking.^{31,32,35} Our finding is consistent with recent research that found that persons with any mental health condition, including depression, are more likely to currently use ECs and favor future EC use.⁵⁶ This is an important area for future research as those with any mental health condition, including depression, are a tobacco disparity group facing high tobacco prevalence, nicotine dependence, and lower cessation rates. Thus, the use and availability of ECs, particularly if marketed as cessation products, may be more appealing to these individuals. It will also be important to examine if ECs have any differential impact on harm reduction, quitting, and cessation outcomes among these individuals.

Furthermore, although not significant in the multivariate model, smokers who use ECs were more likely to have had a medical illness, particularly having had a heart attack, stroke, or cancer. This is also consistent with research among hospitalized smokers that found high current EC use.⁵⁷ Poorer quality of life coupled with potential co-factors, such as depressed mood, is associated with poor cessation outcomes.³² Although reasons for EC use among medically ill smokers are unknown, it is possible that their use is guided by a difficulty of quitting in the past and the perception of ECs as a cessation or harm reduction tool. Again, this is another important population to examine the trajectory of EC use and its potential impact on quitting behavior and health outcomes.

Overall, the present study distinguished smokers who currently use ECs from those who do not on a variety of factors that are associated with smoking cessation difficulty. The results of our study, however, should be interpreted within the context of the specific subpopulation of smokers sampled—stable smokers who have smoked at the same rate for the past six months and used ECs at least occasionally, which would preclude those whom EC helped to reduce or quit smoking. The sample also excludes treatment seeking smokers. Smokers who use ECs and who are actively participating in treatment or have reduced smoking may be more motivated to quit and thus may have other distinguishable characteristics associated with a greater likelihood of quitting.

These smokers may have already and more readily received benefits from EC use (e.g., lowered nicotine dependence, lowered cigarettes smoked per day), and may be more likely to achieve or want to achieve complete cessation. Additionally, a proportion of participants indicated using EC as a previous quit method and it can be presumed that they failed to benefit from EC use for cessation. Thus, our characterization of EC users is among those who potentially have not had or who have not yet had benefit from EC use, or from those who want to continue their dual use. This population may in turn be a harder to treat population and possibly continue to grow as dual cigarette and EC users, if they have greater barriers to quitting. Thus, it is essential to understand the factors associated with current EC use within this unique population of stable and committed smokers.

In addition to this caveat, additional limitations should be noted. Survey data was collected in 2012 and survey data from 2013 or 2014 may look different as more smokers choose to use ECs. Recruitment from an online panel provided a sample drawn from geographic regions throughout the United States, however this limited

participation to individuals who had access to the Internet and were willing to complete online surveys. It must also be acknowledged that we used a voluntary enrollment strategy rather than random sampling and that the present sample may not be representative of U.S. smokers at the population level. Also, the age range in the present study was restricted to 25 years or older, which may have suppressed detecting a significant age difference between smokers who did and did not use ECs. Although the inclusion of a tri-ethnic sample in this study is an important addition to the literature, future studies should expand the investigation to additional ethnic groups. Finally, this was a cross-sectional study and no causal inferences can be drawn from the results.

Despite these limitations, our study identified tobacco use patterns, quitting behavior, and health characteristics, which distinguish stable non-treatment seeking smokers who currently use ECs from those who do not. Future studies examining EC use on cessation outcomes will need to account for the quitting barriers descriptive of this population. In fact, research examining the utility of EC for smoking cessation in which individual risk characteristics are not controlled for may underestimate the efficacy of EC for cessation. Grana and colleagues²⁸ note the failure to control for nicotine dependence is a limitation in several current studies which have found that EC use is associated with a lower quit rate in general smoker populations. These studies have also been criticized for not incorporating those who have already quit into analyses of outcomes.²⁹ In addition, the risk characteristics associated with EC use among stable smokers suggests the possibility that they may need additional clinical assistance for smoking cessation. Overall, current EC use is a growing phenomenon which may be more highly appealing among a select group of smokers—those who have had the most difficulty quitting. Research efforts will need to continue to define and characterize this group and to follow them prospectively in order to understand the implications of EC use by these smokers.

Supplementary Material

Supplementary Table can be found online at <http://www.ntr.oxford-journals.org>

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Declaration of Interests

None declared.

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