E-Cigarette Use Among Adult Primary Care Patients: Results from a Multisite Study

William S. John, PhD[1], Kiran Grover, MPH[1], Lawrence H. Greenblatt, MD[2], Robert P. Schwartz, MD[3], and Li-Tzy Wu, ScD[1,2,4,5]

[1]Department of Psychiatry and Behavioral Sciences, Division of Social and Community Psychiatry , Duke University Medical Center, Durham, NC, USA; [2]Department of Medicine, Division of General Internal Medicine, Duke University Medical Center, Durham, NC, USA; [3]Friends Research Institute, Inc., Baltimore, MD, USA; [4]Duke Clinical Research Institute, Duke University Medical Center, Durham, NC, USA; [5]Center for Child and Family Policy, Sanford School of Public Policy, Duke University, Durham, NC, USA.

BACKGROUND: Primary care settings provide opportunities to identify electronic-cigarette (e-cigarette) use and to implement strategies for changing tobacco use behavior. However, a better understanding of the extent and associated characteristics of e-cigarette use among primary care patients are needed to inform such efforts.

OBJECTIVE: To describe patient demographic and substance use characteristics by e-cigarette use status among a large sample of primary care patients. To examine the prevalence and correlates of e-cigarette use among tobacco users in the sample.

DESIGN: Cross-sectional analysis from a multisite validation study of a substance use screening instrument.

PARTICIPANTS: Adult primary care patients aged 18 and older ($n = 2000$) recruited across 5 primary care clinics in the Eastern USA from 2014 to 2015.

MAIN MEASURES: Patients reported past 3-month e-cigarette use, sociodemographics, tobacco use, and other substance use. Current nicotine dependence and DSM-5 criteria for past-year substance use disorders were also assessed.

KEY RESULTS: Among the total sample, 7.7% ($n = 154$) adults reported past 3-month e-cigarette use. Adults who reported e-cigarette use (vs. no use) were more likely to be younger, white, or have frequent tobacco use, nicotine dependence, or past-year illicit drug use/disorders. Among past 3-month tobacco users, 16.3% reported e-cigarette use. Adjusted logistic regression indicated that odds of e-cigarette use were greater among tobacco users who had some college education or more (vs. < high school) or were daily/almost daily tobacco users (vs. not); odds were lower among Blacks/African-Americans (vs. whites). E-cigarette use among tobacco users was associated with increased odds of current nicotine dependence or tobacco use disorder as well as more severe dependence/disorder.

CONCLUSIONS: Enhanced surveillance of e-cigarette use among adult tobacco users in primary care, particularly among those who use tobacco frequently, may have implications for helping patients with tobacco cessation using established approaches including behavioral support, pharmacotherapy, or referral to specialized care.

KEY WORDS: primary care; tobacco; electronic cigarette; e-cigarette; vaping.

INTRODUCTION

The prevalence of daily/almost daily use of electronic cigarettes (e-cigarettes) and other electronic nicotine delivery systems has increased among adults in the USA.[1] A primary driver of e-cigarette use among adults is to help quit or reduce cigarette smoking or the use of other regular tobacco products.[2,3] This motive corresponds to the widely held perception that e-cigarettes are less harmful than combustible cigarettes.[3] As a result, there is a strong association between e-cigarette and traditional tobacco product use, and many e-cigarette users are also current tobacco users. For example, national survey data estimated that 14.4–16.0% of current (i.e., every day/some days) adult cigarette smokers between 2014 and 2016 were also current e-cigarette users compared to 0.4–1.4% of never cigarette smokers.[4,5] Among adults who report current use of e-cigarettes, national surveys indicate that 52.8–69.7% also report current (i.e., every day/some days) cigarette smoking.[5–8]

Despite a high proportion (79.5%) of adults reporting the use of e-cigarettes as a smoking cessation aid,[3] there is mixed evidence supporting the efficacy of e-cigarettes for this purpose.[9–11] Additionally, e-cigarettes contain several potentially hazardous components such as flavor additives and propylene glycol; however, long-term health effects from these components are inadequately studied, particularly with regard to use by inhalation.[12,13] Therefore, identifying e-cigarette use in healthcare settings where tobacco cessation treatments are offered may provide opportunities to discuss the lack of research on the safety of e-cigarettes and direct patients who use e-cigarettes as a smoking cessation aid toward strategies with

known efficacy and safety (e.g., nicotine replacement therapy, bupropion, varenicline).

Primary care settings, in particular, can play an important role in identifying e-cigarette use. Routine screening, counseling, and providing interventions for tobacco use in primary care settings is already considered best practice based on recommendations from the US Preventive Services Task Force.[14] As a result, this practice may be leveraged to identify and initiate discussions about e-cigarette use for reasons related to tobacco cessation in order to encourage the use of evidence-based tobacco cessation tools. A national survey of primary care providers (PCPs) revealed that nearly two thirds (65%) were asked about e-cigarettes by their patients.[15] Moreover, one study indicated that over three fourths (76.5%) of primary care patients who recently used e-cigarettes reported that they were comfortable discussing e-cigarette use with their PCP.[16] Most PCPs, however, report that they lack sufficient knowledge about e-cigarettes and express an interest in learning more.[17,18]

To inform primary care-based efforts toward addressing e-cigarette use, it is important to better understand the prevalence and correlates of e-cigarette use among primary care patients specifically. The majority of research on e-cigarette use, however, has been conducted among samples from the general population, which may not completely translate to primary care settings. Hence, there is a need for more research on e-cigarette use among primary care patients to specifically inform practice within this setting.

The objective of the present study was to examine the extent of e-cigarette use among a large sample of primary care patients using data from a multisite clinical trial: the National Drug Abuse Treatment Clinical Trials Network's Tobacco, Alcohol, Prescription medications, and other Substance (TAPS) Tool study.[19] Differences in patient characteristics according to e-cigarette use status were also examined. To inform efforts at leveraging already established primary care-based tobacco screening to identify e-cigarette use, we examined the prevalence and correlates of e-cigarette use among primary care patients who were past 3-month tobacco users. We further assessed the association of e-cigarette use and nicotine dependence/tobacco use disorder (TUD). Based on current evidence, we hypothesized that e-cigarette use would be influenced by demographic (e.g., age, race/ethnicity, education, employment status) and substance use characteristics.[20] We also hypothesized that current e-cigarette use would be associated with increased odds of nicotine dependence/TUD among primary care patients.

METHODS

Study Sample

The TAPS Tool study sample was comprised of 2000 adult primary care patients aged 18 or older. Participants were recruited across 5 primary care clinics in the Eastern USA from August 2014 to April 2015. Two of the clinics were urban safety net clinics, which included a Federal Qualified Health Center in Baltimore, MD ($n = 589$) and a hospital-based clinic in New York, NY ($n = 534$). The other clinics included a university-based health center in Richmond, VA ($n = 211$) and two non-academic community-based primary care practices in Kannapolis, NC ($n = 287$ and $n = 379$). A total of 14,171 individuals were initially approached and 12% declined screening. Among those assessed for eligibility, 52% did not meet inclusion criteria (not a clinic patient [$n = 2884$]; non-English language [$n = 2142$]; previously enrolled [$n = 1042$], age < 18 [$n = 278$], or other reason [$n = 172$]). A total of 2057 adults (35% of eligible adults) were enrolled in the study and 2000 participants completed the study. Other methodological details of the parent study have been reported previously.[21] Secondary data analysis of the TAPS Tool Study was approved by the Duke University Health System Institutional Review Board.

Study Variables

E-cigarette use was defined as any use in the 3 months prior to assessment. To evaluate e-cigarette use, participants were asked, "During the past three months, did you use e-cigarettes (an electronic nicotine delivery device or personal vaporizer)?" Those who answered affirmatively were then asked how many times per day e-cigarettes were used.

Lifetime and past 3-month substance use (illicit or nonmedical use) for 10 different substance categories (i.e., tobacco [cigarettes and other tobacco products, e.g., chewing tobacco, cigars, but excluding e-cigarettes], alcohol, cannabis, cocaine, amphetamine-type stimulants, inhalants, sedatives, hallucinogens, opioids, and other drugs) were assessed using the World Health Organization (WHO) Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST).[22] Response categories for past 3-month frequency of use included never, once or twice only, monthly, weekly, and daily/almost daily.

Past-year substance use and DSM-5 substance use disorder (SUD) for 12 different substance categories (i.e., tobacco [cigarettes and other tobacco products], alcohol, marijuana/hashish, cocaine/crack, heroin, prescription opioids, stimulants, methamphetamine, hallucinogens, sedatives, inhalants, and other drugs) was assessed using the modified WHO World Mental Health Composite International Diagnostic Interview (WMH-CIDI).[19,23] SUD according to the DSM-5 was defined as meeting ≥ 2 criteria for a given substance. Because the WMH-CIDI does not include all of the DSM-5 TUD criteria, TUD was assessed by adapting the items from the WMH-CIDI drug section.

The Fagerström Test of Nicotine Dependence (FTND) was used to assess current nicotine dependence.[24] As part of the FTND, current cigarette smoking and number of cigarettes smoked per day (recoded as ≤ 10 and ≥ 11) were assessed and were included as study variables. Sociodemographic variables

included self-reported age, sex, race/ethnicity, education, marital status, and employment status.

Data Analysis

Demographic and substance use characteristics among the total sample and by past 3-month e-cigarette use status were examined using descriptive statistics. Differences in characteristics by past 3-month e-cigarette use status were assessed using chi-square tests. Among past 3-month tobacco users, binary logistic regression models were used to examine the association between past 3-month e-cigarette use and demographic and substance use variables. Adjusted analyses were controlled for demographics, past 3-month substance use, and study site. Adjusted logistic regression was also used to examine the association between e-cigarette use and FTND-based nicotine dependence and DSM-5-based TUD, respectively, given that each measure captures different aspects of tobacco use and may have distinct implications with regards to treatment decisions and etiological research.[25,26] Next, we conducted adjusted multinomial ordinal logistic regression models to examine the association between past 3-month e-cigarette use and increasing levels of severity of nicotine dependence and TUD. Severity of nicotine dependence was classified into 3 mutually exclusive categories based on the FTND score,[24] including none (0), mild (1–4), and moderate/severe (≥ 5). Based on the DSM-5, TUD severity was classified into 3 mutually exclusive categories based on the number of criteria met including none (0–1 criteria), mild (2–3 criteria), and moderate/severe (≥ 4 criteria). Analyses were performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

The total sample of adult primary care patients ($n = 2000$) was predominately female (56.3%), in the 50 years or older age group (47.3%), and Black/African-American (53.5%). Among the total sample, e-cigarette use in the past 3 months was reported by 7.73% ($n = 154$) of participants. Among those reporting past 3-month e-cigarette use, e-cigarettes were used approximately eight (7.7) times per day. The prevalence of past 3-month tobacco use was 42.0% of the sample (Table 1).

A greater proportion of participants who reported e-cigarette use compared to those who did not were younger ages (18–34 years old: 37.0% vs. 25.5%), white (47.4% vs. 27.3%), and used tobacco daily/almost daily (72.7% vs. 26.9%) or smoked > 10 cigarettes per day (45.8% vs. 23.9%) in the past 3 months (Table 1). A higher proportion of e-cigarette users compared to non-users also reported past 3-month nonmedical use of cannabis or other drugs. Moreover, e-cigarette users were more likely to have current nicotine dependence, or DSM-5 criteria for past-year tobacco, cannabis, or other drug use disorder.

Among those who reported past 3-month tobacco use, the prevalence of e-cigarette use was 16.3% (Table 2). The prevalence of e-cigarette use among those who never used tobacco was 0.19%. In the unadjusted model, adults who reported past-3 month tobacco use and had some college education or more (vs. less than high school) or reported daily/almost daily tobacco use in the past 3 months had increased odds of e-cigarette use; those who were aged 50 years or older (vs. ages 18–34), Black/African-American (vs. white), or were disabled (vs. employed) had decreased odds of e-cigarette use (Table 2). In the adjusted model, the same factors, except being 50 years or older, were significantly associated with e-cigarette use. Additionally, study sites located in North Carolina (vs. New York) were associated with increased odds of e-cigarette use in both unadjusted and adjusted models.

Adjusted analyses among tobacco users controlling for demographic and other substance use variables showed that e-cigarette use was associated with increased odds of past-year TUD (AOR, 2.49; 95% CI, 1.55–4.01) and current nicotine dependence (AOR, 1.69; 95% CI, 1.12–2.54). Ordinal logistic regression results indicated that e-cigarette use was positively associated with increased levels of nicotine dependence or TUD (vs. none), while controlling for other covariates (Table 3).

DISCUSSION

The present study examined the prevalence and correlates of past 3-month e-cigarette use among a large sample of adult primary care patients. These findings extend the current literature, which has predominantly examined e-cigarette use among the general population. We found that approximately one out of every thirteen (7.7%) adult primary care patients in this sample used e-cigarettes in the past 3 months. We also found that demographics (age, race/ethnicity), tobacco use, and other drug use characteristics differed by e-cigarette use status.

In particular, the majority of e-cigarette users (72.7%) were daily/almost daily users of tobacco products (not counting e-cigarettes). Similar patterns have been reported from national surveys and may reflect e-cigarette use as a method to stop or cut down the use of cigarettes or other regular tobacco products because users perceive e-cigarettes to be relatively safer.[5–8] The high prevalence of tobacco use among e-cigarette users has implications for leveraging routine tobacco screening/assessment in primary care to identify and initiate discussions about e-cigarette use. For example, a strategy of screening for e-cigarette use among primary care patients in our sample who reported past 3-month or past-year tobacco use could potentially identify approximately 90% of adults who used e-cigarettes in the past 3 months. Given that most adults who use e-cigarettes do so as a tobacco cessation aid,[2,3] e-cigarette use screening has implications for helping to identify more patients interested in changing their tobacco use behavior. This

Table 1 Characteristics of Adult Primary Care Patients in the Total Sample and by Past 3-Month E-Cigarette Use Status (*n* = 2000)

	Total sample		Past 3-month e-cigarette use*		*p* value
			Yes	No	
	n = 2000		*n* = 154	*n* = 1838	
	n	Column % (SE)	Column % (SE)	Column % (SE)	
Sex*					0.3646
Male	874	43.70 (1.11)	47.40 (4.02)	43.47 (1.16)	
Female	1124	56.20 (1.11)	52.60 (4.02)	56.42 (1.16)	
Age in years					< 0.0001
18–34	526	26.30 (0.98)	37.01 (3.89)	25.46 (1.02)	
35–49	528	26.40 (0.99)	36.36 (3.88)	25.63 (1.02)	
50+	946	47.30 (1.12)	26.62 (3.56)	48.91 (1.17)	
Race/ethnicity					< 0.0001
White, non-Hispanic	577	28.85 (1.01)	47.40 (4.02)	27.26 (1.04)	
Black/African-American, non-Hispanic	1058	52.90 (1.12)	35.71 (3.86)	54.30 (1.16)	
Hispanic	233	11.65 (0.72)	9.74 (2.39)	11.86 (0.75)	
Other/unknown[†]	132	6.60 (0.56)	7.14 (2.08)	6.58 (0.58)	
Education*					0.3899
Less than high school	383	19.15 (0.88)	16.23 (2.97)	19.37 (0.92)	
High school/GED	578	28.90 (1.01)	26.62 (3.56)	29.05 (1.06)	
Some college or more	1038	51.90 (1.12)	57.14 (3.99)	51.52 (1.17)	
Employment					0.5054
Employed	712	35.60 (1.07)	38.31 (3.92)	35.36 (1.12)	
Unemployed[‡]	419	20.95 (0.91)	24.03 (3.44)	20.78 (0.95)	
Disabled	472	23.60 (0.95)	20.13 (3.23)	23.94 (1.00)	
Other[§]	397	19.85 (0.89)	17.53 (3.06)	19.91 (0.93)	
Marital status*					0.9900
Married/cohabited	524	26.20 (0.98)	25.97 (3.53)	26.22 (1.03)	
Separated/divorced/widowed	559	27.95 (1.00)	27.27 (3.59)	27.91 (1.05)	
Never married	916	45.80 (1.11)	46.10 (4.02)	45.87 (1.16)	
Tobacco use, lifetime[‖]	1474	73.70 (0.98)	99.35 (0.65)	71.65 (1.05)	< 0.0001
Tobacco use, past year*·[‖]	882	44.10 (1.11)	88.96 (2.53)	40.48 (1.15)	< 0.0001
Tobacco use, past 3 months[‖]	840	42.00 (1.10)	88.96 (2.53)	38.19 (1.13)	< 0.0001
Daily/almost daily tobacco use, past 3 months[‖]	607	30.35 (1.03)	72.73 (3.59)	26.93 (1.03)	< 0.0001
Smoke cigarettes currently[¶]	657	32.85 (1.05)	76.62 (3.41)	29.33 (1.06)	< 0.0001
Number of cigarettes smoked per day, among current smokers*·[¶]					< 0.0001
≤10	473	72.10 (1.75)	54.24 (4.59)	75.88 (1.84)	
≥11	183	27.90 (1.75)	45.76 (4.59)	23.93 (1.84)	
Alcohol use, past 3-months	1078	53.90 (1.11)	60.39 (3.94)	53.37 (1.16)	0.0934
Cannabis use, past 3-months	350	17.50 (0.85)	30.52 (3.71)	16.49 (0.87)	< 0.0001
Other drug use, past 3-months[#]	242	12.10 (0.73)	22.73 (3.38)	11.26 (0.74)	< 0.0001
Nicotine dependence (FTND)—current*·**	560	28.00 (1.00)	70.13 (3.69)	24.59 (1.00)	< 0.0001
Tobacco use disorder—past year*·[‖]	506	25.30 (0.97)	58.44 (3.97)	22.63 (0.98)	< 0.0001
Alcohol use disorder—past year	278	13.90 (0.77)	13.64 (2.77)	13.98 (0.81)	0.9052
Cannabis use disorder—past year*	147	7.35 (0.58)	12.99 (2.71)	6.91 (0.59)	0.0052
Other drug use disorder—past year*·[††]	177	8.85 (0.64)	14.94 (2.87)	8.38 (0.65)	0.0056
Study site					0.0003
Maryland	589	29.45 (1.02)	27.92 (3.62)	29.71 (1.07)	
New York	534	26.70 (0.99)	16.88 (3.02)	27.42 (1.04)	
Virginia	211	10.55 (0.69)	7.14 (2.08)	10.88 (0.73)	
North Carolina	666	33.30 (1.05)	48.05 (4.03)	31.99 (1.09)	

Data from "No" categories of dichotomous variables are not reported

Italic: p value < 0.01 based on chi-square test

*Missing: e-cigarette use (n = 8), sex (n = 2), education (n = 1), marital status (n = 1), past-year tobacco use (n = 1), number of cigarettes smoked per day (n = 1), nicotine dependence (n = 2), FTND among cigarette smokers (n = 1), tobacco use disorder (n = 1), cannabis use disorder (n = 3), other drug use disorder (n = 4)

[†]Other/unknown race includes Indian American, Alaska Native, Native Hawaiian, Guamanian, Samoan, Pacific Islander, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Asian, any other race, race refused/do not know

[‡]Unemployed includes temporarily laid off, sick leave, maternity leave, looking for work, or unemployed

[§]Other employment includes other, retired, or keeping house

[‖]Lifetime/past 3-month/almost daily/daily tobacco use was assessed by the ASSIST and included cigarettes and other tobacco products; past-year tobacco use/use disorder was assessed by the CIDI and included cigarettes and other tobacco products

[¶]Derived from Fagerström Test for Nicotine Dependence

[#]Other drug use includes cocaine, amphetamine-type stimulants, inhalants, sedatives/sleeping pills, hallucinogens, opioids, or other non-specified drugs

**Nicotine dependence based on Fagerström Test for Nicotine Dependence score ≥ 1

[††]Other drug use disorder includes cocaine/crack, heroin, inhalants, hallucinogens, opiates, amphetamines, sedatives, methamphetamine, or other non-specified drugs

in turn could allow for opportunities to provide information regarding the lack of research on the safety of e-cigarettes and to better assist patients with tobacco cessation using evidence-based treatments.

Table 2 Prevalence and Correlates of E-Cigarette Use Among Past 3-Month Tobacco Users (*n* = 840)

Past-3 month tobacco users[†]	E-cigarette use, yes* Row % (95% CI)	E-cigarette use vs. no e-cigarette use Crude OR (95% CI)	E-cigarette use vs. no e-cigarette use Adjusted OR (95% CI)
Total	16.31 (13.81–18.81)	–	–
Sex*			
Male	14.94 (11.68–18.19)	1.00	1.00
Female	18.04 (14.15–21.93)	1.26 (0.87–1.81)	0.98 (0.65–1.49)
Age in years			
18–34	21.43 (16.04–26.81)	1.00	1.00
35–49	21.94 (16.66–27.22)	1.02 (0.66–1.60)	1.29 (0.76–2.18)
50+	9.76 (6.77–12.76)	*0.39 (0.25–0.63)*	0.58 (0.31–1.06)
Race/ethnicity			
White, non-Hispanic	24.70 (19.31–30.09)	1.00	1.00
Black/African-American, non-Hispanic	11.13 (8.28–13.99)	*0.38 (0.25–0.58)*	*0.61 (0.39–0.96)*
Hispanic	14.77 (7.34–22.20)	0.53 (0.27–1.02)	0.84 (0.39–1.81)
Other/unknown[‡]	28.95 (14.50–43.40)	1.24 (0.58–2.65)	1.61 (0.71–3.64)
Education			
Less than high school	10.00 (5.93–14.07)	1.00	1.00
High school/GED	13.58 (9.45–17.72)	1.41 (0.80–2.51)	1.27 (0.70–2.30)
Some college or more	21.92 (17.67–26.17)	*2.54 (1.52–4.24)*	*1.99 (1.15–3.47)*
Employment			
Employed	21.16 (15.99–26.33)	1.00	1.00
Unemployed[§]	14.75 (10.02–19.47)	0.64 (0.39–1.04)	0.90 (0.52–1.55)
Disabled	11.84 (7.78–15.89)	*0.50 (0.30–0.82)*	0.77 (0.43–1.38)
Other	18.25 (11.77–24.73)	0.83 (0.49–1.41)	0.95 (0.53–1.71)
Marital status			
Married/cohabitated	21.76 (15.55–27.98)	1.00	1.00
Separated/divorced/widowed	14.66 (10.10–19.22)	0.62 (0.37–1.03)	1.02 (0.58–1.80)
Never married	15.07 (11.71–18.43)	0.64 (0.41–1.00)	0.88 (0.53–1.46)
Daily/almost daily tobacco use, past 3-months[†]			
No	10.73 (6.75–14.71)	1.00	1.00
Yes	18.45 (15.36–21.54)	*1.87 (1.18–2.98)*	*1.93 (1.17–3.20)*
Alcohol use, past 3-months			
No	16.10 (12.08–20.12)	1.00	1.00
Yes	16.44 (13.24–19.64)	1.03 (0.70–1.50)	0.89 (0.58–1.37)
Cannabis use, past-3 months			
No	15.57 (12.64–18.50)	1.00	1.00
Yes	18.07 (13.28–22.86)	1.19 (0.81–1.77)	1.31 (0.83–2.06)
Other drug use, past-3-months[¶]			
No	15.91 (13.11–18.71)	1.00	1.00
Yes	17.78 (12.18–23.37)	1.14 (0.74–1.76)	1.31 (0.79–2.18)
Study site			
New York	11.42 (7.20–15.64)	1.00	1.00
Maryland	12.54 (8.70–16.38)	1.11 (0.65–1.92)	1.03 (0.54–1.94)
Virginia	10.84 (4.14–17.55)	0.94 (0.42–2.12)	1.18 (0.48–2.88)
North Carolina	26.69 (21.21–32.18)	*2.84 (1.72–4.69)*	*2.02 (1.04–3.92)*

Italic: p < 0.05
*Missing: e-cigarette use (n = 1), sex (n = 1)
[†]*Past 3-month/almost daily/daily tobacco use was assessed by the ASSIST and included cigarettes and other tobacco products*
[‡]*Other/unknown race includes Indian American, Alaska Native, Native Hawaiian, Guamanian, Samoan, Pacific Islander, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Asian, any other race, race refused/do not know*
[§]*Unemployed includes only temporarily laid off, sick leave, maternity leave, looking for work, or unemployed*
Other employment includes other, retired, or keeping house
[¶]*Other drug use includes cocaine, amphetamine-type stimulants, inhalants, sedatives/sleeping pills, hallucinogens, opioids, or other non-specified drugs*

To further inform these efforts, we examined the prevalence and correlates of e-cigarette use among past 3-month tobacco users. Among patients who reported past 3-month tobacco use, increased odds of e-cigarette use were found among whites and those with some college education or more, while no association was found with sex, age, employment, or marital status. We also found regional differences in e-cigarette use such that the prevalence was more than twice as high in clinics in North Carolina than the other states. Relatively higher rates of e-cigarette use in southern regions have also been reported in studies among the general population,[8] which may be attributable to cultural factors, economic factors

(e.g., lower taxes), or more favorable attitudes toward tobacco products.[27–30]

Within the context of prior research, our results showing increased odds of e-cigarette use among whites compared to other races/ethnicities are consistent with nationally representative surveys of current smokers[31] or the general population.[20,32,33] On the other hand, prior studies have found education status to be either not associated[31] or negatively associated[20,33] with e-cigarette use, which is in contrast to our findings. National survey data has also indicated increased odds of current e-cigarette use among younger adults compared to older adults,[20,32] whereas our study found no age differences. While differences across

Table 3 Adjusted Ordinal Logistic Regressions Modeling the Association Between E-Cigarette Use and the Severity Level of Nicotine Dependence and DSM-5 Tobacco Use Disorder Among Past 3-Month Tobacco Users (*n* = 840)

Past-3 month tobacco users	FTND nicotine dependence severity* Adjusted OR (95% CI)	DSM-5 tobacco use disorder severity Adjusted OR (95% CI)
E-cigarette use, past 3-months*		
No	1.00	1.00
Yes	*1.90 (1.32–2.73)*	*1.68 (1.17–2.40)*
Sex*		
Male	1.00	1.00
Female	1.02 (0.77–1.36)	1.05 (0.80–1.39)
Age in years		
18–34	1.00	1.00
35–49	*2.38 (1.61–3.51)*	1.25 (0.85–1.84)
50+	*1.95 (1.30–2.93)*	1.15 (0.77–1.72)
Race/ethnicity		
White, non-Hispanic	1.00	1.00
Black/African-American, non-Hispanic	0.84 (0.61–1.16)	0.98 (0.72–1.35)
Hispanic	0.77 (0.46–1.31)	1.00 (0.60–1.67)
Other/unknown	*0.48 (0.24–0.96)*	0.80 (0.41–1.55)
Education		
Less than high school	1.00	1.00
High school/GED	0.79 (0.55–1.12)	0.99 (0.70–1.40)
Some college or more	*0.59 (0.42–0.83)*	0.97 (0.69–1.36)
Employment		
Employed	1.00	1.00
Unemployed	1.09 (0.75–1.59)	1.00 (0.69–1.44)
Disabled	*1.53 (1.05–2.24)*	1.28 (0.88–1.86)
Other	1.19 (0.78–1.80)	1.35 (0.89–2.04)
Marital status		
Married/cohabitated	1.00	1.00
Separated/divorced/widowed	1.36 (0.92–2.01)	0.87 (0.59–1.28)
Never married	1.09 (0.76–1.55)	0.81 (0.57–1.15)
Alcohol use, past 3-months		
No	1.00	1.00
Yes	0.75 (0.57–1.00)	*0.71 (0.54–0.95)*
Cannabis use, past 3-months		
No	1.00	1.00
Yes	0.90 (0.66–1.22)	0.93 (0.69–1.26)
Other drug use, past 3-months		
No	1.00	1.00
Yes	*2.31 (1.64–3.25)*	*1.92 (1.37–2.68)*
Study site, state		
New York	1.00	1.00
Maryland	1.38 (0.94–2.03)	1.07 (0.73–1.55)
Virginia	1.04 (0.62–1.75)	0.69 (0.41–1.15)
North Carolina	1.54 (0.99–2.38)	*0.52 (0.33–0.80)*

FTND nicotine dependence and DSM-5 tobacco use disorder were categorized as an ordinal variable of severity level (i.e., none, mild, moderate/severe), respectively. Adjusted ordinal logistic regression models included all variables listed in the first column. Footnotes for variables are as described in previous tables
Italic: p < 0.05
*Missing: e-cigarette use (n = 1), nicotine dependence (n = 2), sex (n = 1)

studies could be due to several factors including mode of survey administration, sampling bias, or sample representativeness, our findings suggest that there may also be distinct correlates of e-cigarette use within the context of primary care settings. A better understanding of these factors may inform providers of potential facilitators and barriers to tobacco cessation among patients who use e-

cigarettes and thereby aid with more effective treatment planning and implementation.

This study also found a strong positive association between e-cigarette use among tobacco users and current nicotine dependence or past-year DSM-5 TUD. Moreover, we found e-cigarette use was associated with higher severity levels of nicotine dependence or TUD. These findings may largely reflect the use of e-cigarettes among tobacco users as a cessation aide for nicotine dependence/TUD.[3] However, the association between e-cigarette use and more severe tobacco dependence/disorder is of concern given that greater severity has been found to be associated with worse tobacco cessation outcomes.[34–37] Thus, e-cigarette use among tobacco users may serve as a trigger for the need of more intensive tobacco cessation strategies to improve outcomes. Despite content differences between the FTND and DSM-5 to capture distinct aspects of tobacco dependence,[25,26] findings were similar for both measures, possibly reflecting the association of e-cigarette use with a higher order construct of tobacco dependence, which has implications for informing prevention and intervention strategies.

Another critical feature of our study was analysis of other substance use by e-cigarette use status. While we found that current alcohol or illicit drug users did not have greater odds of e-cigarette use, it was found that relatively more e-cigarette users reported recent nonmedical use and past-year disorder of cannabis and other drugs. Other studies of samples from the general population also suggest an association between e-cigarette use and polysubstance use.[38–40] Together, these findings suggest a broader, underlying profile of shared risk factors for substance use. Research also indicates an increasing use of e-cigarettes as illicit drug delivery systems, which poses increased risk of initiation and regular use of illicit drugs and/or additional health consequences among users.[41] Additional data are needed to better understand the nature of these relationships, particularly with regards to the temporality of e-cigarette and polysubstance use, which may inform prevention and intervention efforts.

This study had some limitations that should be acknowledged. Foremost, the cross-sectional design precluded causal conclusions and temporal sequencing between e-cigarette use and other factors. Additionally, results of this study were reliant on self-reported data, which may have been subject to recall or social-desirability bias. Our study was also limited to the extent that different dimensions of e-cigarette use were not captured including duration, frequency of use over time, and reasons for use. Prior research suggests that more continuous and higher frequency e-cigarette use may be associated with greater intention to quit smoking, whereas infrequent use may suggest experimentation or temporary substitution for cigarettes.[7,42,43] While the primary implications of the present study were to inform initial screening strategies, knowledge of more detailed patterns of e-cigarette use is important for informing subsequent assessment tools and primary care-based approaches to e-cigarette use and tobacco cessation. Furthermore, although our sample included a diverse

set of primary care practices, limitations in the generalizability of our findings should be noted. In particular, approximately half of the sample (54%) came from two urban safety net clinics, in which tobacco use and substance use may be relatively more prevalent. Our sample was also comprised of a relatively high proportion of African-Americans compared to the national average. As a result, some findings may have been biased toward underestimation given the higher overall prevalence of e-cigarette use among whites.[4] Finally, our findings should be considered within the context of changing national trends in e-cigarette use since the time data were collected for this analysis (i.e., 2014–2015). Nonetheless, the present findings are critical to informing primary care-based strategies when current national surveys of substance use are not specific to primary care settings.

In summary, results from the present study contribute an improvement to the literature and serve to further knowledge about e-cigarettes within the context of primary care settings. Prior research indicates that a primary motive of e-cigarette use among adults is to help quit or reduce regular tobacco use.[2,3] Thus, incorporating screening for e-cigarettes into existing primary care-based practice guidelines for tobacco use has the potential to identify more patients motivated in changing their tobacco use behavior for which providers may be able to better assist using established treatment strategies. Our study provided an indication of the extent of this opportunity such that approximately one out of every six tobacco users among this sample of primary care patients was a recent e-cigarette user. Our study also indicated that e-cigarette use was more likely among tobacco users who were white, had some college education or more, or used tobacco daily. These findings suggest that increased monitoring for e-cigarette use among these patient subgroups may maximize efforts at reducing the potential risks of e-cigarette use and facilitate implementation of evidence-based tobacco cessation strategies. Going forward, more research is essential to inform the development of educational resources and primary care-based practice guidelines for providers about e-cigarettes.

Corresponding Author: *William S. John, PhD; Department of Psychiatry and Behavioral Sciences, Division of Social and Community Psychiatry Duke University Medical Center, Durham, NC, USA (e-mail: william.john@duke.edu).*

Compliance with Ethical Standards:

REFERENCES

1. **McMillen RC, Gottlieb MA, Shaefer RM, Winickoff JP, Klein JD.** Trends in electronic cigarette use among u.s. adults: use is increasing in both smokers and nonsmokers. Nicotine Tob Res 2015;17(10):1195-1202.
2. **Rutten LJ, Blake KD, Agunwamba AA, et al.** Use of e-cigarettes among current smokers: associations among reasons for use, quit intentions, and current tobacco use. Nicotine Tob Res 2015;17(10):1228-1234.
3. **Rodu B, Plurphanswat N.** E-cigarette Use among US adults: Population Assessment of Tobacco and Health (PATH) Study. Nicotine Tob Res 2018;20(8):940-948.
4. **Mirbolouk M, Charkhchi P, Kianoush S, et al.** Prevalence and distribution of e-cigarette use among U.S. adults: Behavioral Risk Factor Surveillance System, 2016. Ann Intern Med 2018;169(7):429-438.
5. **Schoenborn CA, Gindi RM.** Electronic cigarette use among adults: United States, 2014. NCHS Data Brief 2015;(217):1-8.
6. **Jaber RM, Mirbolouk M, DeFilippis AP, et al.** Electronic cigarette use prevalence, associated factors, and pattern by cigarette smoking status in the United States from NHANES (National Health and Nutrition Examination Survey) 2013-2014. J Am Heart Assoc. 2018;7(14).
7. **Coleman BN, Rostron B, Johnson SE, et al.** Electronic cigarette use among US adults in the Population Assessment of Tobacco and Health (PATH) Study, 2013-2014. Tob Control 2017;26(e2):e117-e126.
8. **Sharapova SR, Singh T, Agaku IT, Kennedy SM, King BA.** Patterns of e-cigarette use frequency—National Adult Tobacco Survey, 2012-2014. Am J Prev Med 2018;54(2):284-288.
9. **Hartmann-Boyce J, McRobbie H, Bullen C, Begh R, Stead LF, Hajek P.** Electronic cigarettes for smoking cessation. Cochrane Database Syst Rev. 2016;9:Cd010216.
10. **Kalkhoran S, Glantz SA.** E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. Lancet Respir Med 2016;4(2):116-128.
11. **Hajek P, Phillips-Waller A, Przulj D, et al.** A randomized trial of e-cigarettes versus nicotine-replacement therapy. N Engl J Med 2019.
12. **Barrington-Trimis JL, Samet JM, McConnell R.** Flavorings in electronic cigarettes: an unrecognized respiratory health hazard? JAMA. 2014;312(23):2493-2494.
13. **Kosmider L, Sobczak A, Prokopowicz A, et al.** Cherry-flavoured electronic cigarettes expose users to the inhalation irritant, benzaldehyde. Thorax. 2016;71(4):376-377.
14. **Siu AL.** Behavioral and pharmacotherapy interventions for tobacco smoking cessation in adults, including pregnant women: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med 2015;163(8):622-634.
15. **Steinberg MB, Giovenco DP, Delnevo CD.** Patient–physician communication regarding electronic cigarettes. Prev Med Rep 2015;2:96-98.
16. **Doescher MP, Wu M, Rainwater E, Khan AS, Rhoades DA.** Patient perspectives on discussions of electronic cigarettes in primary care. J Am Board Fam Med 2018;31(1):73-82.
17. **Nickels AS, Warner DO, Jenkins SM, Tilburt J, Hays JT.** Beliefs, practices, and self-efficacy of US physicians regarding smoking cessation and electronic cigarettes: a national survey. Nicotine Tob Res 2016;19(2):197-207.
18. **Pepper JK, McRee A-L, Gilkey MB.** Healthcare providers' beliefs and attitudes about electronic cigarettes and preventive counseling for adolescent patients. J Adolesc Health 2014;54(6):678-683.
19. **McNeely J, Wu LT, Subramaniam G, et al.** Performance of the Tobacco, Alcohol, Prescription Medication, and Other Substance Use (TAPS) tool for substance use screening in primary care patients. Ann Intern Med 2016;165(10):690-699.
20. **Chou SP, Saha TD, Zhang H, et al.** Prevalence, correlates, comorbidity and treatment of electronic nicotine delivery system use in the United States. Drug Alcohol Depend 2017;178:296-301.
21. **Wu LT, McNeely J, Subramaniam GA, Sharma G, VanVeldhuisen P, Schwartz RP.** Design of the NIDA clinical trials network validation study of tobacco, alcohol, prescription medications, and substance use/misuse (TAPS) tool. Contemp Clin Trials 2016;50:90-97.
22. **Humeniuk R, Ali R, Babor TF, et al.** Validation of the alcohol, smoking and substance involvement screening test (ASSIST). Addiction. 2008;103(6):1039-1047.

23. World Health Organization (WHO). The World Mental Health Composite International Diagnostic Interview. 2015. http://www.hcp.med.harvard.edu/wmhcidi/index.php. Accessed 12 Apr 2017.

24. **Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO.** The Fagerstrom Test for Nicotine Dependence: a revision of the Fagerstrom Tolerance Questionnaire. Br J Addict 1991;86(9):1119-1127.

25. **Mwenifumbo J, Tyndale IV R.** DSM-IV, ICD-10 and FTND: discordant tobacco dependence diagnoses in adult smokers. J Addict Res Ther 2011;2:1.

26. **Chung T, Martin CS, Maisto SA, Cornelius JR, Clark DB.** Greater prevalence of proposed DSM-5 nicotine use disorder compared to DSM-IV nicotine dependence in treated adolescents and young adults. Addiction. 2012;107(4):810-818.

27. Association AL. Cutting tobacco's rural roots: tobacco use in rural communities. Disparities in Lung Health Serires 2012.

28. **Anand V, McGinty KL, O'Brien K, Guenthner G, Hahn E, Martin CA.** E-cigarette use and beliefs among urban public high school students in North Carolina. J Adolesc Health 2015;57(1):46-51.

29. **Giovacchini CX, Pacek L, McClernon FJ, Que LG.** Use and perceived risk of electronic cigarettes among North Carolina middle and high school students. N C Med J 2017;78(1):7-13.

30. **Boonn A.** State cigarette excise tax rates & rankings. Washington DC: Campaign for Tobacco-Free Kids. 2015.

31. **Giovenco DP, Lewis MJ, Delnevo CD.** Factors associated with e-cigarette use: a national population survey of current and former smokers. Am J Prev Med 2014;47(4):476-480.

32. **Delnevo CD, Giovenco DP, Steinberg MB, et al**. Patterns of electronic cigarette use among adults in the United States. Nicotine Tob Res 2016;18(5):715-719.

33. **King BA, Patel R, Nguyen KH, Dube SR.** Trends in awareness and use of electronic cigarettes among US adults, 2010-2013. Nicotine Tob Res 2015;17(2):219-227.

34. **Courvoisier DS, Etter J-F.** Comparing the predictive validity of five cigarette dependence questionnaires. Drug Alcohol Depend 2010;107(2-3):128-133.

35. **Ferguson JA, Patten CA, Schroeder DR, Offord KP, Eberman KM, Hurt RD.** Predictors of 6-month tobacco abstinence among 1224 cigarette smokers treated for nicotine dependence. Addict Behav 2003;28(7):1203-1218.

36. **Japuntich SJ, Leventhal AM, Piper ME, et al.** Smoker characteristics and smoking-cessation milestones. Am J Prev Med 2011;40(3):286-294.

37. **Kozlowski LT, Porter CQ, Orleans CT, Pope MA, Heatherton T.** Predicting smoking cessation with self-reported measures of nicotine dependence: FTQ, FTND, and HSI. Drug Alcohol Depend 1994;34(3):211-216.

38. **Camenga DR, Kong G, Cavallo DA, et al.** Alternate tobacco product and drug use among adolescents who use electronic cigarettes, cigarettes only, and never smokers. J Adolesc Health 2014;55(4):588-591.

39. **Miech RA, O'Malley PM, Johnston LD, Patrick ME.** E-cigarettes and the drug use patterns of adolescents. Nicotine Tob Res 2016;18(5):654-659.

40. **Morean ME, Kong G, Camenga DR, Cavallo DA, Simon P, Krishnan-Sarin S.** Latent class analysis of current e-cigarette and other substance use in high school students. Drug Alcohol Depend 2016;161:292-297.

41. **Breitbarth AK, Morgan J, Jones AL.** E-cigarettes—an unintended illicit drug delivery system. Drug Alcohol Depend 2018;192:98-111.

42. **Biener L, Hargraves JL.** A longitudinal study of electronic cigarette use among a population-based sample of adult smokers: association with smoking cessation and motivation to quit. Nicotine Tob Res 2014;17(2):127-133.

43. **Brose LS, Hitchman SC, Brown J, West R, McNeill A.** Is the use of electronic cigarettes while smoking associated with smoking cessation attempts, cessation and reduced cigarette consumption? A survey with a 1-year follow-up. Addiction. 2015;110(7):1160-1168.