Electronic cigarette and tobacco use in individuals entering methadone or buprenorphine treatment

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ABSTRACT

Background: Although smoking is prevalent among populations with opioid use disorder (OUD), few studies have examined electronic cigarette (EC) use in individuals seeking opioid agonist therapy (OAT). The aim of this study was to evaluate the prevalence and correlates of EC use among individuals seeking OAT.
Methods: 782 patients seeking OAT for OUD completed surveys assessing current and past EC use, reasons for use, current and past cigarette smoking, nicotine dependence, psychiatric distress, trauma, and pain. Bivariate and multivariate models evaluated correlates of daily EC use, past-30-day EC use, and current cigarette smoking.
Results: 6% of patients reported daily EC use, 18% reported past-30-day use, 62% reported EC use history, and 85% reported current cigarette smoking. 46% reported using ECs to quit or cut down smoking. In multivariate analyses, daily EC use was associated with higher odds of being a former smoker (OR 21; CI 1.7–273) and lower odds of ever smoking more than 100 cigarettes (OR 0.07; CI 0.01–0.32), while EC use in the past 30 days was associated with lower odds of being Caucasian (OR 0.55; CI 0.34–0.89), ever smoking more than 100 cigarettes (OR 0.13; CI 0.02–0.67), and history of chronic pain (OR 0.59; CI 0.38-0.90), and higher odds of reporting psychiatric distress (OR 1.5; CI 1.1–2.2).
Conclusions: EC use is common among people with OUD who smoke cigarettes. Those with daily use had higher odds of being former smokers than current smokers. Interventions using ECs may be effective to help reduce harms and mortality in OUD.

1. Introduction

Both opioid use disorder (OUD) and tobacco use disorder are enormous public health problems in the United States. Opioid agonist therapy (OAT) involving the administration of methadone or buprenorphine is the most effective treatment available for OUD, and significantly improves both health outcomes and morbidity and retention rates (Fiellin et al., 2006). Yet like other substance use disorders, OUD frequently co-exists with other medical and psychiatric conditions. Tobacco use disorder is among the most important and overlooked conditions that affects those with OUD. Despite improvements in tobacco control efforts over the past half century, cigarette smoking claims 480,000 lives per year and remains the leading cause of preventable death in the United States (National Center for Chronic Disease P et al., 2014). For example, in a large, longitudinal cohort study of chronic injection drug users, nearly 25% died from cancer or

heart disease, both of which can be caused by chronic cigarette smoking (Y-i et al., 2001). Novel effective interventions to address tobacco use disorder in patients with OUD are urgently needed.

Electronic cigarette (EC) use is common among adult cigarette smokers, particularly those trying to stop smoking (Schoenborn and Gindi, 2015). ECs are battery-operated devices that heat and aerosolize a liquid solution that may contain nicotine (Baldassarri et al., 2018). However, it remains unclear whether ECs are effective for treating to-bacco use disorder in general and particularly whether they can reduce harm in people with OUD. Small pilot studies investigating EC use for smokers with OUD showed reasonable adherence to EC interventions, but failed to demonstrate efficacy in promoting smoking cessation (Felicione et al., 2018; Stein et al., 2016). Importantly, there are few extant data on the epidemiology of EC use, and the clinical character-istics associated with daily EC use, including current or past cigarette smoking, among patients entering OAT. The primary aim of this study was to determine the prevalence, correlates, and reasons for EC use among people seeking treatment for OUD. We also examined the pre-valence and correlates of daily cigarette smoking. Understanding EC use in people with OUD might lead to the development of more effective smoking cessation interventions and harm reduction strategies in this population.

2. Methods

Data were collected at program entry from a consecutive sample of 782 patients with OUD who presented for treatment at the APT Foundation, an urban addiction treatment and community health center, and were subsequently initiated on either methadone or bu-prenorphine between April and October 2017. The APT Foundation is a Connecticut-based not-for-profit community organization, affiliated with Yale School of Medicine, which operates treatment centers dedi-cated to promoting the health for individuals who live with substance use disorders or mental illness. The APT Foundation is one of the largest providers of opioid agonist treatment in Southern New England (Madden et al., 2018).

A retrospective analysis of intake measures completed by patients was conducted. During the study period, an additional 16 patients did not complete the measures because they did not read or write English and were excluded from data analyses. The study involving a medical record review was approved by the APT Foundation Board and the Human Investigations Committee at the Yale School of Medicine.

Patients completed questionnaires on current use of ECs, history of EC use, reasons for EC use, cigarette smoking history, and level of ni-cotine dependence (Fagerström Test for Nicotine Dependence (Heatherton et al., 1991)). Patients also completed measures to assess potential correlates of EC use, including demographics, history of chronic pain and pain intensity on average and at its worst in the past week using items from the Brief Pain Inventory-Short Form (Cleeland and Ryan, 1994) scored on 0–10 numerical rating scales, the Life Events Checklist for DSM-5 (LEC-5 (Weathers et al., 2013)) to assess trauma history (physical assault and sexual assault), and the Behavioral and Symptom Identification Scale (BASIS-24 (Cameron et al., 2007)), whose overall summary score provides an index of psychiatric distress. The LEC-5 is a validated survey instrument from the National Center for PTSD that includes questions about exposure to physical and sexual trauma, natural disasters, hazardous workplace exposures, life-threa-tening illness and injury, among other serious life events. The BASIS-24 is a self-report measure comprising 24 items (scored on a 0–4 scale) designed to assess psychiatric symptoms across 6 domains: depression, interpersonal relationships, self-harm, emotional lability, psychotic symptoms, and substance abuse. Smokers were defined as having smoked > 100 cigarettes or more lifetime and currently smoking every day or some days. Former smokers were defined as having smoked > 100 cigarettes lifetime but had not smoked at all in the past 30 days. The rationale for using 100 lifetime cigarettes to define smoking status

was to clearly distinguish long-term smokers from those who may have only had a brief smoking history and was based on the question's prior use in multi-purpose national health surveys. (Bondy et al., 2009). An FTND score of 6 or higher was used as a cut off to categorize high nicotine dependence for each patient (Storr et al., 2005). EC use history was assessed with the question, "Have you ever tried an e-cigarette, even just one time?" For those who responded that they had ever tried an EC, follow-up questions included how often they used EC in the past 30 days (every day, some days, or none) and reasons for using the EC (to quit smoking, cut down on smoking, or to use in places where regular cigarette smoking was prohibited).

2.1. Statistical analysis

Descriptive analyses characterized demographic and clinical char-acteristics of the population, and the history and pattern of EC use and cigarette smoking. We performed logistic regression to determine the correlates of the three primary study outcomes: daily EC use, past-30-day EC use, and current cigarette smoking. Each correlate was first tested using bivariate regression, and then a multivariate model as-sessed all the correlates that were significant at a level of $p \le 0.05$. The correlates were entered simultaneously in the model. Data were ana-lyzed using Stata SE Version 15 statistical software.

3. Results

Demographics of the study population are in Table 1. The sample, on average, was young (37 ± 11 years), predominantly Caucasian (70%), and male (60%); 82% had at least a high school level of edu-cation, and 18% had full-time employment.

Combustible cigarette and e-cigarette use characteristics are in Table 2. The majority of respondents had a history of cigarette smoking (89%) and reported current smoking (85%). Daily smoking was re-ported among 72.6% of respondents. Among non-daily smokers, 30.5% smoked more than 10 cigarettes on smoking days. Nearly one third of the smokers (32%) had a high level of nicotine dependence as measured by the Fagerstrom Test for Nicotine Dependence (score > 5) (Heatherton et al., 1991).

The bivariate and multivariate logistic regression models for factors associated with daily EC use, past 30-day EC use, and current com-bustible cigarette smoking in Tables 3–5. *Daily* EC use and any past 30-day EC use were low (6% and 18% respectively), while history of any EC use was reported in the majority of individuals (62%). A large proportion of EC users reported using ECs to either quit (24%) or cut

Table 1
Demographics.

Demographics (n = 782)	
Age, mean (SD)	37 (11)
Female, No. (%)	312 (39.9)
Hispanic, No. (%)	96 (12.3)
Race, No. (%)	
American Indian or Alaskan native	6 (0.77)
Asian	1 (0.13)
Black or African American	117 (15.0)
White/Caucasian	549 (70.2)
Multiracial or other	108 (13.8)
Highest Education, No. (%)	
8th grade or less	20 (2.6)
Some high school	118 (15.1)
High school graduate / GED	355 (45.4)
Some college	236 (30.2)
4-year college graduate or higher	50 (6.4)
Full time employment, No. (%)	143 (18.3)
Any employment, No. (%)	275 (35.2)
Homeless/shelter, No. (%)	58 (7.4)
Recent incarceration, No. (%)	30 (3.8)

Table 2
Substance Use Patterns.

Substance Use (n = 782)	
Tobacco	
History of cigarette smoking, No. (%)	697 (89.1)
Past 30-day smoking, No. (%)	663 (84.8)
Daily Smoking, No. (%)	568 (72.6)
Fagerstrom Test for Nicotine Dependence (FTND), mean (SD)	4.8 (2.5)
FTND > 5, No. (%)	248 (31.7)
Any History of E-Cigarette Use, No. (%)	486 (62.1)
Any Past 30-day E-cigarette Use, No. (%)	139 (17.8)
Daily Past 30-day Daily E-cigarette Use, No. (%)	43 (5.5)
Reasons for E-cigarette Use, No. (%)	
To quit smoking, No. (%)	189 (24.2)
To cut down on smoking, No. (%)	173 (22.1)
To smoke in places where cigarette smoking is not allowed, No. (%)	72 (9.2)
Other, No. (%)	75 (9.6)
Marijuana	
Past 30-day marijuana use, No. (%)	310 (39.6)

down smoking (22%); a smaller proportion reported using them to consume nicotine in places were cigarette smoking was not allowed (9%).

Those who used ECs daily were more likely to be former smokers in both models (Bivariate: OR 5.6; CI 2.2–13.9; Multivariate: OR 21; CI 1.7–273). In the bivariate model, those who used ECs daily were less likely to be: current smokers (OR 0.18; CI 0.1–0.4), report current use of marijuana (OR 0.37; CI 0.18–0.76), and to report a history of chronic pain (OR 0.47; CI 0.25–0.89). Those with daily EC use were more likely to be employed full time (OR 2.8; CI 1.5–5.5).

Those who used ECs in the past 30 days were more likely to be former combustible cigarette smokers in both models (Bivariate: OR 2.4; CI 1.1–5.4; Multivariate: OR 11.9; CI 1.1–131) and reported more psychiatric symptoms than non-EC users (Bivariate: OR 1.4; CI 1.0–1.9; Multivariate: OR 1.5; CI 1.1–2.2). They were also less likely to report having smoked more than 100 cigarettes in their lifetime (OR 0.30; CI 0.11–0.83; Multivariate: OR 0.13; CI 0.02–0.67) and to have a history of chronic pain (OR 0.70; CI 0.47–1.0; Multivariate: OR 0.59; CI 0.38–0.90).

Current combustible cigarette smokers had lower odds of reporting daily EC use in both the bivariate and multivariate models (Bivariate: OR 0.18; CI 0.08–0.41; Multivariate: OR 0.28; CI 0.08–0.95). In the bivariate analysis (but not the multivariate analysis), current smokers were less likely to be older (OR 0.96; CI 0.95–0.98), employed full time (OR 0.62; 0.39–0.98), or to have used e-cigarettes in the past 30 days

(OR 0.44; CI = 0.21–0.90). Current smokers in the bivariate analysis were more likely to report current use of marijuana (OR 2.6; CI 1.6–4.1), history of physical assault (OR 1.8; CI 1.2–2.7), history of sexual assault (OR 1.8; CI 1.1–2.9, and psychiatric symptoms (OR 1.8; CI 1.3–2.5).

4. Discussion

EC use was reported in a sizable majority of people entering treatment for OUD. Most reported trying to use ECs to either quit or cut down on smoking, while a smaller proportion were using ECs to supplement nicotine use in places where smoking was forbidden. These findings confirm those from a prior survey of 315 individuals with comorbid OUD and tobacco dependence in a single center, which found that the most common reasons for EC use were curiosity and to quit all nicotine (Stein et al., 2015). Participants in this earlier study were already receiving methadone or buprenorphine treatment, whereas those in the current study had not yet initiated opioid agonist treatment.

There were several important findings with respect to EC use patterns in the current analysis. First, those with daily EC use made up only 5% of the total EC users in the sample. Most people reporting EC use had used these products in the past 30 days at some point in time, but not regularly. Second, most people reporting any EC use at any point in time were still smoking. These latter results were similar to those from a prior study of 1127 individuals from 24 substance abuse treatment centers that daily EC users were more likely to be on methadone maintenance and to be former cigarette smokers, and the majority of daily EC users were current cigarette smokers (Gubner et al., 2016). Both the results of this earlier study and the current analysis suggest that some individuals successfully switched from combustible cigarette use to EC use, but that switching might require daily EC use (i.e., persistent nicotine use) to maintain smoking abstinence. Alternatively, these individuals might reflect a subpopulation with a particularly strong motivation to stop smoking or who have lower nicotine dependence

Third, we found that past-30-day EC users were more likely to report psychiatric symptoms compared with non-users. This observation is consistent with prior analyses of the National Health Interview Survey that noted higher rates of EC use in people with a variety of chronic psychiatric illnesses including mood and cognitive disorders (Bianco, 2019; Park et al., 2017). The precise nature of this relationship remains unclear, though it might reflect either smoking cessation attempts or a desire to use nicotine-containing products more frequently in this subpopulation.

Fourth, both daily and past-30-day EC users were less likely to

Table 3
Logistic models for Daily EC Use (n = 457).

Daily Current E-Cig Use	OR (Bivariate)	95% CI	OR (Multivariate) (n = 457)	95% CI
Age	1.01	0.98–1.0		
Male gender	1.32	0.68–2.5		
White race	0.68	0.34–1.4		
College or higher	0.93	0.49–1.8		
FTND score	0.99	0.85–1.2		
FTND > 5	1.06	0.46–2.4		
Employed full time	**2.84**	1.46–5.5	1.2	0.5–3.0
Current smoker	**0.18**	0.08–0.41	4.36	0.42–45.5
Former smoker	**5.59**	2.23–13.9	**21.3**	**1.7–273**
Smoked > 100 cig lifetime	**0.20**	0.07–0.60	**0.07**	**0.01–0.32**
Current marijuana use	**0.37**	0.18–0.76	0.43	0.20–0.91
Current chronic pain	0.65	0.33–1.26		
History of chronic pain	**0.47**	0.25–0.89	0.60	0.30–1.2
History of physical assault	0.56	0.30–1.05		
History of sexual assault	0.75	0.37–1.5		
BASIS-24	1.08	0.66–1.8		

Bold text indicates p ≤ 0.05. The multivariate model included independent variables that were statistically significant at p ≤ 0.05 in the bivariate model.

Table 4

Logistic Models for Any Past 30-Day E-Cigarette Use (n = 445).

Any Current E-Cig Use (Past 30 days)	OR (bivariate)	95% CI	OR (multivariate) (n = 445)	95% CI
Age	1.00	0.99–1.0		
Male gender	1.39	0.92–2.1		
Caucasian race	**0.60**	**0.38–0.94**	**0.55**	**0.34–0.89**
College or higher	0.85	0.56–1.3		
FTND score	1.02	0.93–1.1		
FTND > 5	1.15	0.72–1.8		
Employed full time	1.04	0.63–1.7		
Current smoker	**0.44**	**0.21–0.90**	3.26	0.35–30
Former smoker	**2.38**	**1.06–5.4**	11.9	1.1–131
Smoked > 100 cig lifetime	**0.30**	**0.11–0.83**	**0.13**	**0.02–0.67**
Current marijuana use	1.26	0.85–1.9		
Current chronic pain	0.93	0.62–1.4		
History of chronic pain	**0.70**	**0.47–1.0**	**0.59**	**0.38–0.90**
History of physical assault	0.97	0.65–1.4		
History of sexual assault	0.81	0.53–1.2		
BASIS-24	**1.38**	**1.00–1.9**	**1.5**	**1.1–2.2**

Bold text indicates p ≤ 0.05. The multivariate model included independent variables that were statistically significant at p ≤ 0.05 in the bivariate model.

report a history of chronic pain and less likely to have reported smoking more than 100 cigarettes in their lifetime. Epidemiologic and experimental evidence has shown that pain increases smoking motivation and shortens smoking latency, while reported pain intensity is attenuated in former smokers as compared with current smokers (Volkman et al., 2015; Ditre and Brandon, 2008). The observed effects might indicate that those with chronic pain history are less likely to give up cigarette smoking and may therefore find EC use less appealing as an alternative. Furthermore, EC use appeared to be more common in people with a lower reported smoking history, which may indicate the products may hold more appeal in lighter smokers or non-smokers as compared with heavier smokers.

Combustible cigarette smoking rates for people with OUD receiving methadone maintenance treatment range from 74 to 94% (Ali et al., 2013). Our study sample had similarly high smoking rates. These elevated rates are particularly concerning given that individuals with OUD have 1.8 times the relative risk of death due to tobacco-related causes as compared with the general population (Hurt et al., 1996). Many patients who seek treatment for OUD show an interest in smoking cessation if offered during addiction treatment (Nahvi et al., 2006; Clemmey et al., 1997). Yet a large survey of U.S. OUD treatment programs found that only about 18% offered behavioral counseling and 12% prescribed nicotine replacement therapy for people with tobacco use disorder (Richter et al., 2004). Notably, however, smoking cessation studies have failed to show significant improvement in long-term quit rates using pharmacologic or counseling approaches in people with OUD. The poor smoking cessation rate might relate to interactions between nicotine and methadone, where the two substances work synergistically and reinforce dual use (Ali et al., 2013). Our findings suggest that additional investigations should evaluate whether an EC-based smoking cessation intervention can increase smoking cessation rates among patients on OAT.

The current study has several limitations. First, we analyzed patients from a single treatment center; thus, the results may not generalize to other populations and settings. Nonetheless, we note similarities between our patient population and others with OUD that have been previously studied (Gubner et al., 2016; Nahvi et al., 2006; Richter et al., 2004). Second, the cross-sectional data in the current analysis prevented examination of daily changes in smoking and EC use over time. Additional investigations utilizing longitudinal and experimental designs are needed to evaluate the impact of EC-based interventions on smoking cessation in people with OUD. Third, our data lacked important indices of EC use, such as biochemical verification of smoking status, the device that was used, characteristics of the e-liquid, the within-day frequency of use, and additional reasons for EC use not addressed by our survey items. EC products are diverse, and future studies should examine information on product type and specific characteristics that make them appealing to smokers to improve intervention design and treatment outcome. Similarly, substance use data in this study were based on self-report, which might have resulted in an

Table 5

Logistic Regression for Current Cigarette Smoking (n = 439).

Current Cigarette Smoking	OR (Bivariate)	95% CI	OR (Multivariate) (n = 439)	95% CI
Age	**0.96**	**0.95–0.98**	1.01	0.98–1.1
Male gender	0.68	0.45–1.04		
White race	0.69	0.44–1.10		
College or higher	0.74	0.49–1.11		
Employed full time	**0.62**	**0.39–0.98**	0.64	0.27–1.5
Past 30-day e-cig use	**0.44**	**0.21–0.90**	0.71	0.25–2.1
Current daily e-cig use	**0.18**	**0.08–0.41**	**0.28**	**0.08–0.95**
Current marijuana use	**2.57**	**1.61–4.10**	2.1	0.87–5.1
Current chronic pain	1.19	0.79–1.79		
History of chronic pain	1.26	0.84–1.89		
Worst Pain Average	1.04	0.98–1.10		
Average Pain level	1.05	0.99–1.12		
History of physical assault	**1.78**	**1.19–2.65**	1.64	0.67–4.0
History of sexual assault	**1.81**	**1.12–2.92**	0.98	0.34–2.8
BASIS-24	**1.82**	**1.31–2.53**	1.36	0.72–2.6

Bold text indicates p ≤ 0.05. The multivariate model included independent variables that were statistically significant at p ≤ 0.05 in the bivariate model.

underestimation of licit and illicit substance use. Specifically, recall bias may also have affected subjects' classifications both with respect to cigarette smoking status (i.e. whether they smoked 100 or more cigarettes in their lifetime) and other drug use. Fourth, though our sample size was relatively large, a small number were daily EC users. Accumulating more data on this population will increase understanding whether daily EC use is necessary for smoking abstinence.

5. Conclusions

Electronic cigarette use is common among people with OUD who smoke cigarettes. Those who use ECs daily were more likely to be former combustible cigarette smokers than current smokers, but most past-30-day EC users were current combustible cigarette smokers. EC use in this population could represent a novel strategy for smoking cessation and possibly harm reduction, but much remains unknown regarding the optimal approach to treatment and whether such treatment would be effective. Further research is needed to determine whether EC use can reduce harm and be an effective smoking cessation aid for people with OUD.

Declaration of interests

There are no relevant conflicts of interest.

Contributors

S.B., D.F., and D.B. were involved in the study design and data analysis. S.B., D.F., M.S., L.M., M. B., L.D., L.F., D.C., P.B., and D.B were involved in the manuscript writing and editing. All authors have approved the final article.

Conflict of interest

No conflict declared.

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