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## Short Communication

## Lifetime use of non-nicotine drugs in electronic cigarette devices among a sample of individuals in substance use disorder treatment

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## ABSTRACT

**Background:** Limited data are available on other substance use in e-cigarettes (OSUE). The aim of this research was to determine the prevalence and predictors of OSUE among a sample of individuals in substance use disorder (SUD) treatment.

**Methods:** In 2019, we surveyed 553 individuals from 18 residential SUD treatment programs in California, USA. Individuals reporting any lifetime use of an e-cigarette containing nicotine ( $n = 279$ ) were asked about ever use of drugs other than nicotine in their e-cigarette. Those who reported use of non-nicotine drugs in their e-cigarette also reported what psychoactive drugs were used.

**Results:** Among all the participants, 25 % ( $n = 139$ ) reported ever engaging in OSUE. The most common drugs used in vaping devices were marijuana/THC/hash, (70.5 %,  $n = 98$ ) and amphetamines/methamphetamine (51.1 %,  $n = 71$ ). Among those who had engaged in OSUE, 44.6 % ( $n = 62$ ) had vaped drugs for which they sought treatment. Older persons (OR = 0.93, CI 0.91, 0.95) and African Americans (OR = 0.48, CI 0.24, 0.94) were less likely to have ever engaged in OSUE, while persons in treatment for opioid use were more likely (OR = 1.71, CI 1.08, 2.71).

**Conclusion:** Among a sample of clients in SUD treatment, about 25% had ever engaged in OSUE, with THC/marijuana and amphetamines most commonly reported. Further research is needed to evaluate the OSUE to understand the reasons for use and implications among persons enrolled in SUD treatment.

## 1. Introduction

Electronic cigarettes (e-cigarettes) and vape pens designed for nicotine use can be used to consume non-nicotine substances, such as cannabis, amphetamines, cocaine, synthetic cannabinoids, and opiates (Varlet, 2016; Blundell et al., 2018). Users may modify rechargeable e-cigarette/vape devices (e.g., Tanks, Mods or Pod-Mods) to add substances not intended by the manufacturer (e.g., THC, fentanyl or other synthetic drugs) (Massey et al., 2021; DEA, 2020). Limited data are available on other substance use in e-cigarettes (OSUE), however. The use of e-cigarettes to consume cannabis has been reported (Dai & Siahpush, 2020; Miech et al., 2020), but we found no studies reporting e-cigarette use with substances, other than marijuana, in a sample of SUD treatment clients.

Users may find e-cigarettes/vape pens an appealing route of administration to consume non-nicotine substances due to ease of use, ability to use substances discretely, availability for purchase of pre-filled cartridges with cannabis oil containing THC or other drugs, and the ability to modify pre-filled cartridges or prepare customized e-liquid formulations (Lim et al., 2020; Mulder et al., 2019). Concerns have been raised about the potential risks of engaging in OSUE, however, including higher usage levels, potential for toxicity, and exposing non-users to illicit drugs through vapors in public places (Breitbarth et al., 2018).

A significant portion of SUD clients uses e-cigarettes. In a survey of 24 SUD treatment centers, for example, Gubner et al. (2016) reported that about 30 % of SUD clients used e-cigarettes. Considering that a portion of SUD clients use e-cigarettes, and that SUD clients often use multiple substances, SUD clients may engage in OSUE. Published studies

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with adults engaging in OSUE have used small samples, such as users in nightclubs (Thurtle et al., 2017). Although a very small sample, Thurtle et al. (2017) suggest about 6 % of a non-treatment sample engaged in OSUE. Many survey studies of OSUE examine samples of college students. In a study of college students (Kenne et al., 2017), for example, OSUE was higher among men than women, and a trend toward lower OSUE among African American participants compared to white participants. In a sample of U.S. adults, older participants were less likely to ever use an e-cigarette (Levy et al., 2019), and this trend may extend to OSUE.

The aim of this research was to examine the prevalence and predictors of OSUE in a sample of individuals in SUD treatment. We discuss the possible treatment implications of our findings.

## 2. Methods

### 2.1. Sample and data collection procedures

Clients (N = 553) from 18 residential SUD treatment programs in California, USA were surveyed between January 2019 and September 2019. Program selection, recruitment procedures, and data collection procedures for the parent study were previously described in Guydish et al. (2020). In summary, members of the research team set up site visits at participating SUD programs to collect survey data. Sign-up sheets were used to recruit potential participants, and one staff member from each program coordinated data collection activities with the research team. Most site visits were completed on a single day, and all clients enrolled on the day of the site visit were eligible to participate. Client data collection occurred in groups of up to 10 clients at a time.

As part of the informed consent process, research staff reviewed information sheets verbally with clients. Information sheets contained a statement that participation was voluntary, an explanation of the purpose of the research, survey procedures, potential risks and benefits expected from participating in the research, and how confidentiality of the research data would be maintained. Because the study did not involve the identification of participants or their responses a signed informed consent form was not required. Using an iPad, clients reviewed the study information page, agreed to participate online, and began the survey. Surveys were created using Qualtrics™ (Provo, Utah) software, and took about 30 min to complete. Clients received a \$20 gift card for participation. The institutional review board of the University of California, San Francisco approved study procedures.

### 2.2. Measures

The survey included questions to assess demographic information, the primary drug for which clients sought treatment (coded as alcohol, stimulants, opiates, or other drug), and questions about general health, mental health, history of smoking combustible tobacco products, quit attempts, intentions to quit, smoking health risk perceptions, marijuana use, and e-cigarette use, but only questions pertaining to e-cigarette use are reported in this study.

Participants were asked to self-report current smoking status and lifetime smoking status, as indicated by using at least 100 cigarettes in their lifetime. Participants were told e-cigarettes were also called e-cigs, vapes, vape pens, e-hookah, hookah pens, tanks, Juul, Suorin, or mods, and that some come with liquid inside and the user fills others. Participants were not asked about their use of vaping devices specifically designed for the use of marijuana/THC. Participants indicated whether they had ever used e-cigarettes (yes or no), and if so, how often in the past 30 days (daily, weekly and less than weekly). Individuals reporting lifetime e-cigarettes use containing nicotine were asked if they had ever used an e-cigarette with marijuana, THC, or another drug besides nicotine (yes, no, or decline to answer). Those who reported OSUE were also asked which drugs besides nicotine they had used. Response options included: 1) amphetamines/methamphetamines, 2) marijuana,

cannabis, THC or hash, 3) crack/cocaine, 4) heroin, 5) opiates/analgesics (OxyContin, Vicodin, fentanyl), and 6) none of these.

### 2.3. Data analysis

Of the 553 participants, 279 reported lifetime e-cigarette use and were included in the data analysis.

Summary statistics described 1) ever use of drugs other than nicotine in e-cigarette devices; 2) types of drugs other than nicotine used in e-cigarette devices; and 3) use of e-cigarettes to consume non-nicotine drugs for which participants had sought treatment. Group comparisons of demographic and substance use variables were made between those that did and did not report OSUE; t-tests were conducted for continuous variables, and Pearson's chi-square or Fisher-Exact tests were used for categorical variables. Variables correlated with OSUE were explored with a multivariable logistic regression analysis. Variables in group comparisons with  $p < 0.10$  were included in the logistic regression equation to ensure all possible predictors were identified (Hosmer & Lemeshow, 2000). The logistic regression model accounted for nesting participants within treatment program.

## 3. Results

The sample of 553 participants was predominantly male, and racially/ethnically diverse with a mean age of 39.0 years (SD = 11.7). Stimulants (i.e., amphetamines/methamphetamine) were reported as the primary drug for treatment entry by 47.4 %, followed by alcohol 24.4 %, opiates/analgesics 19.5 %, and other drugs 8.7 %.

Of the lifetime e-cigarette users, 49.8 % (139 out of 279) had ever engaged in OSUE, which is 25 % of the total sample. The most frequently reported non-nicotine substances were marijuana/cannabis/THC/hash (70.5 %,  $n = 98$ ) and amphetamines/methamphetamine (51.1 %,  $n = 71$ ). Other substances used in e-cigarettes included: heroin (15.8 %,  $n = 22$ ), other opiates (10.1 %,  $n = 14$ ), and crack/cocaine (5.8 %,  $n = 8$ ). Among those who had engaged in OSUE, 44.6 % ( $n = 62$ ) had vaped drugs for which they sought treatment.

Table 1 shows group comparisons of demographic and substance use variables between ever-users and non-users of OSUE. Participants who had not engaged in OSUE tended to be older than those who had ever engaged ( $p < 0.0001$ ). An omnibus main effect for race/ethnicity was also significant ( $p = 0.042$ ), suggesting that one of the separate group comparisons may have been significant in post-hoc comparisons.

Table 2 shows the results of a multiple logistic regression analysis. Consistent with group comparisons, older participants were less likely to have ever engaged in OSUE, (OR = 0.93, 95 %CI: 0.91, 0.95). The logistic regression analysis clarified the omnibus main effect for race/ethnicity suggested in group comparisons: African American participants were less likely than non-Hispanic white participants to have ever engaged in OSUE (OR = 0.48, 95 %CI: 0.24, 0.94). When statistically controlling for other variables, participants who entered treatment for opiates were 1.71 (95 %CI: 1.08, 2.71) times more likely to have ever engaged in OSUE than those who entered treatment for alcohol.

## 4. Discussion

About 25 % of the sample of 553 individuals receiving SUD residential treatment engaged in OSUE. The most common substances used among participants who engaged in OSUE were THC/marijuana (70.5 %) and amphetamines/methamphetamine (51.1 %). Older persons tended to not engage in OSUE, which is consistent with the finding that ever users of e-cigarettes tend to be younger. African Americans were less likely to use e-cigarettes for non-nicotine substances, which is consistent with a finding reported by Kenne et al. (2017). Participants who entered treatment for opiate use were more likely to engage in OSUE. Vaping as an alternative route of administration for the consumption of non-nicotine psychoactive substances raises concerns

**Table 1**

Group comparisons between participants who engaged and did not engage in other substance use in e-cigarettes (OSUE) among a sample of 279 SUD treatment clients.

	No OSUE (n = 140)	OSUE (n = 139)	$\chi^2 / t$	p
<b>Age</b>	38.1 (10.2)	32.2 (7.7)	5.43	<0.0001
<b>Sex</b>				
Male	106 (75.7 %)	101 (72.7 %)		0.704
Female	31 (22.1 %)	36 (25.9 %)		
Something else	3 (2.1 %)	2 (1.4 %)		
<b>Race/ethnicity</b>			8.18	0.042
Hispanic/ Latino	47 (33.6 %)	61 (43.9 %)		
African American	20 (14.3 %)	7 (5.0 %)		
Non-Hispanic White	58 (41.4 %)	55 (39.6 %)		
Multiracial/ Other	15 (10.7 %)	16 (11.5 %)		
<b>Education</b>			5.88	0.053
<HS	33 (23.6 %)	36 (25.9 %)		
HS/GED	57 (40.7 %)	38 (27.3 %)		
>HS	50 (35.7 %)	65 (46.8 %)		
<b>Primary drug</b>			7.03	0.071
Alcohol	28 (22.1 %)	24 (18.5 %)		
Stimulants	68 (53.5 %)	63 (48.5 %)		
Opiates	21 (16.5 %)	38 (19.2 %)		
Other drug	10 (7.9 %)	5 (3.9 %)		
<b>Cigarette smoking status</b>				0.224
Current smoker	105 (75.0 %)	103 (74.1 %)		
Former smoker	33 (23.6 %)	29 (20.9 %)		
Never smoker	2 (1.4 %)	7 (5.0 %)		
<b>Past 30 day e-cig use</b>	54 (38.9 %)	66 (48.2 %)	2.44	0.118
<b>E-cig use frequency<sup>1</sup></b>	20 (37.0 %)	22 (33.3 %)	0.19	0.911
Daily	15 (27.8 %)	19 (28.8 %)		
Weekly	19 (35.2 %)	25 (37.9 %)		
<Weekly	22 (62.9 %)	28 (68.3 %)	0.25	0.619
<b>Using e-cigarettes and traditional cigarettes on the same day<sup>2</sup></b>				

<sup>1</sup> Past 30 days e-cig users (n = 120).

<sup>2</sup> Weekly e-cig users in the past 30 days (n = 76).

because of the potential for serious health consequences resulting from inhaling dangerous illicit drugs of abuse, such as methamphetamine and fentanyl (Breitbarth et al., 2018; Nguyen et al., 2016). For example, although injection drug use is commonly reported as the route of administration in fentanyl deaths, approximately one-quarter of fentanyl deaths involve alternate forms of consumption such as smoking, snorting, and ingestion (O'Donnell et al., 2021), and the data in our study suggest that some participants may use e-cigarettes to consume these drugs. Unintentional exposure to and poisoning from illicit drugs is also a concern (Jones et al., 2020).

Past cue reactivity studies from the smoking literature have shown heightened self-reported craving, as well as autonomic reactivity, when exposed to salient drug related cues (Carter & Tiffany, 1999). Conklin

**Table 2**

Predictors of other substance use in e-cigarettes (OSUE) among a sample of 279 SUD treatment clients.

	Adjusted OR (95 %CI)	p <sup>1</sup>
Age	0.93 (0.91, 0.95)	<0.0001
Race/ethnicity		
White	1	
Hispanic/ Latino	1.20 (0.68, 2.12)	0.536
African American	0.48 (0.24, 0.94)	0.032
Multiracial/ Other	1.27 (0.52, 3.08)	0.602
Education		
≤ HS/GED	1	
HS/GED	0.76 (0.37, 1.59)	0.472
>HS/GED	1.53 (0.88, 2.66)	0.128
Primary drug for treatment entry		
Alcohol	1	
Stimulants	0.94 (0.48, 1.85)	0.868
Opiates	1.71 (1.08, 2.71)	0.023
Other	0.48 (0.13, 1.64)	0.229

<sup>1</sup> Logistic regression with clients nested within clinic.

et al. (2015) have shown that cue reactivity predicts actual smoking behavior. Moreover, a systematic review of the literature on cue reactivity to electronic nicotine delivery systems (ENDS) reported that most of the studies reviewed found that ENDS related cues elicits craving for ENDS, and this finding was consistent across both cigarette smokers and ENDS users and device designs (Keijsers et al., 2022). These findings may extend to illicit drugs; cigarettes elicit cue reactivity among crack cocaine users whose route of administration is smoking (Reid et al., 1998). It is possible that when SUD clients use e-cigarettes to consume illicit substances, the e-cigarette may become paired with an illicit substance; in other words it may act as a cue, or a high-risk situation, for illicit substance use even when the client uses the e-cigarettes for nicotine use.

The extent to which an e-cigarette may provoke cue reactivity may be limited. Some clients who have engaged in OSUE in the past may experience craving for the illicit substance when using an e-cigarette, while other clients may not. In a revision of the Relapse Prevention Theory of Addictions, Hendershot et al. (2011) argue that clients in SUD treatment may relapse to a variety of possible high-risk situations, such as emotional and cognitive states (e.g., negative affect, diminished self-efficacy), environmental contingencies (e.g., conditional drug cues), or physiological states (e.g., acute withdrawal). Although some high-risk situations appear across many addictive behaviors, most are likely to vary across behaviors, across individuals, and within the same individual across time (Witkiewitz & Marlatt, 2007). For a subset of clients, but not all clients, the use of e-cigarettes may have been conditioned as a high-risk situation for drug use. For this subset of clients, it may be useful to explore the possibility that e-cigarette use may act as a high-risk situation for relapse. However, the potential of e-cigarettes acting as a high-risk situation should be studied further.

Limited data exists on the pharmacology of OSUE, but Breitbarth et al. (2018) suggest that dosage levels may be potentially dangerous. There is also limited data on the motivations for OSUE. An online survey of adult e-cigarette users by Morean et al. (2017) reported that 17.8 % reported lifetime use of an e-cigarette/vape-pen to vaporize cannabis, and for past month cannabis vapers, among the several reasons given for preferring vaping over smoking cannabis included a belief that vaping tastes better, a preference to conceal or hide use, and a desire to increase the subjective high of cannabis (Morean et al., 2017). The Morean et al. (2017) sample was different from our sample in many ways, and thus, their findings may apply to a different population. Morean et al.'s sample was predominately White, and was less likely to use e-cigarettes to consume cannabis. Participants in the current study were 2.5 times more likely to use e-cigarettes to consume cannabis, but statistics from our sample may overestimate cannabis use in e-cigarettes.

Limitations of the study should be noted. This study did not examine

whether nicotine vaping preceded OSUE, changes in the patterns of use, or motivations for OSUE. Assessing the motivations to use e-cigarette devices as an alternative route of administration of psychoactive substances may assist in guiding counseling interventions to inform nicotine dependence treatment. Harm reduction messages concerning the consumption of illicit substances through e-cigarette devices may also benefit from identifying motivations for OSUE. The survey did not address the use of vaping devices designed specifically for cannabis/THC. Additionally, the data used in this study were collected by self-report and were subject to social desirability and recall bias. Our findings apply to clients in residential SUD treatment programs and may not generalize to e-cigarette users with SUDs receiving treatment in other settings (e.g., outpatient SUD treatment programs). Future research should replicate and expand this work to examine reasons for OSUE and the types of substances consumed using longitudinal designs in other SUD treatment settings. It is also critical to understand the impact of using e-cigarette devices as a smoking cessation aid in substance using populations using longitudinal designs.

Study findings suggest that a substantial number SUD treatment clients may engage in OSUE. Future research is needed to improve our understanding of the pharmacology of, and motivations for, OSUE in SUD populations, and effectiveness of using e-cigarettes as a smoking cessation aid among SUD clients in recovery.

#### Author Agreement

The manuscript is the authors' original work. This manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other peer-reviewed media. All authors have seen and approved the final version of the manuscript being submitted.

#### Author Contributions

Carmen Masson: Designed the study, contributed to data analysis and interpretation, wrote the manuscript, approved final submission.

Noah Gubner, Neal Benowitz, and Joseph Gudysh. Contributed to study design, edited the manuscript, approved final submission.

Sindhushree Hosakote: Contributed to data collection, data entry, edited manuscript, approved final submission.

Thao Le: Conducted statistical analyses, contributed to manuscript write up, approved final submission.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

Data will be made available on request.

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