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Dependence and Use Characteristics of Adult JUUL Electronic Cigarette Users

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Abstract

Background: JUUL is a popular electronic cigarette (e-cig) that is capable of delivering nicotine similarly to a cigarette. While known to deliver high doses of nicotine, there is little systematic evidence to show how the nicotine delivery of JUUL translates to user dependence.

Purpose: The purpose of the study was to evaluate self-reported dependence of JUUL users and examine the relationship of dependence to user behaviors.

Methods: Current JUUL users were recruited *via* Amazon Mechanical Turk to complete an online survey about their use of JUUL. Participants were asked to complete the Penn State Electronic Cigarette Dependence Index (PSECDI) and to answer questions about their use patterns and other tobacco use. Means and frequencies were used to describe the sample. A linear regression model was used to predict user dependence.

Results: Participants ($n = 76$) were 65.4% male with a mean age of 31.9 (SD = 8.3) years. The mean PSECDI score was 7.8 (SD = 4.2) and ranged from no (15.8%) to high (14.5%) dependence. Overall predictors of a greater PSECDI score included reporting ever stealth vaping ($\beta = 2.8$, $p < .01$) and reporting greater use days in the past 30 ($\beta = 3.5$, $p < .01$).

Conclusions: On average, JUUL users reported low to medium nicotine dependence on the PSECDI. JUUL user dependence may be more similar to e-cig user dependence than cigarette smoker dependence. These preliminary findings should be followed up in studies of larger samples of Juul users, collecting multiple measures of dependence, as well as biomarkers of nicotine intake (e.g. cotinine).

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Conflict of interest statement

JF has done paid consulting for pharmaceutical companies involved in producing smoking cessation medications, including GSK, Pfizer, Novartis, J&J, and Cypress Bioscience. The other authors have no disclosures to report related to this publication.

Keywords

Tobacco use; electronic cigarettes; JUUL; nicotine dependence; smoking cessation

Introduction

Electronic cigarette (e-cig) use is becoming increasingly popular in the United States (USA) and around the world (Hammond et al., 2019). In the USA in 2019, 27.5% of high school students (Wang et al., 2019) and in 2018, 3.2% of adults (Creamer et al., 2019) reported using an e-cig. While there are many e-cig devices available to users (Yingst et al., 2018; Zhu et al., 2014), one device, JUUL, has quickly gained the majority of the e-cig market share (Campaign for Tobacco Free Kids, 2018; Huang et al., 2019; King et al., 2018).

JUUL e-cig devices are small, breath-activated devices which use small "pods" containing 0.7 ml liquid in a nicotine salt formulation and are available with a high concentrations of 3% or 5% nicotine (up to 59 mg/ml). The salt formulation is reported to provide a smoother, less irritating sensory experience, possibly facilitating nicotine inhalation (Shao & Friedman, 2020). In addition, its use of a high nicotine concentration has raised concerns that the device could be highly addictive. Due to the concerns, recent studies have evaluated the nicotine delivery of JUUL. One small study ($n = 6$) reported that JUUL delivered a mean nicotine boost of 28.6 ng/ml during an intensive puffing schedule of 30 puffs in 10 minutes among regular experienced users (Yingst et al., 2019b). Similarly, another study reported that JUUL delivered a concentration maximum of 20.4 ng/ml during ab lib use (mean 15 puffs over the 5 min ad-lib use period) (Hajek et al., 2020). Finally, a study ($n = 18$) of JUUL naive smokers reported a mean nicotine boost of 9.8 ng/ml after 10 puffs with a 30 second inter-puff interval (Maloney et al., 2020). In addition, a subsequent report on 24-hour nicotine absorption from JUUL versus cigarettes found similar 24-hour nicotine absorption (Harvanko et al., 2020). These studies provide preliminary evidence that JUUL is capable of delivering addictive levels of nicotine to the user.

While known to deliver nicotine efficiently, there is little evidence to show how the nicotine delivery of the device translates to user dependence. To date, there have only been two small studies that have systematically evaluated dependence on JUUL using a self-reported dependence scale. One study ($n = 6$) reported that user dependence levels were similar to that of cigarette smokers (Yingst et al., 2019b), while another ($n = 15$) reported that JUUL users exhibited low to medium dependence, much less than cigarette smokers (Nardone et al., 2019). A qualitative study evaluating Twitter comments reported that users made statements indicative of experiencing symptoms of dependence including comments such as "I wake up and hit the JUUL" or "gotta have my JUUL fix" (Sidani et al., 2019). Given the current contradicting evidence resulting from small studies, the dependence levels of JUUL users remains unclear.

This study aimed to characterize nicotine dependence among regular adult JUUL users using the Penn State Electronic Cigarette Dependence Index. In addition, this study aimed to describe the characteristics of JUUL users and their relationship to dependence. These

characteristics include device features such as flavor and nicotine concentration, behaviors, and other tobacco use.

Methods

This study was a cross-sectional survey study. Participants were current JUUL users recruited from Amazon Mechanical Turk in July 2019. Participants included in the study were at least 18 years of age and reported using a JUUL device in the past 30 days at the time of survey completion. Participants were compensated $2 for their participation. This study was approved by the Penn State Hershey Institutional Review Board and informed consent was obtained from all participants included in the study.

Participants were asked a series of questions about their use patterns and dependence including questions pertaining to the number of days used in the past 30 days and number of times used per day. To measure dependence, participants completed the Penn State Electronic Cigarette Dependence Index (PSECDI) (Foulds et al., 2015). The PSECDI has normative data in over 3,600 e-cig users, and has shown construct validity in that scores are related to the nicotine concentration of liquids used (Foulds et al., 2015), and convergent validity with the E-cig Dependence Scale, with a correlation = +0.71 in exclusive e-cig users (Morean et al., 2019). For this study, the scale was modified to include the product name, JUUL, in all questions to direct participants to answer the questions in relation to solely their JUUL use (i.e. “Do you use your JUUL electronic cigarette now because it is really hard to quit?”). Participants were also asked a series of questions about the pods they use, including the flavor, the place of purchase, and the rate of usage. In addition, participants were asked if they ever refill their pods, purchase generic pods, or use substances other than nicotine in their pods. Finally, participants were asked about behaviors including stealth vaping and questions about intention and attempts to quit JUUL use.

MTurk is an online labor market that uses crowdsourcing to recruit diverse samples for online tasks that require human intelligence. Data collected *via* MTurk for social science research has been shown to be valid and internally consistent, with good test-retest reliability (Kim & Hodgins, 2017; Strickland & Stoops, 2019; Thomas & Clifford, 2017). MTurk is an efficient and convenient method for recruiting smokers and e-cigarette users for survey research, including JUUL users (Bauhoff et al., 2017; Leavens et al., 2019). To improve the reliability and validity of the current survey, respondents were restricted to those in the United States with job approval ratings on MTurk of at least 98%. All responses were reviewed briefly by the researchers before approval and payment were provided to the user. Of the 297 participants who completed the informed consent, only 81 completed the survey and provided a valid Mturk code for cross-verification. To verify that participants were actual users of JUUL, responses to open-ended questions and time of use questions were examined during data analysis. In addition, users were asked to upload a photograph of their actual JUUL device. Participants who provided data that appeared falsified (i.e. repeated number use, logically impossible responses) and/or who did not provide a picture of their device were removed from the data. This resulted in the removal of 5 participants from the sample.

Means and frequencies were used to describe the participants and the characteristics of their device and usage. Independent t-tests were used to test for differences in continuous variables between two groups and one-way ANOVA was used to detect differences in continuous variables between groups of three or more. Chi-square analysis was used to evaluate differences in categorical variables. A linear regression analysis was used to identify statistical predictors of dependence. Independent variables included the model were gender, age, enrolled in college (yes/no), employed (yes/no), use days in the past 30 days, flavor (Virginia tobacco, mint, mango, classic tobacco, crème, menthol, fruit), nicotine concentration, use refill pods (yes/no), use generic pods (yes/no), ever stealth vape (yes/no), ever used other e-cig (yes/no), currently use other e-cig (yes/no), ever used tobacco product other than e-cig (yes/no), ever use other tobacco (yes/no), current smoker (yes/no), and ever tried to quit JUUL (yes/no). Stepwise selection was used to maintain all variables in the model with probability estimate of $p \leq 0.05$.

Results

Participants ($n = 76$) were 64.5% male with a mean age of 31.9 (SD = 8.3) (Range 18–58) years. Participants reported using JUUL for a mean of 357.0 days (SD = 280.8) (Range 7–1500 days). The majority of the sample reported being employed (92.1%) and 21.1% of participants reported current enrollment in college. About a fifth of participants (19.7%) reported current occasional cigarette smoking (dual users).

Use patterns and dependence

Participants reported using JUUL on a mean of 23.9 (SD = 8.2) (median = 30) days out of the past 30 days. About half ($n = 40$, 52.6%) of participants reported using JUUL daily. Overall, participants reported using JUUL a mean of 9.5 (SD = 11.0) (median = 5.0) times per day, with daily users reporting a mean times per day used of 13.4 (SD = 13.6) (median = 7.0). The mean Penn State Electronic Cigarette Dependence (PSECDI) score was 7.8 (SD = 4.2) (Table 1) and ranged from 0 to 18. Among daily users ($n = 40$), the mean PSECDI score was 9.8 (SD = 3.9) and ranged from 3 to 18. Among daily exclusive JUUL/other e-cig users (i.e. non-smokers) ($n = 34$), the mean PSECDI score was 9.7 (SD = 3.9) and ranged from 3 to 18. Overall predictors of a greater PSECDI score included reporting ever stealth vaping ($\beta = 2.8$, $p<.01$) and reporting greater use days in the past 30 days ($\beta = 3.5$, $p<.01$).

Flavor and pod usage

Many participants reported that mint (42.1%) was the flavor used most often with their JUUL device. Other flavors used were mango (14.5%), fruit (11.8%), Virginia tobacco (11.8%), menthol (6.6%), crème (6.6%), and classic tobacco (6.6%). The total PSECDI score and times per day by preferred flavor are displayed in Table 2. There were no significant differences by flavor used.

The majority of participants reported using 5% nicotine concentration pods (60.5%), while the remainder reported use of 3% pods. There were no differences in dependence ($p = .57$) or times used per day ($p = .70$) by nicotine concentration used. Pods were most often purchased from gas stations (42.1%), vape shops (26.3%), and online (22.4%). Most

participants reported that one pod lasted for one day or more (86.8%, $n = 66$), while only a few reported using more than one pod per day (13.2%, $n = 10$).

Almost one in five (19.7%, $n = 15$) participants reported refilling their JUUL pods with other e-liquid. These participants did not report greater dependence ($p = .70$) or use times per day ($p = .81$) compared with those who did not refill. A smaller proportion (9.2%, $n = 7$) reported using generic brand pods with their JUUL device. Among those who reported using generic pods, the most commonly endorsed reasons for using these pods were that they were less expensive (71.4%, $n = 5$), there were additional flavor options (71.4%, $n = 5$), they were refillable (28.6%, $n = 2$), and they were available in 0% nicotine (28.6%, $n = 2$).

Other E-cig use

Almost half (46.1%, $n = 35$) of participants reported ever using an e-cig device other than JUUL, with 9.2% ($n = 7$) reporting current use of another e-cig brand. Ever users of other e-cigs prior to JUUL reported greater dependence compared to those who never used another e-cig (PSECDI score 9.1 v. 6.8 respectively, $p = .02$). There were no differences in use times per day ($p = .20$). Of those who reported current use of another e-cig, 1 participant reported using a cigalike device, 4 reported using a modified device, and 2 reported use of another pod based e-cig. About half (48.6%, $n = 17$) of ever other e-cig users reported that JUUL delivered about the same amount of nicotine as other e-cigs while 31.4% ($n = 11$) reported that JUUL delivered slightly or much more nicotine than other e-cigs.

Participants stated that JUUL was different from other e-cigs because it was smaller and more convenient. Participants said, “It’s easier to carry and easier to use”, “more widely offered”, and “it’s easy to pick up. I normally go to my vape shop, but in a pinch, I could just stop at a gas station”. Other participants stated that JUUL gave a better hit than other devices. They stated, “JUUL feels smooth and pleasant”, “salt gives a real cigarette pull”, and “it has a much better pull and isn’t as harsh”.

Other tobacco use

A small proportion of the sample reported no prior tobacco use (15.8%, $n = 12$). These participants were a median age of 24 years and 50% reported current enrollment in college. The majority of participants (84.2%, $n = 64$) reported ever using some other type of tobacco product prior to using an e-cig. Most of the sample reported having used cigarettes (77.6%, $n = 59$), while fewer reported using hookah (21.1%, $n = 16$), cigars (18.4%, $n = 14$), chewing tobacco (7.9%, $n = 6$), snus/snuff/dip (5.3%, $n = 4$), and pipe (4.0%, $n = 3$). Of those who reported ever use of cigarettes, 15 participants reported current cigarette use in the past 30 days, with a mean days since last smoke of 3.5 (SD = 3.5) (median = 2) (range = 0–14) days. Ever other tobacco use or current cigarette smoking were not associated with greater e-cig dependence or use times per day (all $p > .3$).

Among participants who reported ever cigarette smoking but not in the past 30 days (i.e. cigarette quitters) ($n = 44$, 57.9% of total sample), the mean time since last cigarette was 598.4 (SD = 601.5) days. About a third of these participants reported that they quit smoking after starting JUUL use (36.4%, $n = 16$), another third reported that they quit smoking after using another e-cig brand (36.4%, $n = 16$), and the final third reported quitting smoking

before starting JUUL or any other e-cig brand (27.3%, $n = 12$). Among those who reported never using another tobacco product ($n = 12$), the mean likelihood to try cigarettes was rated as 2.5 out of 10, with 10 indicating the greatest likelihood of trying. The majority of these participants (66.7%, $n = 8$) reported that they were not at all likely to try cigarettes (score of 1).

Intention to quit JUUL use

Only a small proportion (11.8%, $n = 9$) of users reported ever trying to quit using their JUUL e-cig. These attempters reported slightly higher dependence than those who did not attempt to quit (9.3 v. 7.6 respectively), however, this difference was not significant ($p = .26$). Only about 12% ($n = 9$) of participants reported planning to quit JUUL use within a year, with most reporting intent to continue use (71.1%, $n = 54$). Some participants (17.1%, $n = 13$) reported that they were unsure of their plans for use. Mean importance to quit on a scale of 1–10 was 3.5 (SD = 2.5), with many participants (34.2%, $n = 26$) rating importance to quit as not at all important (score of 1).

Discussion

This study utilizing a convenience sample of JUUL users found that users reported low to medium nicotine dependence, as measured by the PSECDI. Compared with other studies evaluating e-cig dependence overall (Foulds et al., 2015; Garey et al., 2019; Liu et al., 2017), this study found that JUUL user dependence was very similar to dependence levels exhibited by other e-cig users. Contrary to other small studies reporting on JUUL user dependence (Nardone et al., 2019; Yingst et al., 2019b), this study provides evidence that JUUL user self-reported dependence may be more similar to e-cig user self-reported dependence than self-reported cigarette smoker dependence. Of interest, while JUUL is capable of delivering higher levels of nicotine compared with many other e-cigs (Yingst et al., 2019b), these findings suggest that users do not use the device in a manner that leads them to report greater dependence than users of other e-cig devices (nor similar to cigarette smokers).

One potential explanation for the relatively low dependence levels among users of efficient nicotine delivery devices could relate to the way that e-cigs including JUUL are used differently than cigarettes. Cigarettes are typically smoked in a concentrated burst of 5–15 puffs in approximately 4–10 min (R I Herning et al., 1981; Ronald I Herning et al., 1983; Strasser et al., 2004), leading to a fairly consistent and strong increase in blood nicotine levels (boost typically 10–30 ng/ml) (Hajek et al., 2020; M. A. Russell et al., 1976; Williams et al., 2010; Yingst et al., 2019). However, with e-cigs, there is not a need to take several puffs in a short period of time, because the device will not burn out. Because of this, e-cig users learn to take puffs intermittently but less frequently over much longer periods (Baweja et al., 2016; Cooper et al., 2016; Yingst et al., 2019a), avoiding the high peaks and troughs in blood nicotine levels that characterize cigarette smoking. It is possible that this different pattern of nicotine absorption with e-cigs leads to lower levels of perceived dependence even with a device capable of delivering nicotine like a cigarette if used like a cigarette.

Greater dependence in this study was associated with greater use days in the past 30 days and ever stealth vaping. Of interest, there were no differences in dependence or use times per

day by nicotine concentration used. This suggests, as alluded to above, that users may be able to titrate their use, with minimal differences in use times per day, to obtain optimal levels of nicotine aside from the nicotine concentration in the liquid (Dawkins et al., 2016). While current studies evaluating the nicotine delivery of JUUL have evaluated 5% pods (Yingst et al., 2019b), future research is needed to understand the nicotine delivery of 3% pods, whether users of 3% are able to obtain similar levels of nicotine to users of 5% nicotine pods, and how it translates to dependence.

In our small sample, we found that few participants reported refilling their pods or buying generic pods, two behaviors that could potentially expose users to more variable quality standards or even more dangerous chemicals. The majority of users who did report using generic pods did so because generic brands were cheaper and available in a greater number of flavors. Of importance, the data collected in this study was collected prior to JUUL voluntarily removing their flavors from the shelf in the United States and prior to the FDA announcement banning flavored pods from the market (United States Food & Drug Administration, 2020). Given that the majority of the sample (76.7%) reported using JUUL flavors that are no longer available, it will be important to evaluate how purchasing behaviors and flavor usage will change in response and whether users will be more likely to try to modify current products. One recent study of long term e-cig users found that nearly 50% of the participants reported that they would “find a way” to buy their preferred flavor, or add flavoring agents themselves if non-tobacco flavors were banned (Du et al., 2020).

Many JUUL users in this study were past other tobacco users, with the majority of these users being former cigarette smokers (78% of the sample). More than two-thirds of former smokers in this sample reported quitting smoking after initiating e-cig use, with about a third reporting quitting only after initiating JUUL use. Of interest, many users who quit smoking reported using non-cigarette flavors with their e-cig. This has also been reported in other studies of e-cig quitting behaviors (Morphett et al., 2019; Russell et al., 2019; Simmons et al., 2016). While much attention has focused on how e-cig flavors facilitate e-cig initiation among never tobacco users (Goldenson et al., 2019; Leventhal et al., 2019), future research is also needed to evaluate the impact of flavors on ability to quit smoking using e-cigs and the impact of flavor scarcity on behaviors such as returning to cigarette smoking.

The primary limitations of the current study are the small sample size and use of convenience sampling with MTurk. MTurk participants are not representative of the general population and we therefore, are not able to make any population-based inferences based on these results (Huff & Tingley, 2015). Alternatively, MTurk may be the ideal platform to recruit JUUL users since workers tend to be younger with an over-representation of substance users (Mellis & Bickel, 2020; Strickland & Stoops, 2019). As with any survey study, we were not able to biochemically verify that participants were nicotine users or JUUL users specifically. Asking participants to upload a picture of their device helped to identify respondents who were not current JUUL users and served as an added check that respondents were people (not bots) who could also understand English. Participants had little incentive to lie about their JUUL use given the many work opportunities on MTurk and the modest compensation provided for completing the current study. Finally, while questions

in the PSECDI referred only to JUUL product use, it is possible that dual users may have been reporting overall nicotine dependence.

In conclusion, we found that the JUUL users in our sample reported nicotine dependence levels similar to other e-cig users and lower than has been reported for cigarette smokers, despite JUUL's ability to deliver nicotine similarly to a cigarette. Nicotine concentration or flavor used did not impact dependence levels. These preliminary findings should be followed up in studies of larger samples of Juul users, collecting multiple measures of dependence, as well as biomarkers of nicotine intake (e.g. cotinine). In addition, future research is needed to evaluate changes in use and dependence in response to restriction on flavor options.

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Table 1.

Penn state electronic cigarette dependence index score and individual components.

Mean PSECDI Score (SD)	7.8 (4.2)
% (n) No Dependence	15.8 (12)
% (n) Low dependence	46.1 (35)
% (n) Medium dependence	23.7 (18)
% (n) High dependence	14.5 (11)
Mean times per day (SD) (Range)	9.5 (11.0) (1–48)
Mean time to first use on waking(in mins) (SD) (Range)	62.6 (100.5) (0–700)
% (n) Awaken at night to use	11.8 (9)
% (n) Use e-cig because it is really hard to quit	44.7 (34)
% (n) Have strong cravings to use e-cig	72.4 (55)
% (n) With very or extremely strong urges to use	9.2 (7)
% (n) Find it hard to keep from using in places where you are not supposed to	34.2 (26)
% (n) More irritable when they cannot use	54.0 (41)
% (n) More nervous when they cannot use	52.6 (40)

Table 2.

PSECDI score and times per day by preferred flavor.

	Mean PSECDI Score (SD)	Mean Times per day (SD)
Mint (*n* = 32)	7.6 (4.0)	7.9 (9.1)
Mango (*n* = 11)	7.7 (5.3)	16.6 (17.1)
Fruit (*n* = 9)	6.7 (3.5)	5.8 (4.8)
Virginia Tobacco (*n* = 9)	8.1 (4.3)	9.8 (8.4)
Menthol (*n* = 5)	11.0 (1.9)	8.4 (3.6)
Crème (*n* = 5)	7.8 (5.5)	13.0 (19.7)
Classic Tobacco (*n* = 5)	8.4 (5.5)	7.4 (9.9)
	p = .7292	*p* = .3184