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Youth Use of E-Cigarettes: Does Dependence Vary by Device Type?

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Abstract

Introduction: Youth nicotine dependence may vary by e-cigarette device used.

Methods: E-cigarette device type (“JUUL,” “similar pod/JUUL like device (i.e., pod mod),” or “other type of e-cigarette” (i.e., tank, mod)), nicotine dependence (Hooked on Nicotine Checklist; HONC), frequency of e-cigarette use (i.e., weekly, daily, monthly), and covariates were examined via a convenience sample of youth who use e-cigarettes in the United States via an online Qualtrics panel survey from April 2019 to May 2019.

Results: Youth aged 13–17 (Mean age = 15.9 years, SD = 1.0 year; $n=185$) were mostly 72.4% female. Primary device used by category was endorsed as follows: JUUL $n = 87$, pod mod $n = 42$, and other type of e-cigarette $n = 56$. Participants endorsed an average of 4.5 / 10 HONC symptoms ($SD=3.6$). Compared to other e-cigarettes, youth who used JUUL and pod mod devices endorsed

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more dependence symptoms, even when adjusting for current smoking status (JUUL IRR = 1.96, 95% CI 1.30–2.97; pod mod device IRR = 1.76, 95% CI 1.08–2.87). In total, HONC symptoms significantly differed by device for 8/10 symptoms, with JUUL and pod mod users reporting higher frequency of items compared to other e-cigarette devices.

Conclusions: Features of nicotine dependence experienced by youth (i.e., feeling a stronger urge to vape) differed by primary device used, with those using JUUL and pod-mods reporting a greater level of dependence. Regulation of features of e-cigarette devices that may increase nicotine delivery and subsequent development of dependence among youth warrant urgent consideration.

Keywords

Youth; Nicotine Dependence; E-Cigarettes

Introduction

Electronic cigarettes (e-cigarettes) are the most commonly used tobacco product among youth in the United State (US)¹ and use of newer, pod-mod e-cigarettes rapidly increased from 2017–2018.² While more recent data from the 2019 National Youth Tobacco Survey³ indicate that overall use of e-cigarettes has declined, results from these data also indicate that 3.6 million youth still currently used e-cigarettes in 2020.³ Keeping up to date with the rapidly changing e-cigarette environment can make monitoring youth use of e-cigarettes and associated nicotine dependence complex. The introduction of new, pod-mod e-cigarettes add a layer of complexity to assessing youth e-cigarette use and subsequent dependence with the addition of nicotine salt-based e-liquid. Nicotine salt is a new type of e-liquid that adds organic acids to change nicotine from a free base to a protonated salt.^{4,5} Due the protonation of nicotine, nicotine salt-based devices appear to increase the product appeal⁴ and allow for easier and more intense inhalation from tobacco naïve users,⁶ to deliver high concentrations of nicotine.⁷ In 2020, the most common types of e-cigarettes were prefilled pod or cartridges (like JUUL products), disposable products, and tank style e-cigarettes³. Among the limited studies examining youth dependence, youth who use these newer products show signs of early onset of nicotine dependence.^{2,7,8} As such, there is concern that newer types of e-cigarettes may increase risk of dependence in a new generation of youth addicted to nicotine.

Given the limited literature examining dependence specifically among youth e-cigarette users, early onset nicotine dependence may differ depending on the type of e-cigarette device used.^{2,8} The primary aim of the present study was to examine differences in self-reported dependence using the Hooked-On Nicotine Checklist (HONC), a well validated^{9,10} self-report measure, among youth populations, to examine if nicotine dependence varies by e-cigarette device used. A secondary aim of this study was to examine if specific features of nicotine dependence, as assessed via the HONC, are more frequently endorsed and if endorsement of specific characteristics of dependence varied across device type.

Methods

These data were collected via Qualtrics from April 2019 to May 2019 among a convenience sample of youth who used e-cigarettes in the US. Participants were able to register on Qualtrics for free and complete online surveys via a computer or on a mobile device. An invitation to participate in the current study with a unique identification code was sent to participants to restrict completing the survey multiple times. Information was provided to Qualtrics regarding the target population for recruitment (i.e., youth aged 13 – 17; nationally representative demographic characteristics; e-cigarette ever and current use) and a brief 5-item screener was used to assess eligibility criteria: age, ever/current use of e-cigarettes, and English language competency. Survey completion took 12 minutes and participants were compensated \$2.40.

Ethics Statement

The study was IRB approved. Per the Children’s Online Privacy Protection Rule, no children below the age of 13 were able to access the Qualtrics platform or participate in the study. The IRB approved consent was presented to participants with an accompanying study description. Participants were informed that “by clicking the agree button below confirms that I agree with the above information and that I agree to take part in this study.” Recruitment and compensation were managed by Qualtrics. No identifiable information was collected as part of the survey and all survey questions (with the exception of the screener and passive assent) were “request response” only, which allowed participants to skip any questions they did not want or feel comfortable answering.

Participants

Participants aged 13 – 17 (N = 507) were recruited to be representative of racial and ethnic demographics of the United States. These numbers were based on the ethnic/minority estimates from the US Census Data¹¹.

Measures

Demographics.—Youth provided information on participant and family characteristics.

Current E-Cigarette Use.—Participants were asked “Do you currently use JUUL, a similar pod/JUUL-like device, or other e-cigarette?” If youth answered “Yes,” they were asked to specify which product they use most often: “JUUL,” “similar pod/JUUL like device,” or “other type of e-cigarette” (i.e., tank, mod). Pictures of each product were provided. For simplicity, when discussing results about device type, “similar pod/JUUL like device” will be referred to as “pod mod device.”

Smoking Status.—Participants were asked how many cigarettes they had smoked in their entire life and those who had smoked at least 1 cigarette were additionally asked, “When was the last time you smoked a cigarette? (today, this week, past 2–3 weeks, 1 month ago, within the last 6 months, 1 year ago or more).” Youth reporting cigarette use within the past month were categorized as “current smokers” and all others were categorized as “not current smokers.”

Nicotine Dependence.—The Hooked On Nicotine Checklist (HONC)^{9,10} is a well-validated, 10-item questionnaire utilizing yes/no responses to assess the loss of autonomy over the use of tobacco. Questionnaire items were modified^{2,12} to replace “smoking” with “vaping” and “cigarette” with “e-cigarette.” A positive response to any item signals a loss of autonomy and the onset of nicotine dependence, whereas the number of positive responses reflects the degree of dependence. Internal consistency was excellent ($\alpha = .91$).

Statistical Methods

Descriptive statistics described demographic characteristics by primary e-cigarette device. Nicotine dependence, as evaluated by the HONC, is a count variable; however, the distribution of HONC responses was over-dispersed and a negative binomial regression model was used to evaluate the relationship between device type and HONC score, while adjusting for current smoking status, frequency of e-cigarette use, sex, age, and race. A series of chi-square (χ^2) tests of independence examined HONC item endorsement by device. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.

Results

Participant Characteristics

A total of 204 / 507 (40%) participants reported current e-cigarette use. The present analytic sample was limited to those participants who were current e-cigarette users and had complete responses for all variables of interest ($n = 185$). Missingness in the data were investigated to examine potential patterns. The main cause of the missingness were the intersection between the 204 individuals who reported current e-cigarette use, only 185 individuals answered both the current e-cigarette use question and all questionnaire items for the HONC. No participant was excluded for missingness in any demographic variables. The majority were daily (46.3%) or weekly (47.5%) e-cigarette users (vs. monthly). Approximately 24.9% were current dual users of cigarettes and e-cigarettes. See Table 1 for participant characteristics.

HONC Item Frequency Endorsement by E-Cigarette User Group

Participants endorsed an average of 4.5 items on the HONC checklist ($SD=3.6$). In total, eight of the ten items on the HONC significantly differed across device types (see Table 1). Specifically, compared to youth who used other types of e-cigarettes, youth who used JUUL or pod mod devices indicated “yes” to more items of dependence (e.g., Have you ever felt like you were addicted to your e-cigarette?; Do you ever have strong cravings for your e-cigarette?; Have you ever felt like you really needed your e-cigarette?). The two items which did not differ asked about quit attempts (i.e., Have you ever tried to quit your e-cigarette, but couldn't?; Do you use an e-cigarette now because it is really hard to quit?).

Nicotine Dependency by E-Cigarette User Group

Users of JUUL and pod devices endorsed significantly more HONC items compared with other e-cigarette product users (Table 2), after adjusting for current smoking status, sex, age,

and race (JUUL IRR = 1.96, 95% CI 1.30–2.97; pod mod device IRR = 1.76, 95% CI 1.08–2.87). Participants who were current smokers (vs. those who do not currently smoke) reported a higher number of endorsed HONC items (IRR = 1.57, 95% CI 1.08–2.29).

Discussion

These findings provide early data on how dependence and dependence symptoms experienced by youth who are current users of e-cigarettes may vary by device type. Only two studies have examined youth dependence by device type^{2,6}. The first study² found no differences in dependence by device type (pod-mod vs other type of e-cigarette), however only 34/437 adolescents reported any loss of autonomy from nicotine via the HONC. In the present study, 185 adolescents affirmed any loss of autonomy from nicotine via the HONC and among those, over 30% reported current dual use of cigarettes and e-cigarettes. Additionally, youth who reported use of JUUL and pod mod devices (compared to other e-cigarette devices) reported higher levels of nicotine dependence. Dual use of cigarettes and any type of e-cigarette also appeared to significantly impact dependence scores in the present study, relative to youth who were e-cigarette exclusive users. The second published study⁸ that examined dependence by device type found that youth using pod mod products had increased nicotine dependence via several items comprised from different dependence⁸ scales (i.e., only incorporated a few questions from each scale) and higher urinary cotinine values. This is similar to the findings in the present study which extend the literature by highlighting that device type used may potentially confer a higher risk for nicotine dependence among youth compared to other e-cigarette device types, utilizing a psychometrically validated scale of dependence in e-cigarette users.

Unlike any other published findings to our knowledge, the present study also examined if specific items endorsed on the HONC varied by e-cigarette device type to provide preliminary insight regarding the differences in dependence symptoms experienced by youth. Eight items significantly differed by e-cigarette device type, with users of JUUL and pod mod devices endorsing more items related to craving, urges, and difficulty abstaining from using their e-cigarette than youth who used other e-cigarettes. Only two items asking about e-cigarette quit attempts did not differ between JUUL/pod mod users and users of other e-cigarette types. It could be that youth who were using these e-cigarette products endorsed the quit attempt items less frequently due to disinterest or lack of intention to quit using their e-cigarette product. More research focused on specific characteristics of nicotine dependence among youth is needed to better understand and characterize e-cigarette products to identify considerations for cessation services designed to help youth who are nicotine dependent.

Our findings provide important data on nicotine dependence among youth e-cigarette users, which may inform future tobacco regulatory policy. Our results suggest that youth who used JUUL, pod mod devices, or who dual used cigarettes and e-cigarettes, may be at higher risk for developing nicotine dependence. Any use of nicotine during adolescence is concerning^{13,14} and dual use of e-cigarettes and cigarettes is associated with poorer health outcomes^{15–17} and may increase long-term dependence.^{16,18} While the specific mechanisms that confer differing risk for nicotine dependence across devices warrant future examination,

the higher levels of nicotine concentration typically found in JUUL or pod mod devices that primarily use nicotine salt-based e-liquid, may play a role in increasing the risk for nicotine dependence. Yet, regulating nicotine concentrations alone, as currently done in the European Union¹⁹, Utah²⁰ and suggested by other public health entities^{21,22}, may not translate to lower product use and/or decreased risk for nicotine dependence over time. E-cigarettes offer manufacturers and users other ways beyond nicotine concentration (e.g., device wattage and compensatory puffing) to increase nicotine delivery and addiction, which may have unintended adverse consequences^{23–25}, such as greater toxicant exposure. It is also critical that and regulatory action also remain mindful that e-cigarettes provide adult smokers a less harmful alternative to smoking. A comprehensive and thoughtful regulatory approach combined with effective cessation interventions to reduce youth e-cigarette use is urgently needed.

Limitations

The present findings are limited by the small sample size, convenience sampling, and cross-sectional design. All data were collected via an anonymous, online survey. While we asked which devices youth had tried, we then asked youth to indicate their “main device” or the device they used most frequently; this was then used to characterize the specific device used in all analyses. It is possible that youth indicated their main device, but also co-used multiple devices. We also did not assess specific characteristics related to youth e-cigarette use, such as e-liquid flavor, wattage, or nicotine concentration, or current use of other nicotine products aside from conventional cigarettes. These factors likely impact risk for nicotine dependence and future studies should gather in depth information regarding e-cigarette product use to better inform how these factors confer risk for nicotine dependence.

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None.

Abbreviations:

HONC hooked on nicotine checklist

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HIGHLIGHTS

- Features of nicotine dependence among youth differed by primary e-cigarette device used.
- Pod mod users reported increased nicotine dependence compared to other device types.
- Youth endorsed an average of 4.5 out of 10 HONC symptoms.
- The number of positive HONC responses reflects the degree of dependence.

Table 1.

Participant Characteristics and Nicotine Dependence Symptom Endorsement on the Revised Hooked on Nicotine Checklist (HONC) by Youth E-Cigarette User Group

Variable	JUUL <i>n</i> = 87	Pod Mod Device* <i>n</i> = 42	Other Type of E-cigarette Device <i>n</i> = 56	Total Sample <i>n</i> = 185
Demographic Characteristics				
Age (years), mean (SD)	15.9 (1.1)	15.9 (1.0)	16.0 (0.9)	15.9 (1.0)
Gender, <i>n</i> (%)				
Male	29 (33.3%)	11 (26.2%)	11 (19.6%)	51 (27.6%)
Female	58 (66.7%)	31 (73.8%)	45 (80.4%)	134 (72.4%)
Race, <i>n</i> (%)				
White	34 (39.1%)	21 (50.0%)	12 (21.4%)	67 (36.2%)
Black	19 (21.8%)	12 (28.6%)	11 (19.6%)	42 (22.7%)
Asian	7 (8.0%)	0 (0.0%)	3 (5.4%)	10 (5.4%)
Other / Multiple	27 (31.0%)	9 (21.4%)	30 (53.6%)	66 (35.7%)
Grade, <i>n</i> (%)				
6 th – 8 th	9 (10.3%)	1 (2.4%)	4 (7.1%)	14 (7.6%)
9 th – 12 th	75 (86.2%)	39 (92.9%)	50 (89.3%)	164 (88.6%)
High School Graduate	3 (3.4%)	2 (4.8%)	2 (3.6%)	7 (3.8%)
Current Smoker (yes), <i>n</i> (%)	21 (24.1%)	8 (19.0%)	17 (30.4%)	46 (24.9%)
Frequency of Use (main device), <i>n</i> (%)				
Daily	43 (51.2%)	19 (47.5%)	20 (37.7%)	82 (46.3%)
Weekly	41 (48.8%)	15 (37.5%)	28 (52.8%)	84 (47.5%)
Occasional	0 (0.0%)	6 (15.0%)	5 (9.4%)	11 (6.2%)
Revised Hooked on Nicotine Checklist (HONC)				
Item Frequency Endorsement by User Group (yes), <i>n</i> (%)				X² (<i>p</i>- value)
1. Have you ever tried to quit your e-cigarette, but couldn't?	36 (41.4%) ^a	16 (38.1%) ^a	17 (30.4%) ^a	1.79 (<i>p</i> = 0.41)
2. Do you use an e-cigarette now because it is really hard to quit?	33 (37.9%) ^a	12(28.6%) ^{a,b}	11 (19.6%) ^b	1.79 (<i>p</i> = 0.41)
3. Have you ever felt like you were addicted to your e-cigarette?	49 (56.3%) ^a	25 (59.5%) ^a	16 (28.6%) ^b	13.08 (<i>p</i> <.001)
4. Do you ever have strong cravings for your e-cigarette?	54 (62.1%) ^a	22 (52.4%) ^a	17 (30.4%) ^b	13.8 (<i>p</i> <0.001)
5. Have you ever felt like you really needed your e-cigarette?	54 (62.1%) ^a	25 (59.5%) ^a	20 (35.7%) ^b	10.3 (<i>p</i> = 0.01)
6. Is it hard to keep from vaping in places where you are not supposed to?	48 (55.2%) ^a	23 (54.8%) ^a	18 (32.1%) ^b	8.2 (<i>p</i> = 0.02)
7. Did you find it hard to concentrate because you couldn't vape?	44 (50.6%) ^a	16 (38.1%) ^a	10 (17.9%) ^b	15.51 (<i>p</i> <0.001)
8. Did you feel more irritable because you couldn't vape?	45 (51.7%) ^a	23 (54.8%) ^a	16 (28.6%) ^b	9.29 (<i>p</i> = 0.01)
9. Did you feel a strong need or urge to vape?	53 (60.9%) ^a	24 (57.1%) ^a	15 (26.8%) ^b	17.07 (<i>p</i> <0.001)

Variable	JUUL <i>n</i> = 87	Pod Mod Device* <i>n</i> = 42	Other Type of E-cigarette Device <i>n</i> = 56	Total Sample <i>n</i> = 185
10. Did you feel nervous, restless, or anxious because you could not vape?	46 (52.9%) ^a	21 (50.0%) ^a	15 (26.8%) ^b	10.11 (<i>p</i> = 0.01)

Note. Frequencies and percentages or mean and standard deviation are presented for each item as appropriate.

* = similar pod/JUUL like device.

Current smokers = individuals who had smoked in the past month. Frequencies and percentages are presented for each item on the HONC as the percent that responded “yes” to each item. Chi-square tests of independence were conducted to examine differences by e-cigarette user groups and *p* values are reported. Chi-square values for items with statistically significant differences are bolded. Superscripts indicate column proportions that differ significantly from each other at the .05 level.

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Table 2.

Association of Device Type and Conventional Smoking Status with HONC dependence score

	HONC DEPENDENCE SCORE		IRR (95% CI)
	Mean	SD	
Primary Device			
JUUL	5.31	3.46	1.96 (1.30, 2.97)
Pod Mod device	4.93	3.87	1.76 (1.08, 2.87)
Other type of e-cigarette	2.77	2.88	<i>Ref</i>
Current dual use of e-cigarettes and cigarettes			
No	4.05	3.56	<i>Ref</i>
Yes	5.67	3.29	1.57 (1.08, 2.29)

Note. IRR = incidence rate ratio. IRR adjusted for Sex, race, and age

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