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Brief Report

# Critical Challenges and Creative Solutions for Quantifying Nicotine Vaping: Qualitative Reports From Young Adults

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## Abstract

**Introduction:** Previous studies suggest that young adults who vape nicotine experience difficulty when answering survey items assessing the quantity of vaping. The current study asked young adults who vape to provide suggestions for improving the scientific measurement of vaping.

**Aims and Methods:** We conducted semi-structured qualitative interviews with 62 young adults who vape in Los Angeles, California between June 2018 and June 2019. We analyzed participants' responses to the following question: "What do you think is the best way for us to understand how much people vape?" using thematic content analysis.

**Results:** We identified two major themes: (1) challenges stemming from differences between the way researchers query about vaping and how individuals self-monitor vaping frequency, and (2) insights for future measurement of vaping. Participants reported that challenges of accurately quantifying vaping were due to inherently hard-to-answer questions (eg, puffs per day), lack of awareness of or not actively monitoring consumption of vaping products, or because vaping behaviors vary considerably between and within individuals over time, making "on-average" questions challenging. Participants discussed ideas for improving survey measures that could accurately assess vaping quantity, including querying about the type of device used, and frequency of replenishment of nicotine solutions.

**Conclusions:** Existing vaping behavior survey measures may not accurately capture the quantity of vaping as they differ from how (or if) participants track their own vaping consumption patterns. While continued research is needed to optimally refine survey measures on vaping consumption, future measures may better align with vapers' self-monitoring by including questions on device-type and replenishment frequency.

**Implications:** The present study provides insights regarding the variability that exists between vaping quantity measurements utilized by researchers and individuals who consume e-cigarettes. The qualitative data analyzed for this study support previous reports of difficulties faced by vapers when asked questions by researchers related to their vaping behavior. Furthermore, the present findings suggest the direction for the future development of accurate measurements of vaping frequency.

## Introduction

While vaping nicotine has become increasingly common among adolescents, researchers have struggled to develop and utilize measures that accurately report consumption patterns. Extant research assesses the current quantity and frequency of nicotine vaping via number of days used in the past 30 days, number of times vaped per day, or number of puffs per day or vaping session.<sup>1-4</sup> While these metrics provide some insight into the frequency of vaping, participants have difficulty responding to such items. For example, one study found that 42% of respondents could not answer how many times they used their vaping device per day.<sup>5</sup> Another study using an e-cigarette with an internal mechanism for passively recording puff count suggests that vapers underestimate the number of puffs taken per day, having found that the number of self-reported puffs were 87% of the actual number of puffs recorded by the device.<sup>6</sup> To better understand respondent perspectives on their vaping consumption and to garner additional ideas and suggestions for how to improve measurement of the quantity of vaping, we conducted qualitative interviews with young adult vapers. We aimed to learn how vapers quantify their own vaping behavior and present their suggestions for new survey items to provide preliminary evidence for the development of a valid measure to quantify vaping behavior.

## Methods

### Participation and Recruitment

Young adults who consume e-cigarettes ( $N = 62$ ) in the Los Angeles, California metropolitan area were recruited for in-depth, semi-structured interviews conducted at the University of Southern California (USC) from June 2018 to June 2019. Participants were recruited online through social media advertisements on Twitter, Facebook, and Instagram that invited nicotine vapers to participate in a research study to understand why people use different tobacco products. To be included in the study, participants must have been 18–25 years old and a user of an e-cigarette, JUUL, or another nicotine vaping device at least weekly for the past 5 months. All participants provided written informed consent prior to study enrollment. Participants received \$50 compensation for study completion. The USC Institutional Review Board approved the study.

### Interviews

Interviews were conducted at USC in a private interview room by one of three interviewers (SJS, KAS, AK) trained in the administration of qualitative interviews and in the specific protocol for this qualitative study. Each interview lasted between 30 and 90 minutes and was audio-recorded. Interviews were semi-structured, guided by prompts about a multitude of experiences related to vaping described previously.<sup>7,8</sup> Prior to the interview, interviewers explained the purpose of the research and encouraged participants to speak openly and honestly about their experiences. After the interview, participants completed a short quantitative survey to assess basic demographic and substance use information.

### Data Analysis

Interview sessions were transcribed verbatim by trained undergraduate research assistants using Express Scribe transcription software. We uploaded all transcripts to NVivo (Version 12.5) and analyzed participants' responses to the following question: "As

researchers, we are currently trying to figure out the best way to measure how much people are vaping. In your opinion, what do you think is the best way to understand how much people vape? What's a question we should be asking people to get at this?" All responses to this question were placed into a single organizational code, and thematic content analysis was utilized to develop emergent themes from participants' responses.

## Results

### Participant Characteristics

Our sample included 62 participants (79% male; 51% White, 27% Hispanic or Latino, 14% Asian, 5% Black or African American, 19% Multiethnic or Multiracial, and 10% identified as another race/ethnicity; Table 1). The mean age was 20.9 years ( $SD = 1.3$ ). Over half of participants were enrolled in a higher education program at the time of study ( $N = 33$ ; 53%), and most young adults reported living within comfortable financial means ( $N = 46$ ; 74%). Half of participants ( $N = 31$ ; 50%) identified as e-cigarette-only users and the other half as dual users of e-cigarettes and combustible cigarettes. Nearly half of the sample reported using e-cigarettes every day in the past 30 days ( $N = 28$ ; 47.5%).

### Thematic Analysis

We identified two overarching themes: (1) Common challenges in accurately quantifying vaping behavior and (2) Insights for future measurements.

**Challenges in Quantifying Vaping: Vapers Do Not Monitor Their Vaping Consumption the Same Way Researchers Ask About It**  
Participants reported not actively monitoring vaping consumption by the number of puffs they take per vaping session or per day.

*"I would never count how many [puffs] I take." - ID28, male, age 19*

Some participants indicated that it is difficult for them to define the volume of e-liquid (solution containing nicotine) they use per vaping session, or times throughout the day during which they vape. For example, one participant described the ambiguity and lack of precision involved in determining how much e-liquid was consumed at a given point in time:

*"I mean it's really hard because say it's a pod - like I know this whole thing is two milliliters. Right? I mean I can eyeball it but there's no like, Hey, you're down to one [mL], you're down to half [of a mL]." - ID50, male, age 19*

Participants also expressed difficulty in comprehending how much nicotine they consumed per vaping session. For example, one participant reflected on this difficulty in assessing her own consumption:

*"I wish that I was able to measure how much I was [vaping]. I have no idea how much nicotine I'm taking in. I really don't. I'm probably taking in more than a pack [of cigarettes] a day" - ID61, female, age 19*

Participants also described how puff size, puff duration, and number of puffs taken vary between and within vapers over time. For example, one participant described the varying nature of the number of puffs and the size of the puffs taken in each vaping session based on the context of his day:

**Table 1.** Sociodemographic and Substance Use Characteristics of Total Sample of Young Adult Vapers Aged 18–25 (N = 62)<sup>a</sup>

Characteristic	N (%) or M (SD)
<b>Gender, N (%)</b>	
Male	49 (79%)
Female	13 (21%)
<b>Race/ethnicity, N (%)</b>	
American Indian	0 (0.0%)
Asian	8 (13.6%)
Black or African American	3 (5.1%)
Native Hawaiian or Pacific Islander	1 (1.7%)
White	30 (50.8%)
Multithnic or Multiracial	11 (18.6%)
Other	6 (10.2%)
Hispanic/Latino	16 (26.7%)
<b>Age, M (SD)</b>	20.9 (1.3)
<b>Currently enrolled in higher education, N (%)</b>	
Yes	33 (53.2%)
No	24 (38.7%)
Don't know/missing	5 (8.0%)
<b>Current subjective financial status, N (%)</b>	
Don't meet basic expenses	1 (1.7%)
Just meet basic expenses	13 (21.7%)
Meets needs with a little left	24 (40.0%)
Live comfortably	22 (36.7%)
<b>E-cigarette/combustible cigarette user, N (%)</b>	
Sole e-cigarette user	31 (50.0%)
Dual e-cigarette/combustible cigarette user	30 (48.4%)
<b>Past 30-day combustible cigarette use, N (%)</b>	
0 day	12 (28.6%)
1–5 days	18 (42.9%)
6–19 days	8 (19.0%)
20 or more days	4 (9.5%)
<b>Past 30-day number of days vaped nicotine product, N (%)</b>	
1–5 days	6 (10.2%)
6–19 days	12 (20.3%)
20–29 days	13 (22.0%)
All 30 days	28 (47.5%)
<b>Ever felt addicted to vaping, N (%)</b>	
Yes	25 (55.6%)
No	20 (44.4%)
<b>Ever tried to stop or cut down use of electronic nicotine devices, N (%)</b>	
Yes	45 (75%)
No	15 (25%)

<sup>a</sup>Available data Ns for denominator ranged from 45 to 62.

*"Maybe you'll sit down and take like only three puffs one time or maybe just one little baby one just to kinda keep [you] going."*  
- ID8, male, age 20

Participants also reported that a "puff" may not be consistent across individuals and may be difficult to quantify. For example, one participant described how the duration between puffs is not standardized, and how the variation in puff sizes may make the relative volume of a "puff" challenging to define:

*"With a lot of these vapes, it gives a very inconsistent [puff]. There's no constant set interval between each consecutive puff. Like 5 puffs can be equal to one puff sometimes... it's impossible to quantify how much one puff means."* - ID11, male, age 20

#### Insights for Future Measurements

Participants commonly suggested that vaping behaviors should be assessed separately by the type of device used – refillable (devices

that are manually filled with nicotine e-liquid solutions) or pod-based (devices that use replaceable, pre-filled pods, which are cartridges containing nicotine e-liquid solution).

*"I would ask if they use pods or [if] they drip the juice."* - ID14, male, age 21

Here, the participant referred to those who "use pods" as pod-based device users and those who "drip the juice" as refillable device users.

Participants who used refillable devices reported being able to estimate how often they refill their device with e-liquid solutions, even if they were unable to assess the volume used in a session or puffs taken. For example, one participant noted that he knows how frequently he refills his e-liquid despite being unable to recall how many puffs he takes:

*"I can't say for myself how many times I hit [puff] it in one day, but I can say I go through the 100 mL bottle in maybe two and a half weeks"* - ID14, male, age 21

Similarly, some participants who used pod-based devices also suggested asking about the frequency of pod replacement, rather than number of puffs:

*"No one can count how many times or how many hits in an hour. It's a pretty subconscious, well not subconscious, but you know you don't count... Now with pods, you can use it in one day or you could go through a week."* - ID32, female, age 21

Participants discussed the branching logic that could assist in future measurements (See Figure 1). Based on the type of device they reported using most frequently, branching logic would lead them to the most relevant set of follow-up questions. For example, one participant discussed if a vaper uses a refillable device, they should be asked how often they refill their device with e-liquid.

*"You can't ask people how many times they [vape] a tank [in] a day because there's a bunch of different sizes. I think just, 'How many bottles [of e-liquid do] they go through in a month?'"* - ID12, male, age 20

Another participant suggested that among vapers who use a pod-based device, the follow-up question should pertain to how often they replace the e-liquid pods:

*"You can say like 'How many JUUL pods do you go through, or how long does it take you to go through a pod?'"* - ID61, female, 21

Finally, some participants mentioned that measuring purchasing frequency of pods or e-liquid bottles can also indicate vaping usage and can serve as a point of recalling how often they replenish their device with e-liquid. A refillable device user suggested the following:

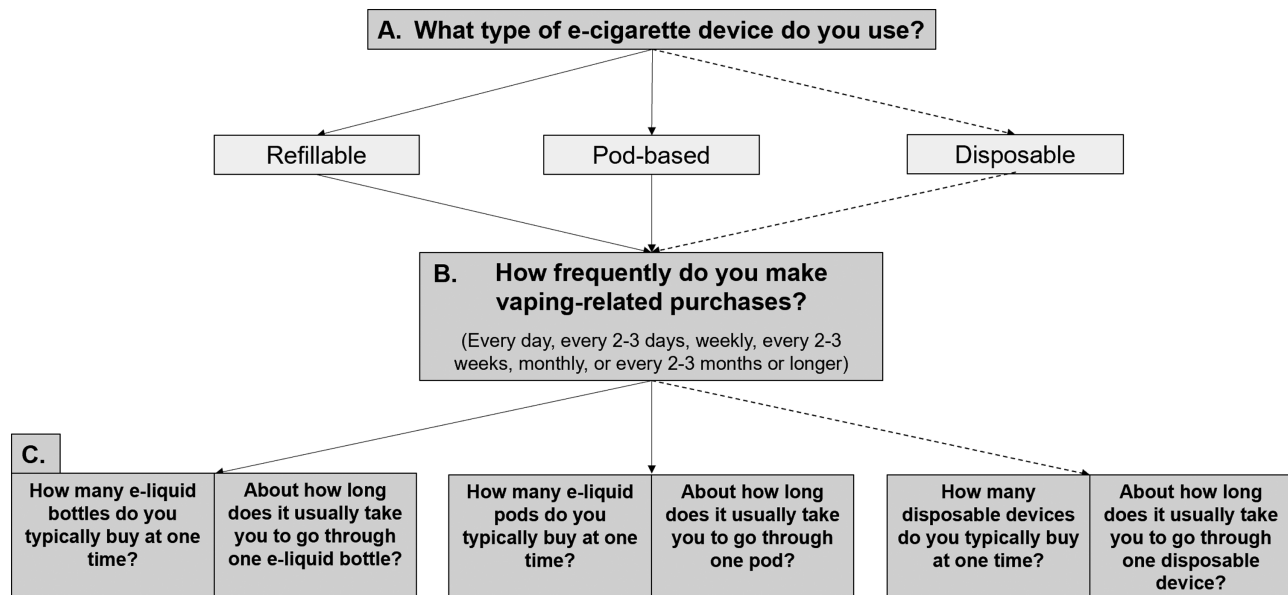
*"Ask them the size of the bottles they buy and how many bottles they buy [per] month and that will give you a pretty good idea."*  
- ID12, male, age 20

And a pod-based user suggested the following:

*"Ask them how many times a week they buy the cartridges and they can give you a number and you can kind of divide those cartridges to give you the number they use."* - ID21, male, age 21

## Discussion

The present findings describe participants' perspectives on common challenges for quantifying vaping behavior and provide creative solutions for the development of more accurate measurement items.



**Figure 1.** Suggested branching logic to assist the development of measurements of vaping quantity.

Note: Solid lines = branching logic based on reported findings; Dotted lines = proposed branching logic for device type not reported in findings.

Participants noted the difficulty in accurately reporting the number of puffs taken, amount of e-liquid consumed, and amount of nicotine consumed in a given vaping session or day. Participants also discussed how vaping behaviors often vary between and within individuals and across different vaping sessions, referencing variations in number of puffs, puff sizes, and duration between subsequent puffs. Participants had several suggestions for the development of items to assess vaping frequency such as using device-specific metrics and assessing the frequency of replacing e-liquid in those specific devices over a given period of time since they and other vapers reported this being the metric they used to track their consumption. The current study contributes specific suggestions for the scientific community to consider for revising the measurement methods of assessing vaping behavior.

Some participants in our sample reported having a relatively good understanding of how much they vape based on how many times they refill their device, and specifically contrasted this with not actively monitoring “number of puffs,” which is a commonly used assessment in the quantitative literature. This finding is consistent with previous reports of vapers struggling to respond to questions such as “how many puffs did you take in a day?” or “how many times did you pick up your device?”<sup>9</sup> On the other hand, many participants noted that they simply didn’t keep track of how much they vaped, raising concerns regarding the potential for the development of nicotine dependence if individuals increase their vaping frequency without awareness of the amount of nicotine that they are consuming.

While vapers may recognize that the e-liquid volume in their pod or tank has decreased, they noted that it is difficult to accurately report how much e-liquid they have consumed based on this relative decrease that they observe. This aligns with previous research reporting that vapers recalled the quantity of e-liquid they consume at varying self-reported confidence levels.<sup>10</sup> In an effort to alleviate such difficulties faced by participants and hopefully improve the validity of measures, future studies attempting to assess vaping quantity may benefit from utilizing questions and

prompts that parallel how vapers typically track their consumption patterns.

Several questions should be considered when developing vaping quantity survey items. First, researchers should ask vapers to report the type of vaping device(s) they use most frequently (or in the past month), with categorical answer choices that include all current market products, where possible: refillable devices, pod-based devices, and disposable devices (a newer category of devices that were not yet popular at the time of this study, but which are the predominant type of e-cigarette device currently used among adolescents). Then, vapers should be asked how frequently they make vaping-related purchases, including responses ranging from “Every day, every couple days, weekly, every couple weeks, monthly, or less than monthly,” as suggested by participants. Next, questions specific to the type of device used should assess how long each bottle of solution, pack of pods, or new disposable device is used before replenishment. Additional detail on the quantity purchased at each purchase interval is also needed. Such measures may provide additional metrics for approximating vaping quantity with more accuracy; additional study to determine the accuracy of the self-reported items suggested here is needed. See Figure 1 for suggested branching logic based on current study findings.

The following limitations should be considered when interpreting study findings. First, this study was based on a small sample of young adults, majority male, vapers in Los Angeles, California, between 2018 and 2019. As such, our findings may not be generalizable to other study populations, including female vapers, or for assessing vaping behavior related to devices that became popular in late 2019 or more recently; replication of study findings across diverse sample populations is warranted. Furthermore, the current study only asked participants about their suggestions for improving current vaping behavior measures. While such insights hold great value for consideration in the development of future measurements, future studies are needed to validate these subjective questions against an objective measure (eg, biomarkers of e-cigarette exposure such as cotinine<sup>11</sup> or frequency of use as measured via a device that can record use

patterns<sup>6</sup>). For example, tracking participants' vaping behavior and asking suggested self-report questions may help scientists to improve the measurement of the dose of e-cigarette exposure. Moreover, we did not specifically prompt participants to discuss the role of nicotine strength or formulation (eg, salt-based or free-base), which are also important considerations when evaluating the quantity of vaping consumption.

## Conclusion

The current study provides insight for how researchers can better estimate the quantity and frequency of vaping consumption among young adults. Our data suggest that the way vapers self-monitor their quantity of consumption is different from how researchers have been asking them to self-report on their quantity of consumption. The current findings suggest future measurements may be more accurate if they include a device-specific approach and focus on the frequency with which e-liquid solutions, pods, or disposable devices are replenished, which more closely aligns with participants' tracking of vaping behavior. Furthermore, our findings highlight the importance of consulting user perspectives through qualitative methods to study the usage characteristics of novel and emerging substances. Findings from this study may inform the development of more accurate and precise measurements of vaping quantity.

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## Declaration of Interests

*The authors have no conflicts of interest to declare.*

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