Qualitative insights on how adult e-cigarette users describe quantity of e-cigarettes used – PATH Study 2018

Sherry T. Liu [a,*], Jocelyn Newsome [b], Victoria Castleman [b], Karl Poonai [a], MeLisa R. Creamer [c], Heather L. Kimmel [c], Izabella Zandberg [a]

[a] Office of Science, Center for Tobacco Products, U.S. Food and Drug Administration, Silver Spring, MD, United States
[b] Westat, Rockville, MD, United States
[c] National Institute on Drug Abuse, National Institutes of Health, Bethesda, MD, United States

ABSTRACT

The purpose of this qualitative study was to gain a deeper understanding of how adult e-cigarette users describe quantity of e-cigarettes used. Data for this analysis came from a qualitative study of U.S. adult dual e-cigarette and cigarette users and former cigarette smokers aged 18 years and older. Eligible respondents from Wave 4 (2016–2017) of the Population Assessment of Tobacco and Health (PATH) Study responded to a brief web questionnaire and participated in an in-depth telephone interview (n = 112) between March and August 2018. Using the respondent's native terminology for their e-cigarette device, interviewers asked respondents to describe in their own words the quantity of e-cigarettes used. Using NVivo software, interview transcripts were coded and analyzed to identify themes and patterns. Respondents described quantity used in three different ways: number of times and/or puffs; device-specific terms (i.e., replacement of disposable devices, cartridges/pods; use of e-liquid); and perceived equivalence to a quantity of traditional cigarettes. The most commonly reported approach across all device types and levels of device proficiency, although with varying ease and specificity, was the number of times and/or puffs taken in a day. Several respondents used multiple approaches to describe quantity. E-cigarette users use a variety of approaches to describe quantity of e-cigarette used, contributing to challenges developing standardized survey measures. The variety of approaches should be taken into consideration along with device type and other contextual factors such as device proficiency when developing survey questions.

1. Introduction

Compared to measuring self-reported cigarette use, quantifying e-cigarette use behaviors or vaping has been more difficult. E-cigarette use patterns can vary greatly, ranging from one or two puffs at a time to continuous use throughout the day (Halpern-Felsher and Kim, 2018). The variety of e-cigarette device types available, including various sizes of e-cigarette refillable tanks and e-liquid bottles, variability in nicotine concentrations and its labeling, and different terminology used by e-cigarette users to describe their devices, have also contributed to measurement challenges (Bold et al., 2018; Weaver et al., 2018). While frequency of e-cigarette use has been commonly measured by most tobacco surveys as the number of days used in the past 30 days, there has been little consensus on measures assessing quantity used (Pearson et al., 2018; Weaver et al., 2018). Tobacco surveys have asked about the number of disposable e-cigarettes, cartridges/pods, or refills used; number of e-cigarette puffs per session or day; how long it takes to use up a disposable e-cigarette, cartridge/pod, tank, or e-liquid bottle; and/ or the size of the last e-liquid bottle purchased, as measures to assess quantity (Pearson et al., 2018; Weaver et al., 2018).

Qualitative research can provide valuable insight on how e-cigarette users think and talk about their e-cigarette use behavior to inform survey measure development (Pearson et al., 2018). Previous qualitative studies exploring e-cigarette use patterns and puffing behavior have been relatively small-scale and with e-cigarette users recruited from specific geographic areas (Cooper et al., 2016; Kim et al., 2017). Kim et al. (2017) conducted focus groups in August-October 2014 with a total of 35 adult e-cigarette users recruited from the Seattle, WA area. Cooper et al. (2016) conducted in-depth interviews in December 2014-April 2015 with 50 adult e-cigarette users recruited via a University of

Texas posting. These studies found that e-cigarette users generally had difficulty describing vaping sessions, quantifying puffs per session or the amount of time spent vaping, and estimating the amount of e-liquid used within a time period. However, little is known about how approaches to quantifying e-cigarette use may vary by device type and level of device proficiency. As the e-cigarette landscape continues to evolve, it is also important to assess whether current literature findings remain relevant (Huang et al., 2019; King et al., 2018). The purpose of this qualitative study was to gain a deeper understanding of how adult e-cigarette users describe quantity of e-cigarettes used and to explore differences by e-cigarette device type and proficiency level using respondents from a nationally representative longitudinal cohort study.

2. Methods

2.1. Participant selection

Data for this analysis came from a qualitative study of adult dual e-cigarette and cigarette users and former cigarette smokers aged 18 years and older whose primary focus was to explore how subjective experiences of e-cigarette use relates to trajectories for e-cigarette use and cigarette smoking. Potentially eligible respondents (n = 1256) from the Population Assessment of Tobacco and Health (PATH) Study, a nationally representative longitudinal cohort study of civilian, non-institutionalized US adults and youth (see https://doi.org/10.3886/Series606 for additional information), were identified based on e-cigarette and cigarette use status at Wave 4 (2016–2017). Of the 1256 respondents, 852 were purposively selected for screening to achieve a balanced mix of characteristics within and across the following: age, sex, race, ethnicity, geographic region, education, and e-cigarette device type as reported in Wave 4. Sampled respondents (n = 852) were contacted by an interviewer to screen for eligibility. To be eligible, respondents had to screen into one of the following groups: current dual users of e-cigarettes and cigarettes who were not using e-cigarettes to quit cigarette smoking; current dual users of e-cigarettes and cigarettes who were using e-cigarettes to quit cigarette smoking; current e-cigarette users who successfully used e-cigarettes to quit cigarette smoking for at least one month (former cigarette smokers). E-cigarette use was defined as now using electronic nicotine products every day or some days. Respondents who reported e-cigar, e-pipe, and/or e-hookah as their primary type of electronic nicotine product were excluded. Respondents who reported using e-cigarettes for marijuana every time or most of the time were ineligible. Eligible respondents (n = 277) participated in a short (10–15 min) web questionnaire and were then invited to participate in a 45-minute in-depth semi-structured telephone interview between March and August 2018. Those who completed both the web questionnaire and interview were included in this analysis (n = 112). Fig. 1 provides a flow chart illustrating study sample selection.

2.2. Short web questionnaire and in-depth interview

A structured web questionnaire collected information about respondent's e-cigarette terminology, e-cigarette use, cigarette use, other tobacco use, and e-cigarette devices used. Questions were based on the PATH Study instruments (available at https://doi.org/10.3886/Series606). Respondents were also asked to submit photographs of their e-cigarette device(s). Devices were categorized by analysts[1] into disposable (unable to be recharged or refilled), cartridge/pod (rechargeable, with a replaceable cartridge/pod of e-liquid), tank (rechargeable, with the ability to refill e-liquid), and dripper (rechargeable, where e-liquid is dripped directly on the coil).

The interviews were semi-structured and covered a range of topics,

including e-cigarette use patterns and e-cigarette devices used. Throughout each interview, interviewers employed the native terminology for e-cigarettes provided by respondents in the web questionnaire. For example, if respondents used the term "vapes" to refer to "e-cigarettes," interviewers adopted "vapes" terminology in the interview. Using the respondent's native terminology for their e-cigarette device, interviewers asked the respondents to describe in their own words the quantity of e-cigarettes used. Interviewers framed the discussion of e-cigarette quantity by acknowledging that, while it is easy to ask how many cigarettes someone smokes, it is harder to ask how much [respondent's native terminology for e-cigarettes] someone uses. To emphasize the difficulty of asking about e-cigarette quantity, interviewers were instructed to use an inflection that highlighted the awkward wording when asking, "*How much [respondent's native terminology] do you use?*"

E-cigarette device proficiency was assessed based on knowledge displayed during the interview on topics such as how the respondent's device functioned and any modifications made by the respondent. Level of device proficiency was categorized by analysts as low, medium, and high using a combination of two factors: device knowledge (the respondent's awareness of how their device functions) and device skills (the respondent's ability to reuse/recharge their device, perform maintenance, swap out components, or customize/modify their device).

Respondents who completed both the web questionnaire and interview were sent a thank you letter and an incentive check of $50. This study was conducted by Westat and approved by the Westat Institutional Review Board.

2.3. Data analysis

Our qualitative approach was content analysis, using both deductive and inductive approaches. Coding and analysis were conducted by analysts with expertise in qualitative research using NVivo 11 software. Web questionnaire data and interview transcripts were imported into an NVivo database. In NVivo, two analysts coded the interview transcripts using a priori codes based on the study's research questions. As analysts identified themes in the data, "emergent" codes were added as needed. Coding comparison queries were run in NVivo to evaluate the degree of agreement for coding between analysts. In the case of discrepancies, analysts met to resolve their differences and come to an agreement on how to apply a code or codes in subsequent transcripts. Discussions continued until the degree of agreement between analysts was consistently above 90%. NVivo queries were used to identify any patterns by respondent characteristics.

3. Results

3.1. Participant characteristics

Table 1 shows the demographic characteristics of respondents participating in the web questionnaire and interviews. About 70% of respondents used a tank device, either as their only device type or in combination with other device types. About 80% of respondents had a low or medium level of device proficiency: with about half of those having minimum proficiency (e.g., knew how to recharge or refill) and the other half, a medium level (e.g., were aware of how different components work, able to replace parts such as the coil). About 20% of respondents had high proficiency (e.g., ability to make technical modifications to device or in-depth understanding of device mechanisms).

3.2. E-cigarette quantity terminology

Respondents tended to describe quantity used in one of three ways: the number of times and/or puffs; in device-specific terms, i.e., replacement of devices (disposable users), replacement of cartridges/
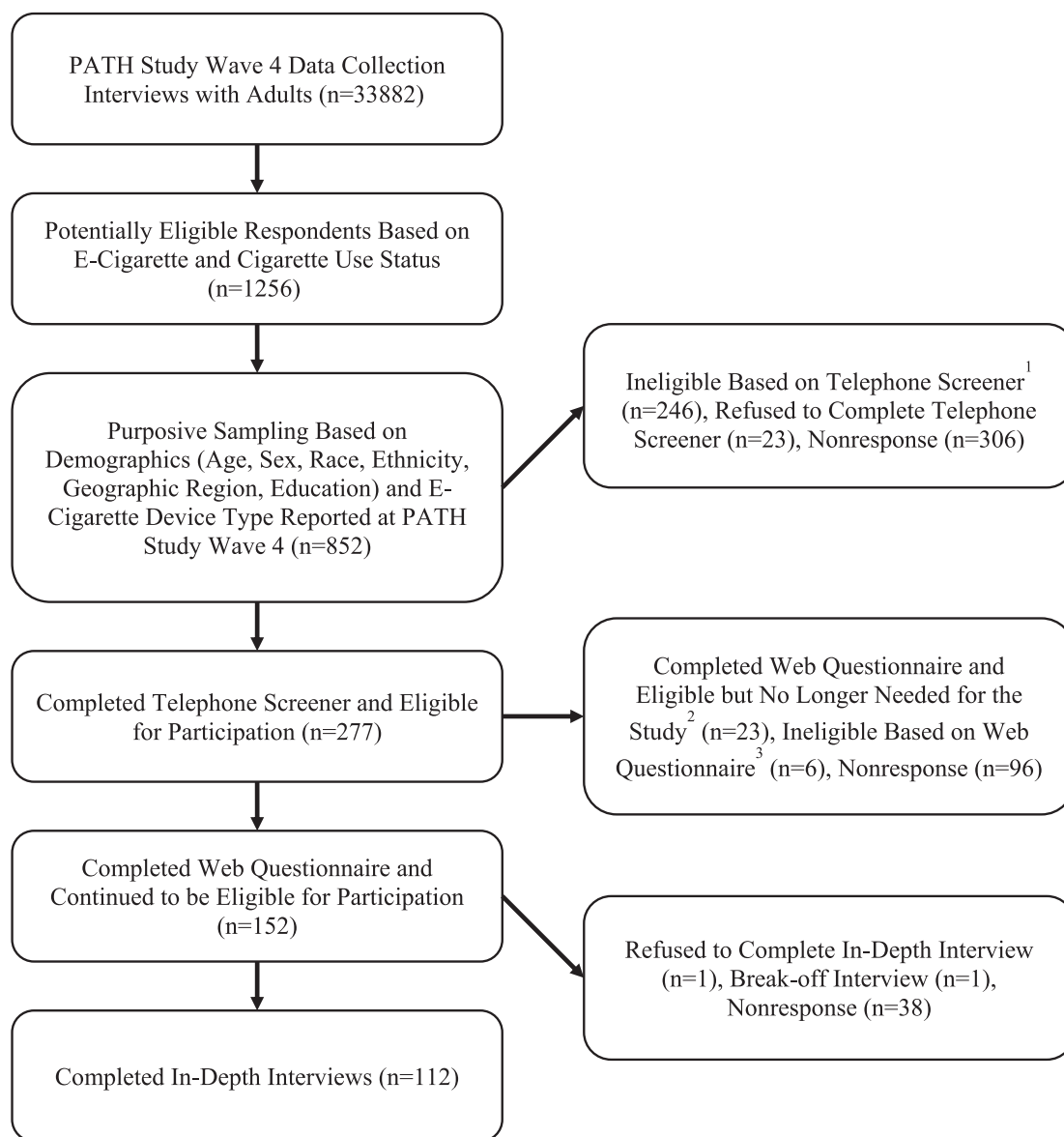
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[1] Analysts received extensive training on e-cigarette types, components, and functionality.

Fig. 1. Flow Chart of Study Sample Selection [1]Reported no longer used e-cigarettes, primarily used marijuana in e-cigarettes, had quit smoking less than a month prior, quit smoking without using an e-cigarette, had not tried to quit smoking in the past three months, or no longer smoked but did not consider themselves to have "quit" smoking in the telephone screener [2]Targeted number of completed in-depth interviews had been met [3]Reported no longer using e-cigarettes or primarily using marijuana in e-cigarettes in the web questionnaire.

pods (cartridge/pod users), use of e-liquid (tank and dripper users); and the perceived equivalence to a quantity of traditional cigarettes. Several respondents used multiple approaches to describe quantity. Most commonly, respondents described the number of times and/or puffs taken in a day in conjunction with another approach, such as the frequency of refilling e-liquid. Findings did not appear to vary by age, sex, race/ethnicity, education level, geographic region, e-cigarette frequency of use, or other tobacco use.

3.2.1. Number of times and/or puffs

Overall, about half of all respondents initially spoke about e-cigarette quantity in terms of the number of times they use their device during the day and/or the number of puffs they take when they use it. This approach was used across all device types and all device proficiency levels.

Some respondents reported quantity in terms of how many times they used an e-cigarette, in a day, week, or month, depending upon frequency of use. Some easily gave a number of times, others pointed out

that the number may vary. One former cigarette smoker and current tank user walked the interviewer through their calculations: "I would say I would use it, and of course this is all anecdotal - I don't have anything to really back it up - maybe five times, five to ten times an hour for, you know, 12 h a day. So, I don't know. I'd say on the low end, 50 times and on the high end, 100 times a day."

Some respondents reported quantity in terms of the total puffs they took during the course of day. A handful of respondents had a tank device that counted puffs using a digital display, so were able to provide very specific counts. One pack-a-day cigarette smoker, who has no plans to quit but vapes when indoors because it "smells better," reported that they took an average of 238 puffs per day according to their device. Another cigarette smoker had a device that told them the number of puffs over the lifetime of the device: 9987. Since they do not use their "vaporizer" every day, they gave a monthly estimate: "So, I would say over a lifetime I may have hit it 200, 300 times a month maybe."

Some deduced the number of puffs based on the lifetime of a device or component. One respondent, who is using a disposable to try to quit

Table 1

Characteristics of adult e-cigarette users participating in the web questionnaire and in-depth interview, March–August 2018.

Characteristic	Adult e-cigarette users (n = 112) % (n)
Sex	
Male	45% (50)
Female	55% (62)
Age (years)	
18–24	21% (24)
25–34	28% (31)
35–44	23% (26)
45–54	14% (16)
55 or older	14% (15)
Race/Ethnicity	
White, Non-Hispanic	64% (72)
Black, Non-Hispanic	8% (9)
Hispanic	18% (20)
Other, Non-Hispanic	10% (11)
Education	
Less than high school	12% (13)
High school graduate or GED	26% (29)
Some college/Associate's degree	47% (53)
Bachelor's degree or higher	15% (17)
Geographic region	
Northeast	19% (21)
South	32% (36)
Midwest	22% (25)
West	27% (30)
Current device types used[1]	
Disposable	13% (14)
Cartridge/pod	33% (37)
Tank	68% (76)
Dripper	4% (5)
Number of current device types	
Single device type	80% (90)
More than one device type[2]	20% (22)
Frequency of current e-cigarette use	
Every day	65% (73)
Some days	35% (39)
Level of device proficiency[3]	
Low	38% (43)
Medium	42% (47)
High	20% (22)
Current cigarette use[4]	
Yes	63% (71)
Current use of other combusted products[5]	
Yes	30% (34)
Current use of other non-combusted products[6]	
Yes	5% (6)
Current dual users of e-cigarettes and cigarettes who were not using e-cigarettes to quit cigarette smoking	
Yes	30% (34)
Current dual users of e-cigarettes and cigarettes who were using e-cigarettes to quit cigarette smoking	
Yes	35% (40)
Current e-cigarette users who successfully used e-cigarettes to quit cigarette smoking for at least one month	
Yes	34% (38)

[1] E-cigarette device types were categorized by analysts as follows using information provided during the interview and supplemented with device photographs and web questionnaire data: disposable (non-rechargeable and non-refillable, discarded after running out of e-liquid or battery power), cartridge/pod (rechargeable, refilled by replacing the pre-filled cartridge/pod of e-liquid), tank (rechargeable and refillable by refilling e-liquid in a tank reservoir; including open pod systems that are refillable), dripper (rechargeable, refilled by dripping e-liquid on the coil). Percentages do not total 100%; respondents could report multiple device types during the interview.

[2] Among respondents using more than one device, 4 used a cartridge/pod and disposable; 3 used tank and disposable; 11 used tank and cartridge/pod; and 4 used tank and dripper.

[3] Level of e-cigarette device proficiency was categorized using a combination of two factors: device knowledge (the respondent's awareness of how their device functions) and device skills (the respondent's ability to reuse/recharge their device, perform maintenance, swap out components, or customize/modify their device). Low demonstrates minimum device proficiency (e.g., how to recharge or refill). Medium demonstrates moderate proficiency (e.g., aware of how different components work, able to replace parts such as the coil). High demonstrates high proficiency (e.g., ability to make technical modifications to device or in-depth understanding of device mechanisms).

[4] Current cigarette use is defined as now smokes cigarettes every day or some days and smoked at least 100 cigarettes in entire life.

[5] Respondents who reported currently using traditional cigars, cigarillos, or filtered cigars; pipe tobacco; or hookah tobacco.

[6] Respondents who reported currently using snus (including loose snus and snus pouches) or smokeless tobacco (including dip, spit, moist snuff, pouches, or chewing tobacco).

smoking cigarettes, explained: "They say there's 200 puffs on one. So, I guess you could say I go through about 400 puffs every two weeks because sometimes I'll buy two." A former cigarette smoker, who used their mod to replace smoking cigarettes, calculated the number of puffs based on how often they replace the atomizer: "If we can do some math, one atomizer lasts me about 1800 puffs and the atomizer lasts me from 7 to 10 days. So if we divide that 1800 puffs into 10 is that 180 puffs a day?"

Other respondents framed quantity in terms of how many times they use their e-cigarette during the day and how many puffs they take each time. One everyday cigarette smoker explained how often they use their tank: "I use it maybe five, six times a day and I take three or four puffs at a time." Others had a more difficult time determining the exact number of times. One tank user, who used their vape to quit smoking cigarettes, expressed:

> I smoke my vape literally throughout the day, like through the entire day. So I can't really give too good of a guess. But I'd say that I pick it up – sometimes, I can pick it up, you know, every three minutes or so. And then there'll be other times where I'm just – you know, I just don't feel the need to and it'll be every 10–15 min. But every time I do pick it up, I take about two to three hits. So I wish I could put a better number on it.

3.2.2. Device-specific

Some e-cigarette users described quantity in terms that were specific to the device type they used. Among disposable or cartridge/pod device users, about one-fourth of respondents reported quantity in terms of how often they replaced a cartridge/pod or disposable device.

Among tank users, about one-third described quantity used in terms of refilling their device with e-liquid. The majority of these users had medium or high device proficiency and about half were able to provide precise amounts in milliliters (mL) of e-liquid quantity used over a period of time, usually based on either the size of the e-liquid bottle or size of the tank. One former cigarette smoker, who had medium device proficiency, explained, "This little bottle of e-liquid will probably last me about two weeks. And it's 15 mL." In contrast, one tank user with medium device proficiency determined their quantity based on the size of their tank: "It usually can hold up to 1.6 mL. And I fill it to 1.2 usually and that will last me two or three days." Only a handful were able to provide an amount of mL per day. One former cigarette smoker, who had

high device proficiency, provided the number of mL per day: "I can tell you that I go through almost four mL of vape fluid per day."

Of those tank users who reported quantity in terms of e-liquid refills, the other half were unable to provide an amount in mL. Instead, these users described generally how often they filled their tank or how long a bottle of e-liquid would last. A former cigarette smoker with medium device proficiency explained, "Hmm. Well, I'm not sure exactly how much my tank holds inside of it, but I would say that I go through about, anywhere from like two and a half to four tanks a day." A cigarette smoker with high device proficiency explained, "I think the tank is, I think the tank holds, not too sure of how much the tank holds, really. But…I can probably go through a small bottle of juice in like three days."

3.2.3. Perceived equivalence to cigarettes

Several respondents, mostly dual e-cigarette and cigarette users and a handful of former cigarette smokers, described quantity used in terms of an equivalence to traditional cigarettes. Almost all were disposable or cartridge/pod device users and majority used tobacco and mint/menthol e-liquid flavors. Most had low device proficiency and were older (ages 45 and up).

Typically, these respondents described quantity in terms of how many cigarettes the e-cigarette was replacing. One cigarette smoker using e-cigarettes to quit smoking, when asked about their quantity, answered, "I want to say when I have the e-cigarettes, I will take a couple… yeah, you're right, it is kind of hard. I take a couple puffs here and there. I hold onto it more than anything. But I probably… if anything, I want to say I smoke maybe equivalent to about a half a pack a day." On days they use an e-cigarette, they try not to smoke any cigarettes, so they concluded that the e-cigarette was replacing the half pack of cigarettes they typically smoke each day.

A couple of respondents cited package labeling when describing quantity in terms of cigarettes. One former cigarette smoker with low device proficiency noted "[it] claims on the box that it's 300 puffs, which is equivalent to one pack of cigarettes. And I use about one [a] day. So it actually probably comes out to like a pack a day."

4. Discussion

A variety of approaches were used by respondents to describe e-cigarette quantity. The most commonly reported approach across all device types and levels of device proficiency was the number of times and/or puffs taken in a day. It is possible that this pattern was influenced by respondents' previous experience with the PATH Study, since the PATH Study instruments ask about quantity in terms of number of times per day and number of puffs per time. In fact, one respondent prefaced their answer by saying, "Well, let's see. If we're talking about… because I know in the PATH Study, that one of the questions is how many times do you use your vape?" before going on to talk about the times per day they use their e-cigarette.

While some expressed difficulty specifying a quantity, most respondents – although with varying ease and specificity – reported quantity in terms of number of times they used an e-cigarette, in a day, week, or month; total puffs during the course of the day; or number of times they used their e-cigarette during the day and puffs per time. Since most respondents across all device types and levels of device proficiency reported quantity in these terms, questions that assess these constructs are likely important to include in surveys. This contrasts findings from earlier studies that found respondents generally had difficulty describing vaping sessions and quantifying puffs per session (Cooper et al., 2016; Kim et al., 2017).

Findings from this study emphasize the importance of considering device type when surveying about quantity, acknowledging the different consumable component of the device that is used or replaced across types. Depending on the study design and research objectives, there may be value in asking about e-cigarette use patterns using tailored survey questions based on the type of device used most often. About one-fourth

of respondents who used a disposable or cartridge/pod device reported quantity in terms of how often they replaced a cartridge/pod or device. Among tank users, about one-third described quantity in terms of refilling their device with e-liquid, with about half of those providing an amount in mL based on size of the e-liquid bottle or size of the tank. Interestingly, the majority of tank users who described quantity in terms of refilling e-liquid demonstrated medium or high device proficiency, suggesting that individual's device knowledge and skills may be important context when surveying tank users about quantity used. Some tank users reported quantity in terms of how long a bottle of e-liquid lasted and did not know the quantity of e-liquid held in their tank, which was also reported by Cooper et al. (2016). Given the variability in tank users ability to describe quantity of e-liquid used, it may be useful to ask about quantity using multiple constructs in surveys.

Several respondents, mostly disposable or cartridge/pod device users with low device proficiency, described how many cigarettes the e-cigarette was replacing. Kim et al. (2017) found that participants naturally compared vaping to cigarette smoking.

This study has several limitations. First, as a qualitative study conducted with purposive sampling, the findings may not be generalizable to the larger population. Secondly, the study was limited to English-speaking adults and may not reflect experiences of non-English speakers. Third, all respondents were part of the existing PATH Study and had been exposed previously to PATH Study terminology for e-cigarettes and questionnaire conventions. Priming effects, however, may have been moderated by the time between interviews, since the average amount of time between a respondent's PATH Study Wave 4 interview and the qualitative study interview was about 15 months. Fourth, the study sample consists of only current dual cigarette and e-cigarette users and former smokers who used e-cigarettes to quit smoking cigarettes, which could have influenced framing around cigarette comparisons. The study sample did not include e-cigarette users who never smoked cigarettes who may describe their patterns of use differently than those who have smoked cigarettes. Lastly, about 70% of respondents used a tank device. Since fewer used a disposable, cartridge/pod, or dripper device, it was not always possible to identify patterns by device type. Despite these limitations, this study has several strengths. Respondents in the qualitative study were purposively recruited from the PATH Study Wave 4, a large nationally representative sample. The study sample, which was relatively large, reflected a balanced mix of characteristics including age, sex, race, ethnicity, geographic region, and education. Furthermore, interviewers in this study used the respondent's native terminology for e-cigarette device throughout each interview to facilitate respondent's use of their own words in describing their e-cigarette use. Overall, this study expands on previous findings by exploring the mental processes of e-cigarette users when describing quantity used, including how the level of device proficiency may impact an e-cigarette user's descriptions of quantity used.

5. Conclusions

A variety of approaches are used by adult e-cigarette users to describe quantity used, contributing to challenges developing standardized self-report survey measures. This study highlights the importance of understanding the context, including device type and level of proficiency, of the individual's e-cigarette use when assessing use patterns. Approaches may vary by e-cigarette device type and level of device proficiency, which should be taken into consideration when developing survey questions.

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CRediT authorship contribution statement

Sherry T. Liu: Conceptualization, Writing - original draft, Supervision. **Jocelyn Newsome:** Conceptualization, Formal analysis, Writing - original draft. **Victoria Castleman:** Conceptualization, Formal analysis, Writing - original draft. **Karl Poonai:** Conceptualization, Writing - review & editing. **MeLisa R. Creamer:** Conceptualization, Writing - review & editing. **Heather L. Kimmel:** Conceptualization, Writing - review & editing. **Izabella Zandberg:** Conceptualization, Writing - review & editing.

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.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Department of Health and Human Services or any of its affiliated institutions or agencies.

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