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Biochemically verified smoking cessation and vaping beliefs among vape store customers

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ABSTRACT

Aims To evaluate biochemically verified smoking status and electronic nicotine delivery systems (ENDS) use behaviors and beliefs among a sample of customers from vapor stores (stores specializing in ENDS). **Design, Setting and Participants** A cross-sectional survey of 215 adult vapor store customers at four retail locations in the Midwestern United States; a subset of participants ($n = 181$) also completed exhaled carbon monoxide (CO) testing to verify smoking status. **Measurements** Outcomes evaluated included ENDS preferences, harm beliefs, use behaviors, smoking history and current biochemically verified smoking status. **Findings** Most customers reported starting ENDS as a means of smoking cessation (86%), using newer-generation devices (89%), vaping non-tobacco/non-menthol flavors (72%) and using e-liquid with nicotine strengths of ≤ 20 mg/ml (72%). There was a high rate of switching (91.4%) to newer-generation ENDS among those who started with a first-generation product. Exhaled CO readings confirmed that 66% of the tested sample had quit smoking. Among those who continued to smoke, mean cigarettes per day decreased from 22.1 to 7.5 ($P < 0.001$). People who reported vaping longer [odds ratio (OR) = 4.659, 95% confidence interval (CI) = 2.001–10.846], using newer-generation devices (OR = 2.950, 95% CI = 1.037–8.395) and using non-tobacco and non-menthol flavors (OR = 2.626, 95% CI = 1.133–6.085) were more likely to have quit smoking. **Conclusions** Among vapor store customers in the United States who use electronic nicotine delivery devices to stop smoking, vaping longer, using newer-generation devices and using non-tobacco and non-menthol flavored e-liquid appear to be associated with higher rates of smoking cessation.

Keywords Electronic cigarettes, electronic nicotine delivery systems, smoking cessation, tank systems, vaping, vapor stores.

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INTRODUCTION

During the last 7 years, the sale of electronic nicotine delivery systems (ENDS) has increased threefold [1]. Approximately 23% of current smokers have tried ENDS, a figure that has demonstrated constant growth in the last several years [2]. Approximately 86% of the population is aware of ENDS and 6% of adults use this product [3]. ENDS are often bought and sold online, at convenience stores, gas stations and in mall kiosks. Recently, however, there has been a surge in ENDS specialty stores or 'vape' stores in the United States. Currently the fastest-growing sector of the ENDS market, these stores predominately sell tank system-style ENDS [5]. Tank systems have been shown to deliver higher doses of nicotine

to the user compared to 'cig-a-like' ENDS [4]. Tank systems account for more than one-third of the US\$2.2 billion ENDS market, with more than US\$800 million in revenue and US\$500 million coming from 'vape' stores [5,6]. Moreover, vape stores often mix their own e-liquid and provide a selection of 'gourmet' flavors with various strengths of nicotine, including nicotine-free liquids. Customers are encouraged to sample flavors, given recommendations on how to use their tank system and offered in-store seminars on personalizing and modifying tank systems (e.g. rebuildable atomizers and 'mod tanks'). Many specialty vapor stores foster a vaping community in which individuals socialize in a setting similar to a traditional pub or lounge. Thus, specialty vapor stores may be serving individuals with vaping characteristics distinct

from those purchasing their products from convenience stores, gas stations or online.

The current ENDS literature has primarily utilized online surveys of ENDS forums to profile the vaping community. The findings suggest that a majority of vapers begin ENDS as a way to reduce or quit smoking combustible cigarettes, find their ENDS satisfying, experience curbed cravings and the urge to smoke and view ENDS as healthier than smoking regular cigarettes (e.g. [7–9]). Lack of biochemical verification of smoking status, however, has been a major limitation for these studies. Moreover, no research has investigated the characteristics, tobacco use patterns, vaping beliefs and use behaviors among those frequenting vape stores. Individuals who purchase ENDS from vape stores are believed to be ‘aficionados’ who use advanced vapor devices and are more affiliated with the vaping culture [10]. Therefore, they may represent a subculture of vapers who differ from other vapers in use behaviors as well as ENDS perceptions.

The purpose of the current study was to estimate the following characteristics among a convenience sample of vapor store customers: (1) ENDS preference (first-versus newer-generation, e-liquid flavor and nicotine strength), (2) ENDS use behaviors (reasons for use, length of use, dependence), (3) perceived harm and health beliefs of various smoking cessation medications, nicotine replacement therapies and nicotine/tobacco products and (4) smoking history and current biochemically verified smoking status. The relationship between smoking cessation and ENDS preferences and select use behaviors was also examined to elucidate more clearly what characteristics may improve smoking cessation rates.

METHOD

Participants and procedure

All procedures were approved by the Institutional Review Board. Prior to data collection, managers of four retail ‘vape stores’, demographically representative (e.g. urban, suburban and rural) of a large metropolitan city in the Midwestern United States, were contacted and asked to provide letters of support for serving as data collection sites. Using a convenience sample approach, all customers who entered the approved retail location were approached by a study research assistant and asked to participate. It was rare that individuals refused to participate in the research study; however, no information was collected regarding the number of participants who declined. We conservatively estimate that no more than 10% of individuals approached declined participation. A frequent reason for decline was being ‘too busy’, as we collected the majority of these participants at lunchtime. Survey collection occurred during 15 weekdays between June and August 2013 and consisted of 2–3 hours of participant recruitment during ‘higher traffic’ times (i.e. lunch: 11 a.m.–2 p.m. and

after work: 4 p.m.–6 p.m.). Due to equipment malfunction, only a subset of the participants ($n = 185$; 86%) completed exhaled carbon monoxide (CO) biochemical verification. Only four participants refused CO measurement. No compensation was given to participants for their participation.

Measures

Participants completed a questionnaire in which they were asked to report on demographic characteristics, including age, ethnicity, income, employment status and education level. Current and past use of tobacco and ENDS was also assessed, including: (1) life-time number of 24-hour smoking quit attempts; (2) previous use of smoking cessation medications (Chantix and Wellbutrin) and nicotine replacement products (gum, lozenge, inhaler, nasal spray, patch); (3) current cigarette dependence was measured using the Fagerstrom Test for Cigarette Dependence (FTCD; [11]) question: time to first cigarette (TTFC [11]); (4) current ENDS dependence was measured using a modified FTCD TTFC, replacing time from waking until ‘first daily cigarette’ to ‘first daily ENDS puff’ (reported as FTCD TTFC-e); (5) self-reported duration of ENDS use (reported in years, months and days); (6) primary reason for initiating ENDS use (quit smoking, recreational use, use in places where not allowed to smoke, other: open text); (7) frequency of ENDS use (self-reported estimated number of daily puffs); (8) initial and current ENDS liquid nicotine strength (mg/ml); (9) type of ENDS used [i.e. ‘a cartomizer’ system with disposable cartridges, tank (refillable e-liquid) system, other: open text]; and (10) preferred e-liquid flavors (open text categorized as fruity, bakery/dessert, tobacco blends, mint/menthol, candy or nuts and coffee flavors). Customers were also asked if and at what frequency (daily, weekly, monthly, less than monthly or never) they had used the dripping technique to vape (‘How often, if ever, do you use the dripping technique?’). Dripping is a method of e-liquid delivery where the individual drips e-liquid directly onto the atomizer/coil prior to inhalation, rather than using a cartridge or tank reservoir. Participants were asked to rate perceived harm of nicotine replacement products, smoking cessation medications, ENDS and other tobacco products (‘On a scale from 0 to 10, where 0 = “not at all harmful” and 10 = “extremely harmful”, how harmful to your health do you think the following are?’). Lastly, two questions were asked to assess participants’ perceived health: (1) ‘Since you’ve started using the ENDS, do you feel that your health has improved, stayed the same, worsened?’ and (2) ‘Which of these has improved (if any) since regular ENDS use (check all that apply): smoker’s cough; ability to exercise; sense of smell; sense of taste’.

Biochemical verification of self-reported smoking status

A subsample of participants were asked to verify their smoking status biochemically via exhaled CO, using a piCO+ Smokerlyzer® [12], with CO \leq 10 parts per million (p.p.m.) indicating confirmed smoking cessation. Participants who refused CO verification ($n = 4$) were excluded from analyses examining self-reported quit status.

Design and statistical analyses

Analyses were conducted using SPSS version 20.0 [13]. Descriptive analyses were conducted for participants' preference, beliefs and patterns of use concerning ENDS. All intraclass correlations (ICC) were below 1%, suggesting minimal heterogeneity, with the exception of one variable, which had an ICC of 7.9% (i.e. 'How long have you been using an e-cig?'). Because small sample sizes at either level can bias standard errors [14], as well as the low amount of heterogeneity at the level of ENDS store, a one-way between-groups analysis of variance (ANOVA) was conducted to examine self-reported perceptions of harm of ENDS, tobacco products, nicotine replacement therapies and smoking cessation medications. Lastly, a logistic regression, controlling for age and sex, was performed to assess the associations between flavor (traditional tobacco/menthol versus non-traditional), nicotine strength (0–20 mg/ml versus greater than 20 mg/ml), generation of ENDS product (first- versus second-generation), length of use (less than 6 months versus greater than 6 months) and reason for initiating ENDS use (to quit smoking versus any other reason) on customers' biochemically verified smoking status. Participants reporting using both newer- and first-generation ENDS concurrently were categorized as using newer-generation devices in the logistic regression analysis. The convenience sample of 215 participants provided sufficient (>80%) statistical power. The logistic regression of the binary response variable 'biochemical confirmed quit attempt' on the binary independent variable 'ENDS generation' achieves 87% power at a 0.05 significance level to detect an odds ratio of 3.

RESULTS**Participant characteristics**

A total of 215 current ENDS users [mean_{age} = 36.23 years; standard deviation (SD) = 12.97 years; male = 54.3%] completed the survey. See Tables 1 and 2 for complete demographic information and participant smoking and ENDS use history. Participants had been vaping for an average of 7.4 months (SD = 8.18 months; range = 0 days–4.2 years), with 62% using ENDS for 6 months or less.

Table 1 Demographic information ($n = 215$).

| | % or mean (SD) |
|--------------------------------|----------------|
| Age (years) | 36.2 (13.0) |
| Sex (% male) | 52.6% |
| Ethnicity | |
| Caucasian | 84.0% |
| African American | 4.7% |
| American Indian/Alaskan Native | 32.1% |
| Asian | 0.5% |
| Hispanic | 1.4% |
| Other | 2.8% |
| No response | 1.4% |
| Level of education | |
| Less than high school | 6.1% |
| High school graduate/GED | 23.5% |
| Some college | 33.3% |
| Technical/business school | 8.5% |
| College graduate | 22.1% |
| Graduate school | 6.1% |
| Household income | |
| \$0–29 999 | 36.0% |
| \$30 000–59 999 | 37.4% |
| \$60 000–79 999 | 12.8% |
| > \$80 000 | 13.3% |
| Employment status | |
| Full time | 70.1% |
| Unemployed | 6.2% |
| Homemaker | 4.7% |
| Retired | 6.6% |
| Student | 1.4% |

GED = general education development; SD = standard deviation.

Vaping preferences, behaviors and reasons for use

Most participants were using a newer-generation device (e.g. tank system-style, mechanical model, etc.; 77.9%), as opposed to the 'cig-a-like' or 'first-generation' ENDS (11.5%) and 10.6% of individuals indicated using both generations of ENDS. While most vapor store customers initiated with the tank system, a small minority initiated with 'cig-a-like' ENDS (23.3%); however, 91.4% (95% CI = 81.7–100) of these customers eventually switched to newer-generation products. Participants reported various reasons for trying multiple ENDS, including poor quality or satisfaction with their previous system (flavor, battery or price) and increases in information regarding products available (upgrade to larger tanks or models, flavor customization). Participants reported using a median concentration of 18.00 [interquartile range (IQR) = 12] mg/ml of nicotine in their e-liquid. Non-traditional flavors, such as fruity (46.7%; e.g. strawberry, blueberry) and candy/nuts (12.6%; e.g. cotton candy, SweetTart, Hazelnut, Almond) e-liquids, were the most preferred flavors. The TTFC-e indicated moderate dependence, mean = 1.93 (SD = 1.01; 95% CI = 1.79–2.08). Twenty-five per cent of

Table 2 Participant smoking and ENDS use history ($n = 215$).

| | % or mean (SD) | 95% CI |
|---|-------------------|-------------|
| No. of cigarettes smoked/day (before initiating ENDS) | 19.3 (12.5) | 17.6–21.0 |
| Number of 24-hour quit attempts (traditional tobacco) | 6.1 (13.0) | 4.3–7.9 |
| Products used to quit traditional tobacco | | |
| Nicotine gum | 61.1% | 54.6–70.3 |
| Nicotine patch | 59.5% | 50.6–68.4 |
| Nicotine lozenge | 23.7% | 17.0–30.5 |
| Nicotine inhaler | 7.7% | 3.5–11.9 |
| Nicotine nasal spray | 2.6% | 0.06–5.1 |
| Chantix | 32.1% | 24.7–39.5 |
| Wellbutrin/Zyban | 17.9% | 11.9–24.0 |
| ENDS use | | |
| Initiated use to quit smoking | 86.1% | 81.4–90.9 |
| First-generation device | 11.5% | 7.2–15.9 |
| Newer-generation device | 77.9% | 72.2–83.6 |
| First- and newer-generation device | 10.6% | 6.4–14.8 |
| ≤6 months using ENDS | 62% | 55.4–68.7 |
| Number of daily puffs | 170.6 (234.3) | 134.8–206.4 |
| Current ENDS nicotine strength | | |
| 0 mg/ml | 3.6% | 1.0–6.2 |
| 1–20 mg/ml | 68.2% | 61.6–74.8 |
| >20 mg/ml | 28.2% | 21.8–34.6 |
| Current ENDS flavour preference | | |
| Fruity | 46.7% | 39.7–53.7 |
| Tobacco blends | 18.6% | 13.1–24.1 |
| Candy/nuts | 12.6% | 7.9–17.2 |
| Bakery/dessert | 11.1% | 6.7–15.5 |
| Mint/menthol | 9.0% | 5.0–13.1 |
| Coffee | 2% | 0.04–4.0 |

CI = confidence interval; ENDS = electronic nicotine delivery systems; SD = standard deviation.

vapers reported 'dripping' their e-liquid. Further, 90% (95% CI = 86.2–94.4) endorsed vaping in the home and car, 3% (95% CI = 0.60–5.2) only in the car and 2% (95% CI = 0.04–3.8) only in the home. Only 5% (95% CI = 1.9–7.8) kept a vape-free home and car. Interestingly, 89.7% (95% CI = 77.9–100.0) of participants who reported keeping a smoke-free home and car prior to using ENDS reported that they now use an ENDS in the home and/or car. In addition, 13.8% (95% CI = 0.4–27.1) reported that they had begun smoking in their home/car since beginning ENDS. See Table 2 for additional information regarding ENDS use.

Reasons for electronic cigarette use

Eighty-six per cent ($n = 180$) of participants reported initiating ENDS use as a means to quit smoking. Others reported recreational use (5.7%, 95% CI = 2.6–9.1), to use in

places where smoking was not allowed (5.7%, 95% CI = 2.6–9.1) and other (2.4%, 95% CI = 0.3–4.5; e.g. 'all of the above', 'work') as reasons for initiation.

Perceived harm and reported health effects

A one-way between-groups analysis of variance indicated that participants perceived ENDS as significantly less harmful than all other tobacco products, all nicotine replacement products and all smoking cessation medications, ($F_{(7, 1448)} = 197.23, P < 0.001$; see Fig. 1). A majority of participants reported improved overall health (84.6%, 95% CI = 79.6–89.8) including: decreased smokers' cough (78.9%, 95% CI = 73.1–84.8), increased ability to exercise (58.1%, 95% CI = 51.1–65.2); increased sense of smell (79.5%, 95% CI = 73.7–85.3); and increased sense of taste (77.9%, 95% CI = 71.9–83.9).

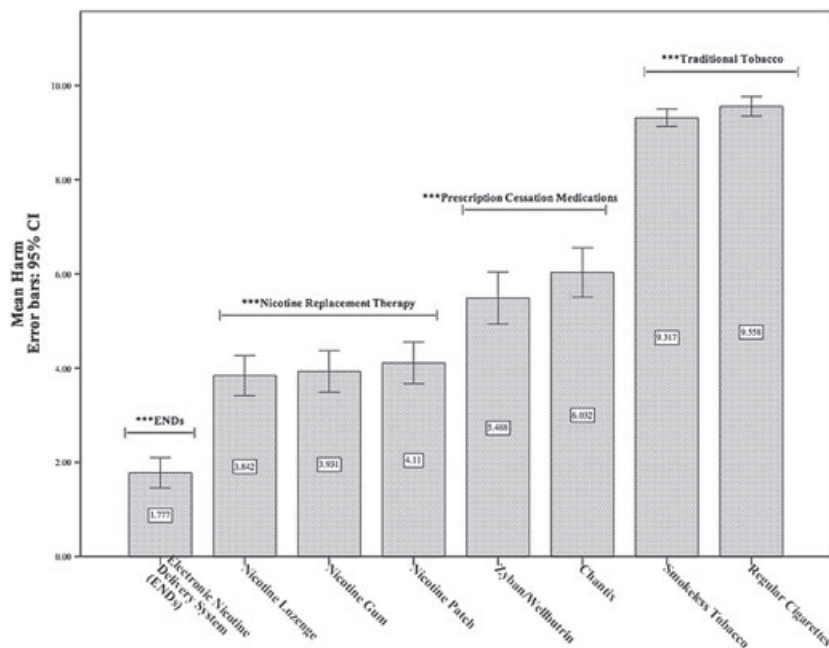
Smoking status

The majority of participants reported previous combustible tobacco use via number of cigarettes smoked per day ($n = 208$), two individuals were smokeless tobacco users and five individuals refused to report on current and past number of smoked cigarettes per day. Due to equipment malfunction, only a subsample ($n = 185$; 86%) were asked to complete exhaled CO measurement ($n = 4$ refused). Of the 181 participants who completed CO measurement, 68% ($n = 123$) self-reported smoking cessation and exhaled CO readings confirmed that 66% ($n = 117$) were smoking abstinent (mean_{CO} = 4.3, SD = 2.2). Among those who continued to smoke, mean cigarettes per day decreased from 22.1 to 7.5 ($P < 0.001$) since using ENDS and mean CO levels were 12.5 p.p.m. (SD = 7.7).

A logistic regression indicated that those reporting vaping longer (OR = 4.9, 95% CI = 2.11–11.16, $P < 0.001$), using newer-generation devices (OR = 3.1, 95% CI = 1.10–8.70, $P = 0.032$) and non-tobacco and non-menthol flavors (OR = 2.4, 95% CI = 1.07–5.53, $P = 0.035$) were more likely to have quit smoking. Smoking status was not associated with strength of nicotine liquid (OR = 0.70, 95% CI = 0.31–1.53, $P = 0.367$) or reason for initiating ENDS use (OR = 0.81, 95% CI = 0.25–2.64, $P = 0.73$). See Table 3 for additional information for the logistic regression predicting likelihood of biochemically verified quit status.

DISCUSSION

The present study is the first to examine vaping behaviors and beliefs among the fastest-growing sector of the ENDS market—vapor store customers. The current study improves upon previous online studies by biochemically confirming self-reported smoking abstinence using exhaled CO. Survey respondents, on average, had used ENDS for



Note: *** All groups were significantly different from each other at $P < .0001$.

Figure 1 Perceived harmfulness of various nicotine-containing products and smoking cessation medications

Table 3 Logistic regression predicting likelihood of biochemically verified quit status.

| | B | SE | Wald | d.f. | Sig. | Exp (B) | 95% CI for EXP(B) | |
|-------------------------------|--------|-------|--------|------|--------------|--------------|-------------------|--------|
| | | | | | | | Lower | Upper |
| Age | 0.000 | 0.016 | 0.001 | 1 | 0.978 | 1.000 | 0.969 | 1.033 |
| Sex | -0.184 | 0.391 | 0.222 | 1 | 0.638 | 0.832 | 0.386 | 1.790 |
| Cigarettes per day (pre-ENDS) | 0.015 | 0.018 | 0.743 | 1 | 0.389 | 1.015 | 0.981 | 1.051 |
| Reason for initiating ENDS | -0.205 | 0.600 | 0.117 | 1 | 0.732 | 0.814 | 0.251 | 2.641 |
| Length of use | 1.539 | 0.431 | 12.737 | 1 | 0.000 | 4.659 | 2.001 | 10.846 |
| END generation used | 1.082 | 0.534 | 4.113 | 1 | 0.043 | 2.950 | 1.037 | 8.395 |
| Nicotine strength | -0.305 | 0.417 | 0.536 | 1 | 0.464 | 0.737 | 0.326 | 1.668 |
| Flavour type | 0.965 | 0.429 | 5.067 | 1 | 0.024 | 2.626 | 1.133 | 6.085 |
| Constant | -1.376 | 1.025 | 1.803 | 1 | 0.179 | 0.253 | | |

Reason for initiating electronic nicotine delivery systems (ENDS): to quit smoking versus any other reason; END generation: first versus newer generation; flavour type: traditional (menthol or tobacco) versus non-traditional (fruity, coffee, candy, etc.); nicotine strength: ≤ 20 mg/ml versus > 20 mg/ml; length of use: ≤ 6 months versus > 6 months. CI = confidence interval; SE = standard deviation. Bolded numbers are statistically significant at the $P \leq .005$ or $P \leq .001$ level.

approximately 7 months. Most reported starting ENDS as a means of smoking cessation (79%), were using newer-generation devices (89%), vaping non-traditional flavors (72%) and using e-liquid with nicotine strengths of ≤ 20 mg/ml (72%). This vaping profile is generally consistent with previous online survey research, which found that most vapers had been vaping for less than a year [7,8,15], primarily used a tank system [7,15], preferred non-traditional flavors [15] and generally used e-liquid that contained nicotine and had concentrations equal to or below 20 mg/ml [7,15]. Of those who completed biochemical verification, 66% were successful in quitting smoking. Those who reported vaping longer, using newer-

generation devices and non-tobacco and non-menthol flavors were more likely to have quit smoking. Smoking status was not associated with reasons for initiating ENDS use (for quitting versus other reasons) or with strength of nicotine liquid; 69% of participants using e-liquid with nicotine amounts of ≤ 20 mg/ml, and 63% of participants who reported using e-liquid with nicotine amounts of > 20 mg/ml, were biochemically confirmed as quit. Additionally, the overall average decline in combustible tobacco use among those who had not quit was almost 15 cigarettes per day. This finding is consistent with research showing significant smoking reduction with ENDS use [16–18]. Consistent with other ENDS research [7],

the majority of ENDS users reported improved health. Interestingly, participants believed that ENDS were less harmful than all other tobacco products, nicotine replacement therapy (NRT) and smoking cessation medications. This finding was surprising but, at the same time, many ENDS users may receive inaccurate information about the relative safety of ENDS products from advertisements and websites [17].

The present study has implications for tobacco control policy. Concerns over nicotine poisoning to both children and adults and initiation of youth to combustible cigarette addiction ('gateway' effect) has led to public health officials in the United States and the European Union to consider several important regulations for ENDS. These include banning flavored e-liquids [19] and e-liquids with nicotine content exceeding 20 mg/ml [20,21]. Moreover, some contend that the current US Food and Drug Administration (FDA) regulations on ENDS would essentially ban all newer-generation devices, as ENDS models brought to market after 2007 (i.e. most newer-generation models) will be subject to burdensome regulations as 'new tobacco products' under section 910(a)[1] of the Family Smoking Prevention and Tobacco Control Act [22]. The current study suggests that by banning flavors and newer-generation devices, these regulators may be doing more harm than good. Quitting was three times more likely among vapers using newer-generation devices and two-and-a-half times more likely among those using fruity, candy or bakery flavors. Nicotine strength was not associated with smoking status, as both groups achieved similar levels of cessation, but approximately two-thirds of those using nicotine-containing e-liquid greater than 20mg/ml were smoking abstinent. In light of recent research not supporting the gateway effect of ENDS [23] or the potentially high risk of death associated with nicotine poisonings [24], regulators should carefully examine the potential cost-benefit of banning flavors, newer-generation devices and higher nicotine strengths. The current available science would not support a decision to do so.

A potentially concerning finding is that ENDS users reported vaping in places that they previously kept smoke-free (e.g. their home and/or car). The research examining the potential risk/harm of second-hand vapor continues to grow, with current studies suggesting that second-hand vapor has much lower levels of toxic and carcinogenic constituents than combustible cigarettes, but it is not toxicant/carcinogen-free [16,18]. Alternatively, a recent review of the ENDS literature concluded that studies evaluating second-hand vapor suggest that it is likely to pose a much lower risk, if any risk at all, to bystanders [25]. However, previous second-hand vapor studies have only investigated first-generation devices, and under certain conditions newer variable voltage devices can produce high levels of harmful constituents [26–28]. As such, the effects of second-hand vapor needs continued monitoring,

especially among vulnerable populations such as children living with care-givers who vape inside the home.

Most vapor store customers initiated with the tank system, but a small minority initiated with 'cig-a-like' or 'first-generation' ENDS; however, few were still using this style of ENDS. Various reasons for trying multiple ENDS were reported, including flavor and device customization to product satisfaction. Not surprisingly, most customers had not tried dripping (75%), as most were relatively new users and dripping is an advanced ENDS technique. There has been some concern that vapers move on to tank-style systems and dripping because of the availability of higher nicotine content e-liquids and greater nicotine absorption with more sophisticated models and techniques [4]; consequently, ENDS users may become more addicted to nicotine, especially if they continue to use combustible cigarettes. However, research suggests that with increased duration, ENDS users often decrease their nicotine levels in their e-liquid as well as decrease their combustible cigarette use suggesting that, for some, addiction severity may decrease over time with ENDS use [29,30]. Alternatively, the decrease in e-liquid nicotine strength may be due to naive ENDS users learning how to extract nicotine more efficiently from their device [31,32]. Continued surveillance of dual versus exclusive ENDS use as well as changes in users' nicotine dependence will be necessary as ENDS products continue to evolve.

Despite these important and interesting findings, this study has several notable limitations. First, the sample included a convenience sample of vape store customers recruited during high-frequency times (e.g. lunchtime). It is possible that this sample may over-represent tank-style users; these individuals may have different vaping behaviors and beliefs (e.g. nicotine addiction level, perceived relative risk of these products, quitting history) than those who use primarily cig-a-like ENDS. Secondly, although data were collected recently, ENDS technology continues to develop rapidly. For example, we did not assess among our users which of them were using entry-level tank systems versus mechanical rebuildable systems—a relatively recent ENDS trend. Finally, although customers reported improvements in health and combustible cigarette cessation was verified biochemically, we did not conduct physiological tests to confirm improved lung function or general health. Future research may improve on this by prospectively conducting pulmonary function tests, blood pressure and other biological markers of effect among ENDS users.

This study provides detailed information on the use behaviors and beliefs of vapor store customers. Unlike many previous studies, it differentially assessed 'cig-a-like'/'first-generation' ENDS and tank-style ENDS use, rather than assessing both as simply ENDS, and biochemically verified combustible cigarette use and cessation. While many of our results have produced new questions, it appears as

though many vapor store customers have used ENDS successfully as a quit method for combustible cigarettes and view vaping as a safer alternative to smoking than even NRT or smoking cessation medications. Moving forward, controlled, longitudinal research should examine whether smoking cessation is maintained over the long term and what percentage of ENDS users dual use indefinitely.

Declaration of interest

None.

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