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Adverse symptoms users attribute to e-cigarettes: Results from a national survey of US adults*

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Abstract

Background—Little is known about the prevalence of adverse symptoms electronic cigarette (e-cigarette) users report experiencing.

Methods—Between August 2016 and May 2017, we conducted a nationally representative cross-sectional telephone survey of 4,964 US adults age 18 and over. Respondents who reported ever trying e-cigarettes were asked whether they ever experienced six symptoms they thought were caused by e-cigarette use. In weighted analyses, we assessed whether symptoms varied by demographics, e-cigarette use frequency, and cigarette smoking status.

Results—Approximately one-fourth of respondents (n=1,624, 26.8%) reported ever trying e-cigarettes. Most were current (40.3%) or former (30.7%) cigarette smokers, with 29.0% never smokers. Just over half (58.2%) reported at least one symptom and on average 1.6 (SE=0.1) symptoms. Symptoms included cough (40.0%), dry or irritated mouth or throat (31.0%), dizziness or lightheadedness (27.1%), headache or migraine (21.9%), shortness of breath (18.1%), change in or loss of taste (12.9%), or other (6.2%; most commonly nausea, tight chest, congestion). Among past 30-day e-cigarette users, current and never cigarette smokers were more likely than former

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Contributors

JLK directed the study analyses and wrote the first draft of the manuscript. BAR conducted statistical analyses. KDW oversaw item development and preliminary testing. KMR, ABS, and ELS originated study idea. All authors provided critical feedback and approved final submission.

Conflict of Interest

No Conflict declared.

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smokers to report any symptoms (AOR=5.25, CI=2.05–13.46 and AOR=2.58, CI=0.85–7.81, respectively).

Conclusions—A majority of e-cigarette users reported at least one symptom, most commonly cough or dry or irritated mouth or throat. Former cigarette smokers who used e-cigarettes in the past 30 days were less likely than current or never smokers to report adverse symptoms of e-cigarette use. Future research should examine frequency of symptoms among different user groups to understand how e-cigarettes may influence public health.

Keywords

Electronic Cigarette; Health Symptoms

1. Introduction

Electronic cigarettes (e-cigarettes) were introduced into the US in the mid-2000s and now are among the most prevalent and frequently used tobacco products (Wang, 2018). Primary reasons adults use e-cigarettes are to quit smoking combustible cigarettes and to use in situations when cigarette smoking is not acceptable (Caraballo et al., 2017; Patel et al., 2016; Pepper et al., 2014). Consistent with this, e-cigarettes and cigarettes are the most commonly reported tobacco product use combination (Wang, 2018).

According to the National Academies of Sciences, Engineering, and Medicine (NASEM) Report, e-cigarettes have the potential to expose users to less health risk compared to cigarettes (NASEM, 2018). However, e-cigarettes are not risk-free; e-cigarettes heat a liquid, typically containing nicotine and flavoring, to create an aerosol of ultrafine particles that are inhaled into the lungs. The NASEM report concluded, “most e-cigarette products contain and emit numerous potentially toxic substances” (NASEM, 2018). These substances are associated with adverse health effects, including pulmonary disease and myocardial infarction (Alzahrani et al., 2018; Benowitz and Fraiman, 2017; Callahan-Lyon, 2014; Glasser et al., 2017; Hajek Peter et al., 2014; Perez et al., 2018). These adverse health effects may be reflected in symptoms self-reported by e-cigarette users. A 2014 systematic review of 20 studies on adverse effects of e-cigarettes found symptoms were ‘inconsistent and contradicting’ and stated that although no conclusions could be drawn on safety, e-cigarettes could hardly be considered harmless (Pisinger and Døssing, 2014). Most studies examined in that review, and those published since, used small samples (e.g., laboratory studies) or convenience samples (Baweja et al., 2016; Etter, 2016; Goniewicz et al., 2017; Volesky et al., 2016; Wang et al., 2018). Given the limitations of previous studies, additional research is needed to further understand the prevalence of symptoms e-cigarette users might experience.

The purpose of this study was to examine the prevalence of self-reported adverse symptoms attributed to e-cigarette use in a nationally representative sample of US adults. We also examined whether symptoms varied by demographic variables, e-cigarette use frequency, and cigarette smoking status.

2. Methods

2.1. Study Sample

From August 2016 through May 2017, we conducted a nationally representative cross-sectional telephone survey of 4,964 US adults; the weighted response rate was 38.7% (Agans et al., 2018; Boynton et al., 2016). The Carolina Survey Research Laboratory (CSRL) at the University of North Carolina (UNC) recruited a probability sample of adults living in the US using two independent and non-overlapping random-digit-dial landline and cell phone frames. Coverage extended to 98% of all US households. The CSRL oversampled counties with higher rates of smoking and poverty to obtain more smokers, oversampled cell phone numbers to obtain more young adults, and undersampled adults ages 65+ because they are overrepresented in landline frames. The CSRL recruited additional smokers and lesbian/gay/bisexual/transgender (LGBT) individuals through respondent-driven sampling procedures in order to increase sample sizes of those groups. The final sample had higher rates of smokers, individuals living in poverty, LGBT, and young adults than the US population. Additional details on sampling design, sampling weights (estimated from the American Community Survey) and adjustments, and sample characteristics are published elsewhere (Agans et al., 2018; Boynton et al., 2016).

2.2. Procedures

Eligible participants were 18 years or older and spoke English or Spanish. The interview lasted approximately 26 minutes, and participants were compensated \$40. The UNC Institutional Review Board approved this study.

2.3. Measures

All participants were read this statement: “The next few questions are about electronic or e-cigarettes and other vaping devices, such as vape pens. Popular brands include Blu, Vuse, NJOY, and Flavor Vapes.” Then, we asked participants whether they ever used an e-cigarette or other vaping devices, even one or two times. We asked participants who reported ever using e-cigarettes on how many of the past 30 days they used e-cigarettes.

We asked participants who ever used an e-cigarette “Have you ever experienced any of the following symptoms or side effects you think were caused by using e-cigarettes or other vaping devices” prior to listing six specific symptoms and an open-ended “other” option. Participants responded yes or no following each symptom. We identified the six symptoms through a two-stage process. In May 2016, we identified 14 symptoms experienced by e-cigarette users through literature review of observed and self-reported symptoms. In June 2016, we surveyed 392 e-cigarette users via Amazon’s Mechanical Turk to identify the most frequent symptoms of e-cigarette use (Supplement 1)¹. The most common symptoms were dry mouth or throat (43.4%), cough (42.3%), throat or mouth irritation (36.0%), dizziness or lightheadedness (33.5%), headache or migraine (21.0%), shortness of breath (15.1%), and changes in or loss of taste (14.0%). Overlap between throat or mouth irritation and dry mouth or throat led to combining those two categories.

¹Supplementary material can be found by accessing the online version of this paper at <http://dx.doi.org> and by entering doi:...

For cigarette status, we asked participants: “Have you smoked at least 100 cigarettes in your entire life” and “Do you now smoke cigarettes every day, some days, or not at all.” Participants were considered *current cigarette smokers* if they smoked at least 100 cigarettes and now smoked every day or some days, *former cigarette smokers* if they smoked at least 100 cigarettes and now smoked ‘not at all’, and *never cigarette smokers* if they had not smoked at least 100 cigarettes.

2.4. Analyses

Descriptive statistics were calculated to describe the sample’s demographic characteristics, e-cigarette use, and cigarette smoking status. Weighted percentages were estimated using PROC SURVEYFREQ and weighted means using PROC SURVEYMEANS in SAS V9.4 to account for sampling design features. Differences in the prevalence of symptoms attributed to e-cigarette use among current e-cigarette users were compared by demographic characteristics, including age, race, gender, ethnicity, income, e-cigarette use status, cigarette use status, combustible use status, and e-cigarette use frequency in a multivariable logistic regression model using PROC SURVEYLOGISTIC in SAS V9.4. We compared the number of symptoms reported using PROC SURVEYREG. We conducted similar analyses for the sample of ever e-cigarette users.

3. Results

Of 4,964 adults surveyed, 26.8% reported ever using e-cigarettes. Thus, our analytic sample consisted of 1,624 ever e-cigarette users. Participants were 43.9% female, 67.3% white, with mean age 37.9. Approximately one-fourth reported past 30-day e-cigarette use (28.1%). Table 1 reports additional sample characteristics.

Over half (58.2%) of participants attributed one or more symptoms to their e-cigarette use (range 0–6 symptoms). On average, users reported 1.6 (SE=0.1) symptoms, most frequently cough (40.0%), dry or irritated mouth or throat (31.0%), dizziness or lightheadedness (27.1%), headache or migraine (21.9%), shortness of breath (18.1%), and change in or loss of taste (12.9%). Few (6.2%) reported other symptoms, including nausea (1.6%), chest pain (0.8%), and congestion (0.8%).

We found few demographic differences in symptoms reported within the multivariable model among ever e-cigarette users (Supplement 2)². Adults ages 25–44 and 45+ were less likely to report any symptom compared to younger adults (AOR=0.52, CI=0.29–0.92 and AOR=0.28, CI=0.15–0.52, respectively). Females, 25–44-year olds, 45+ year olds, and never smokers were more likely to report shortness of breath than their respective counterparts (Supplement 2)².

Among past 30-day e-cigarette users, current and never cigarette smokers were more likely than former smokers to report any symptoms (AOR=5.25, CI=2.05–13.5 and AOR=2.58, CI=0.85–7.81, respectively). Current smokers also reported more symptoms than former smokers (β =1.09, CI=0.55, 1.63). Adults ages 25–44 and 45+ were more likely than younger

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adults (18–24) to report any symptoms (AOR=0.22, 0.08–0.60 and AOR=0.12, 0.04–0.39, respectively). Whites were less likely than nonwhites to report any symptoms (AOR=0.43, 0.19–0.96). We also identified some differences among individual symptoms, notably related to age, cigarette smoking status, and income (Table 2).

4. Discussion

In our large, national sample of U.S. adults, more than half of ever e-cigarette users reported at least one adverse symptom related to their e-cigarette use. The most common symptoms were cough and dry or irritated mouth or throat, which is consistent with findings from other studies of self-reported or observed symptoms related to e-cigarette use (Pisinger and Døssing, 2014). With few exceptions, self-reported symptoms were generally consistent across demographic groups of ever e-cigarette users.

Among past 30-day e-cigarette users, former cigarette smokers were less likely than never or current cigarette smokers to self-report adverse symptoms of their e-cigarette use. There are several reasons *former* cigarette smokers may report fewer symptoms of e-cigarette use than *current* cigarette smokers. First, former cigarette smokers may experience fewer symptoms when using e-cigarettes compared to current cigarette smokers because they may be accustomed to higher levels of symptoms, and therefore, not consider present symptoms to be severe enough to warrant mentioning (e.g., the cough I had while smoking cigarettes is far worse than the cough I have from an e-cigarette). Additionally, former cigarette smokers may interpret their e-cigarette symptoms as a carry-over effect from their former cigarette use, and thus choose to not report. Alternatively, *current* cigarette smokers may attribute symptoms caused by their cigarette smoking to e-cigarette use, which may also explain why former smokers reported fewer symptoms. Regardless of the mechanism, it is noteworthy that former cigarette smokers self-reported fewer symptoms related to e-cigarette use, as this may explain, in part, the attractiveness of e-cigarettes to this group.

Twenty-nine percent of our sample of ever e-cigarette users were never cigarette users. In past 30-day models, never cigarette users reported higher rates of cough and dizziness or lightheadedness than former smokers. Higher reporting of symptoms among *never* cigarette smokers compared to former cigarette smokers may be due to negative effects when individuals are first introduced to nicotine. For instance, those experimenting with cigarettes for the first time often report symptoms of dizziness and nausea, which are likely due to nicotine effects (DiFranza et al., 2004; Pomerleau et al., 1999). Similar symptoms would be expected among nicotine-naïve e-cigarette users. However, overall, never cigarette smokers reported experiencing similar symptoms as former cigarettes smokers. While we would expect nicotine naïve individuals to report more adverse symptoms (i.e., due to nicotine effects), these incipient experiences may also deter use. Future research is needed to monitor never smokers' use of e-cigarettes to understand predictors of initiation and progression to regular e-cigarette use and to other tobacco product use.

We found few differences in symptoms reported across demographic groups. Most consistently, we found that younger adults were more likely than older adults to report symptoms. In past 30-day models, we also found nonwhites were more likely than whites to

report symptoms, and we found differences in individual symptoms across income categories. Demographic groups may vary on flavor, brand, or device preferences, which might influence symptoms. We did not observe differences in frequency of use by demographic groups (data not presented). However, future research should examine flavors and brands used by different demographic groups in examining symptoms reported.

There are several limitations to our study. First, we did not assess an exhaustive list of symptoms; although the symptoms we included were the most commonly reported symptoms in a prior convenience sample, one or more of the original 14 symptoms we measured could be more prevalent in a national sample. Second, symptoms were self-reported. While perceptions are important for understanding use, clinical verification might be needed to verify symptoms and identify the severity of symptoms. Additionally, e-cigarette products vary widely, and different product characteristics may be associated with different types and frequencies of symptoms. Our study used a crude measure of device type, which may not have been adequate to detect differences across devices. Finally, our sample had a higher proportion of ever e-cigarette use rates among adults than other national surveys.

5. Conclusions

As the first national sample of US adults in which symptoms of e-cigarette use were examined, this study highlights the prevalence of symptoms users self-report from e-cigarette use. A large proportion of e-cigarette users attribute at least one symptom to their e-cigarette use. Although symptoms examined in this study are widespread among most users, symptoms do not appear to be deterring individuals from use, as over 50% of those who reported symptoms were past 30-day e-cigarette users.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- This is the first national sample of adults that examines e-cigarette use symptoms
- Most ever-e-cigarette users attribute at least one symptom to their e-cigarette use
- Symptoms are generally consistent across demographic and e-cigarette user groups

Table 1.

Sample Characteristics, unweighted n (weighted %)

	Ever e-cigarette users n=1624*	Past 30-day users, n=456*
Age		
18–24	383 (25.5)	125 (37.2)
25–44	712 (48.2)	195 (41.4)
45+	529 (26.3)	136 (21.5)
Sex		
Male	802 (56.1)	246 (63.1)
Female	820 (43.9)	210 (36.9)
Race		
Nonwhite	477 (32.7)	142 (34.9)
White	1140 (67.3)	313 (65.1)
Ethnicity		
Non-Latino	1477 (82.4)	412 (90.2)
Latino	140 (17.6)	41 (9.8)
Annual Income		
< \$25,000	558 (30.4)	172 (32.9)
\$25,000 – \$49,999	439 (30.7)	122 (27.8)
\$50,000 – \$74,999	265 (19.1)	68 (18.6)
\$75,000 – \$100,000	149 (9.3)	38 (12.2)
Above \$100,000	144 (10.5)	38 (8.5)
Cigarette Use Status		
Former Smoker	369 (30.7)	97 (28.0)
Current Smoker	912 (40.3)	274 (45.5)
Never Smoker	343 (29.0)	85 (26.5)
Combustible User		
No	1280 (77.4)	318 (69.3)
Yes	343 (22.5)	138 (30.7)
E-cigarette Use Status		
Former User	1167 (71.9)	NA
Current <5 days	201 (11.2)	201 (39.7)
Current 5+ days	255 (16.9)	255 (60.3)

* Sample sizes vary due to missing data on covariates

Table 2.

Symptoms Reported among Past 30-Day E-Cigarette Users, n=459

	Any Symptom AOR (95% CI)	# of Symptoms Beta (95% CI)	Cough AOR (95% CI)	Dry Mouth or Throat AOR (95% CI)	Dizziness or lightheaded ness AOR (95% CI)	Headache or Migraine AOR (95% CI)	Shortness of breath AOR (95% CI)	Change in or loss of taste AOR (95% CI)
Age								
18-24	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
25-44	0.22 (0.08-0.60)	-0.59 (-1.21, 0.02)	0.59 (0.21-1.64)	0.38 (0.13-1.16)	0.85 (0.29-2.51)	0.60 (0.16-2.25)	0.29 (0.10-0.84)	1.46 (0.48-4.37)
45+	0.12 (0.04-0.39)	-0.68 (-1.43, 0.07)	0.32 (0.09-1.16)	0.23 (0.07-0.77)	0.82 (0.24-2.75)	0.45 (0.12-1.72)	0.72 (0.21-2.46)	2.97 (0.94-9.44)
Sex								
Female	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Male	1.82 (0.90-3.68)	0.07 (-0.45, 0.58)	1.00 (0.49-2.04)	1.19 (0.53-2.66)	1.32 (0.54-3.20)	0.64 (0.25-1.66)	0.68 (0.28-1.65)	2.23 (0.76-6.55)
Race								
Nonwhite	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
White	0.43 (0.19-0.96)	-0.56 (-1.16, 0.04)	1.12 (0.50-2.50)	0.56 (0.24-1.29)	0.71 (0.30-1.68)	0.76 (0.27-2.12)	0.32 (0.13-0.80)	0.41 (0.14-1.15)
Ethnicity								
Non-Latino	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Latino	0.71 (0.20-2.48)	0.26 (-0.54, 1.06)	0.71 (0.21-2.34)	1.09 (0.33-3.66)	2.60 (0.93-7.28)	3.20 (0.98-10.4)	1.62 (0.43-6.10)	0.48 (0.05-4.37)
Annual Income								
< \$25,000	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
\$25,000 - \$49,999	0.61 (0.24-1.57)	-0.76 (-1.36, -0.15)	0.65 (0.24-1.74)	0.57 (0.23-1.39)	0.28 (0.10-0.81)	0.49 (0.15-1.58)	0.33 (0.09-1.17)	1.31 (0.40-4.25)
\$50,000 - \$74,999	0.48 (0.16-1.47)	-0.61 (-1.23, 0.01)	0.30 (0.09-0.98)	0.40 (0.11-1.48)	0.09 (0.03-0.33)	1.62 (0.52-4.98)	1.18 (0.32-4.33)	0.98 (0.18-5.22)
\$75,000 - \$100,000	0.68 (0.21-2.19)	-0.22 (-1.21, 0.77)	1.14 (0.25-5.32)	0.30 (0.06-1.54)	0.95 (0.22-3.98)	2.13 (0.57-7.96)	0.41 (0.07-2.50)	0.55 (0.05-5.98)
Above \$100,000	1.96 (0.32-11.9)	0.88 (-0.58, 2.35)	2.04 (0.48-8.64)	1.56 (0.38-6.34)	1.31 (0.33-5.17)	4.51 (1.04-19.6)	3.04 (0.70-13.2)	0.04 (0.004-0.27)
Cigarette Use Status								
Former Smoker	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Current Smoker	5.25 (2.05-13.5)	1.09 (0.55, 1.63)	10.1 (2.70-37.1)	1.24 (0.50-3.05)	3.12 (0.88-11.0)	3.20 (0.94-10.9)	3.63 (0.90-14.7)	23.4 (4.32-126.3)
Never Smoker	2.58 (0.85-7.81)	0.52 (-0.12, 1.15)	6.1 (1.30-29.8)	0.48 (0.14-1.60)	5.94 (1.38-25.6)	1.34 (0.29-6.19)	2.67 (0.54-13.2)	6.81 (0.68-67.8)
Combustible User								

	Any Symptom AOR (95% CI)	# of Symptoms Beta (95% CI)	Cough AOR (95% CI)	Dry Mouth or Throat AOR (95% CI)	Dizziness or lightheaded ness AOR (95% CI)	Headache or Migraine AOR (95% CI)	Shortness of breath AOR (95% CI)	Change in or loss of taste AOR (95% CI)
No	Ref 0.70 (0.30–1.60)	Ref -0.42 (-0.92, 0.08)	Ref 0.89 (0.37–2.13)	Ref 0.53 (0.22–1.30)	Ref 0.70 (0.28–1.76)	Ref 0.31 (0.10–0.96)	Ref 0.54 (0.20–1.45)	Ref 1.12 (0.35–3.55)
E-cig Use Status								
Current <5 days	Ref 2.17 (0.96–4.93)	Ref 0.21 (-0.33, 0.76)	Ref 1.10 (0.51–2.36)	Ref 1.80 (0.81–3.99)	Ref 1.23 (0.53–2.86)	Ref 1.40 (0.56–3.54)	Ref 1.91 (0.77–4.78)	Ref 0.52 (0.17–1.59)
Current 5+ days								

Note: Bold indicates significant at $p < 0.05$; AOR=Adjusted odds ratio