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A Longitudinal Study of Electronic Cigarette Use Among a Population-Based Sample of Adult Smokers: Association With Smoking Cessation and Motivation to Quit

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Abstract

Aims: Increasingly popular electronic cigarettes (e-cigarettes) may be the most promising development yet to end cigarette smoking. However, there is sparse evidence that their use promotes cessation. We investigated whether e-cigarette use increases smoking cessation and/or has a deleterious effect on quitting smoking and motivation to quit.

Methods: Representative samples of adults in 2 US metropolitan areas were surveyed in 2011/2012 about their use of novel tobacco products. In 2014, follow-up interviews were conducted with 695 of the 1,374 baseline cigarette smokers who had agreed to be re-contacted (retention rate: 51%). The follow-up interview assessed their smoking status and history of electronic cigarette usage. Respondents were categorized as intensive users (used e-cigarettes daily for at least 1 month), intermittent users (used regularly, but not daily for more than 1 month), and non-users/triers (used e-cigarettes at most once or twice).

Results: At follow-up, 23% were intensive users, 29% intermittent users, 18% had used once or twice, and 30% had not tried e-cigarettes. Logistic regression controlling for demographics and tobacco dependence indicated that intensive users of e-cigarettes were 6 times more likely than non-users/triers to report that they quit smoking (OR: 6.07, 95% CI = 1.11, 33.2). No such relationship was seen for intermittent users. There was a negative association between intermittent e-cigarette use and 1 of 2 indicators of motivation to quit at follow-up.

Conclusions: Daily use of electronic cigarettes for at least 1 month is strongly associated with quitting smoking at follow-up. Further investigation of the underlying reasons for intensive versus intermittent use will help shed light on the mechanisms underlying the associations between e-cigarette use, motivation to quit, and smoking cessation.

Introduction

The electronic cigarette (e-cigarette) phenomenon has captured the attention of the popular press, tobacco control researchers, advocates, and policy makers alike. As with most products seen as potential harm reduction devices, e-cigarettes have sparked controversy: on the one hand, they are being promoted by some as effective tools for promoting smoking cessation and on the other hand they raise concerns about potentially increasing uptake among youth or renormalizing smoking.[1,2] Although they appeared on the US market in 2006

around the same time as low nitrosamine smokeless tobacco (snus), it was becoming clear by 2013 that in spite of heavy marketing by major tobacco companies, smokers were not very receptive to snus or smokeless tobacco, but that e-cigarettes were gaining more and more users.[3,4] The trend toward increasing uptake by smokers has continued[5–9] and the reported motivation for uptake of e-cigarettes has frequently been their potential use as a quit smoking device,[10] but as yet there has been little definitive research indicating whether or not e-cigarette use does, indeed, increase the likelihood that smokers will quit.[7,11,12] Some tobacco control professionals fear that they will actually reduce smokers' motivation to quit smoking, allowing them to maintain their nicotine dependence by using them only in places where they could not use traditional cigarettes. This use of e-cigarettes as a supplement rather than a substitute for smoking, it is believed, will result in extended periods of exposure to combustible tobacco that may increase morbidity and mortality.[7] The aims of the current research, using a longitudinal survey of a population-based sample of smokers in two US metropolitan areas, are to answer the following questions: (a) does use of e-cigarettes increase the likelihood of smoking cessation? (b) does e-cigarette use reduce motivation to quit smoking? (c) what reasons are given for starting to use e-cigarettes and, among former e-cigarette users who continued to smoke, what reasons are given for stopping e-cigarette use? If we find that e-cigarette use is associated with smoking cessation, it will be important to understand why they fail to be adopted by some smokers.

Existing Research on the Association Between E-Cigarette Use and Quitting Smoking

Recent reviews that discuss existing research on the association between e-cigarette use and cessation[7,11,12] seem to agree that the current published studies, although suggesting that the e-cigarette may be as effective as the nicotine patch, do not provide good evidence that in the population at large, e-cigarette use significantly increases the likelihood of smoking cessation in comparison to non-use. The most recent published study to date, has given more support to the expectation that e-cigarettes may be an important pathway to smoking cessation. In a large cross-sectional sample of English smokers who had made a quit attempt in the prior year, the authors compared the likelihood of being abstinent from smoking among those who had used e-cigarettes to those using over-the-counter nicotine products, and those using no aid at all. They found that the e-cigarette users were significantly more likely to be abstinent at the time of the survey than both those who had used nicotine replacement products and those who used no aid.[13]

To date, two randomized trials have been published.[14,15] Caponnetto et al.[14] conducted a trial using two levels of nicotine cartridges (5.4 mg and 7.2 mg) compared to placebo (0.0 mg), finding no differences among study groups in terms of reduction or quitting rates. Their sample in Italy included regular smokers not intending to quit who were recruited via community newspapers. Bullen et al.[15] conducted a controlled trial in New Zealand among 657 regular smokers recruited via community newspapers or television in physicians' offices, and compared e-cigarettes with 16 mg cartridges and 21 mg nicotine patches to placebo e-cigarettes finding that the e-cigarette group was more likely to have reduced tobacco cigarette consumption than those in the patches group. However, they observed a small difference in quit rates that was not statistically significant. These randomized trials lack population-based data and have limited external validity.

Three longitudinal surveys obtaining self-reports of e-cigarette use and smoking behaviors have recently been reported. In a longitudinal study using an internet panel with one-year follow-up,

e-cigarette use was not followed by greater quit rates or reduction in cigarette consumption.[16] A larger, multinational study that asked about trying e-cigarettes or currently using them found that e-cigarette users were not more likely to quit smoking than non-users.[17] A study based on recruiting from smoking cessation websites and other internet sites, found that almost one half of dual users of cigarettes and e-cigarettes had stopped smoking after one year.[18] However, since the study recruited specifically among e-cigarette users or "vapers," participants were self-selected. Since none of these were randomized trials, the possibility of selection bias cannot be ruled out, and causality cannot be established.

In addition to the problem of establishing causality, another of the problems with investigating the impact of e-cigarettes on smoking cessation in general population surveys, is the difficulty of specifying the extent of use. With tobacco cigarettes, there is agreement that lifetime use of 100 cigarettes is the standard for "ever use" among adults.[19] In 1991, the US National Health Interview Survey set the standard for "ever use" of smokeless tobacco as having used 20 times in one's life. For e-cigarettes, the most frequent definition is having tried the product, even once. Simple trial may be highly affected by curiosity about the new product which seems to be featured daily in the print and broadcast news and online. A recent study has attempted to correct this problem by defining "established use" as having used an e-cigarette 50 times.[20] This is certainly an improvement, but 50 uses could be achieved with occasional use over the course of months, or during the course of using up one free sample, if the respondent defines a "time" as a puff. In the current study, we have made an effort to distinguish trial and intermittent use from intensive use in hopes of having a more robust indicator with which to assess impact on smoking cessation and on motivation to quit. This study also improves upon much of the existing research by investigating the impact in a population-based sample of smokers contacted by telephone and interviewed twice over the course of three years when e-cigarettes have been widely available.

Methods

Sample Design

The sample for the current study was a subset of the respondents to a population-based survey of over 5,000 adults residing in the Dallas/Fort Worth, Texas and Indianapolis, Indiana metropolitan areas. The original study, carried out in 2011/2012, was designed to assess receptivity to snus which had been available in those two areas for an extended period of time. This was a dual-frame, address-based sample with data collected mainly via telephone interviews with a small supplementary mail survey for a sample of households for which a telephone number could not be obtained. Details of the sample, baseline data collection methods and response rates have been published elsewhere.[21] Among the 5,155 respondents to the original survey, were 1,675 smokers who had been interviewed by telephone. Eighty-two percent ($N = 1,374$) gave permission to be re-contacted and constituted the sample frame for the current study. Only telephone respondents were included because the supplementary mail survey did not include detailed questions on smoking history such as daily smoking rate and motivation to quit smoking. Follow-up surveys were conducted between January and March 2014.

Measures

Main Dependent Variables

The main dependent variables were smoking cessation, and reduction in motivation to quit smoking among those who had not quit

by follow-up. All respondents had reported being cigarette smokers at baseline. Follow-up smoking status was assessed with the question, "Do you now smoke cigarettes every day, some days or not at all?" If the response was "not at all," it was followed with the question, "About how long has it been since you last smoked cigarettes on a regular basis?" Smoking cessation was defined as abstinence from cigarettes for at least 1 month. Two measures of motivation to quit smoking were included on both the baseline and follow-up survey. Smokers were scored on a 3-point scale of readiness to quit smoking at baseline and, if still smoking at follow-up, depending on whether they reported an intention to quit within 30 days (3), within 6 months (2), or not within 6 months (1). We then computed the difference between the baseline and follow-up score and dichotomized the result to differentiate between those whose readiness to quit had decreased versus those for whom it had stayed the same or increased. The second measure asked smokers how likely they were to be smoking cigarettes in 12 months on a 4-point scale from 1 (very likely) to 4 (not at all likely). Again, the difference between baseline and follow-up scores was computed, and the result dichotomized to differentiate those whose predicted likelihood of smoking at the end of a year increased (and hence likelihood of being abstinent decreased) from those for whom it had stayed the same or decreased. These two variables were positively correlated (Wald chi-square = 38.21; $p < .001$).

E-Cigarette Usage

At baseline, three questions were asked about e-cigarettes: whether the respondent had "ever heard of electronic cigarettes, also known as e-cigarettes"; if so, whether he/she had ever used an e-cigarette even one time, and if so, on how many of the past 30 days the respondent had used an e-cigarette. To assess how intensively and for how long the respondent had used e-cigarettes during the period between interviews, the follow-up interviews included questions to describe e-cigarette usage. Those who were not aware of e-cigarettes at baseline were asked if they had heard of them at follow-up. Those who had not tried e-cigarettes at baseline were asked if they had done so by follow-up. All respondents who reported ever trying them by follow-up were asked whether they currently used e-cigarettes every day, some days or not at all. If not at all, they were asked if they ever used e-cigarettes "fairly regularly." If not, whether they had used only once or twice or more often than that. All who had used more than once or twice, were asked a series of questions about their patterns of use: for how long they had used e-cigarettes (less than a month, 1–6 months, more than 6 months); whether they had ever used e-cigarettes daily for at least one week; if so for how long they had used e-cigarettes daily. From these variables, a 3-level measure of intensity of e-cigarette usage was computed: 3 = intensive (used daily for at least 1 month); 2 = intermittent (more than once or twice but not daily for a month or more); 1 = non-use or at most once or twice.

Reasons for Starting and Stopping E-Cigarette Use

Those who had tried e-cigarettes were asked which of several reasons motivated their use of e-cigarettes. Those who had tried e-cigarettes and were still smoking at follow-up were asked to rate the importance of several reasons for stopping use of e-cigarettes.

Covariates

Age group (18–30, 31–49, 50–65), gender, education level (less than 4 years of college versus bachelor's degree or more) and race

ethnicity (White non-Hispanic versus minority) as measured at baseline were used as demographic covariates. In addition, smoking level at baseline was dichotomized into heavy smokers (those reporting smoking 20 or more cigarettes per day and smoking the first cigarette within 30 min of waking) versus not heavy smokers.

Analyses

Bivariate cross tabulations were run to investigate the demographic and baseline smoking characteristics of respondents as a function of the intensity of their use of e-cigarettes. Logistic regression analyses, controlling for demographic characteristics and baseline smoking level, were conducted to examine the extent to which the intensity of e-cigarette use predicted smoking cessation and, for those still smoking at follow-up, the extent to which e-cigarette usage predicted reduced motivation to quit smoking. Bivariate analyses were run to examine the relationship between intensity of e-cigarette use and reasons given for initiating use. Similar analyses were run examining reasons for stopping use among those who were no longer using e-cigarettes at follow-up but were still smoking conventional cigarettes. Data were weighted at baseline to account for the probability of selection and survey non-response, and were then post-stratified to match the sample to the age, gender, and smoking status of persons in the two geographic regions being sampled. Details on weighting have been published elsewhere.[21] All analyses were conducted using IBM SPSS Statistics 20, complex sample procedures which adjust for the complex survey design.

Results

Interviews were completed with 695 of the 1,374 sample members for a retention rate of 50.6%. Among those whom we were able to trace ($n = 1,088$), the cooperation rate was 63.9%.

Prevalence of E-Cigarette Use at Follow-Up

Awareness of e-cigarettes was high (89.4%) among the respondents at baseline and was universal (100%) at follow-up. Trial increased greatly in the 2–3 years between surveys, from 22.3% at baseline to 70.4% at follow-up. At follow-up, 23% percent were intensive users, having reported that they had used e-cigarettes daily for 1 month or longer. Twenty-nine percent were classified as intermittent users who had used more than once or twice, but not daily for at least a month. The remaining respondents comprised 18% who had used once or twice and 30% had not tried e-cigarettes. For analyses of association with smoking cessation and intentions to quit smoking, those who tried e-cigarettes only once or twice are grouped with never users ("non-users/triers"). Table 1 shows the characteristics of the sample as a function of their level of e-cigarette use. Bivariate analyses indicate significant differences in the 3 groups in terms of baseline smoking level and race/ethnicity, with intensive users more likely to be heavier smokers, and minorities. Gender differences showed a non-significant trend ($p = .06$) indicating a higher likelihood of intensive users being male than female.

Association Between E-Cigarette Use and Smoking Cessation

At follow-up, 13.1% of respondents reported having been abstinent from smoking for at least 1 month (95% CI = 7.3, 22.3). The highest rate of cessation (20.4%) was observed among intensive users compared to 8.5% and 12.4% in the intermittent and non-users/triers,

Table 1. Sample Characteristics and Outcomes by Level of Electronic Cigarette Use[a]

	n[b]	Non-use/trial ($n = 364$) % (CI)	Intermittent use ($n = 220$) % (CI)	Intensive use ($n = 111$) % (CI)	Total ($N = 695$) % (CI)	p
Gender						
Male	398	45.8 (30.1, 62.3)	47.6 (21.3, 75.4)	84.1 (59.9, 94.9)	55.2 (40.3, 69.2)	.06
Female	297	54.2 (37.7, 69.9)	52.4 (24.6, 78.7)	15.9 (5.1, 40.1)	44.8 (30.8, 59.7)	
Age group (y) at baseline						
18–30	90	12.3 (5.0, 27.1)	8.6 (3.1, 21.8)	30.9 (8.6, 68.1)	15.5 (7.6, 29.1)	.42
31–49	197	50.9 (34.3, 67.3)	47.6 (20.0, 76.7)	48.6 (20.2, 77.9)	49.4 (35.3, 63.5)	
50–65	408	36.8 (23.1, 53.0)	43.8 (19.6, 71.4)	20.5 (7.1, 46.5)	35.1 (24.2, 47.7)	
Education at baseline						
< BA	529	67.5 (51.1, 80.6)	45.7 (20.7, 73.2)	72.8 (45.1, 89.7)	62.5 (47.4, 75.5)	.27
≥ BA	165	32.5 (19.4, 48.9)	54.3 (26.8, 79.3)	27.2 (10.3, 54.9)	37.5 (24.5, 52.6)	
Race/ethnicity						
Minority	121	19.6 (10.6, 33.5)	16.5 (6.0, 38.0)	53.8 (25.2, 80.1)	26.6 (15.5, 41.8)	.02
White/non-Hispanic	572	80.4 (66.5, 89.4)	83.5 (62.0, 94.0)	46.2 (19.9, 74.8)	73.4 (58.2, 84.5)	
Heavy smoker, baseline						
Yes	240	20.6 (11.4, 34.4)	28 (11.3, 54.2)	68.2 (40.3, 87.2)	33.9 (21.6, 48.7)	.01
No	448	79.4 (65.6, 88.6)	72 (45.8, 88.7)	31.8 (12.8, 59.7)	66.1 (51.3, 78.4)	
Smoking cessation						
Quitter	130	12.4 (5.1, 26.9)	8.5 (2.4, 25.9)	20.4 (7.3, 45.5)	13.1 (7.3, 22.3)	.5
Smoker	565	87.6 (73.1, 94.9)	91.5 (74.1, 97.6)	79.6 (54.5, 92.7)	86.9 (77.7, 92.7)	
Changes in readiness to quit[c]						
Decreased	110	26.8 (12.6, 48.3)	46.6 (17.8, 77.9)	62.8 (28.0, 88.0)	39.2 (23.7, 57.2)	.24
Same or increased	430	73.2 (51.7, 87.4)	53.4 (22.1, 82.2)	37.2 (12.0, 72.0)	60.8 (42.8, 76.3)	
Changes in likelihood of being quit in one year[c]						
Decreased likelihood	125	14.3 (7.0, 26.9)	52.7 (23.8, 80.0)	11.7 (2.8, 37.8)	25.4 (12.5, 44.8)	.01
Increased likelihood	427	85.7 (73.1, 93.0)	47.3 (20.0, 76.2)	88.3 (62.2, 97.2)	74.6 (55.2, 87.5)	

[a]Non-use/trial = never used or used one or two times; intermittent use = used more than twice but not daily for 1+ months; intensive use = used daily for 1+ months.
[b]Ns are unweighted; percentages are weighted. CI = 95% confidence interval.
[c]Includes only those continuing to smoke.

respectively. These differences were not significant in bivariate tests (see Table 1). Logistic regression models, controlling for gender, age group, race/ethnicity, and education level as well as baseline smoking level, demonstrate that intensive use of e-cigarettes was significantly associated with the likelihood of smoking cessation, with intensive users being more than six times as likely to have quit smoking as those who never used e-cigarettes or used only one or two times (see Table 2). Intermittent users were no more likely to quit than non-users/triers. The analysis also shows that more highly educated respondents were significantly more likely to quit smoking and ethnic minorities were significantly less likely to quit, compared to those who were White non-Hispanic. None of the other covariates had a significant independent association with smoking cessation.

Association Between E-Cigarette Use and Motivation to Quit Smoking

Bivariate analysis of the relationship between e-cigarette use and changes in motivation to quit among those still smoking at follow-up (Table 1) indicates that e-cigarette use is significantly associated with one indicator of motivation to quit (perceived likelihood of being a non-smoker in one year) and not the other (readiness to quit). The logistic regression models (Table 2) clarify the effect. Specifically, intermittent e-cigarette users were about six times as likely to expect that they would still be smoking in one year's time relative to non-users/triers (OR: 6.04; 95% CI = 1.49, 24.38). Intensive users who were still smoking at follow-up were no different from non-users/triers in their expectations about quitting in a year. However, the measure of change in readiness to quit as measured by respondents'

reports at baseline and follow-up about whether they planned to quit within 1 month, 6 months or not in 6 months, did not yield any significant association with extent of e-cigarette usage.

Reasons for Starting to Use E-Cigarettes

At follow-up, respondents were read six possible reasons for why they might have started using e-cigarettes: as a substitute for smoking in places where smoking is prohibited, to avoid exposing others to second-hand smoke, to avoid smelling like tobacco smoke, to help cut down on the number of cigarettes smoked, to help quit smoking entirely, and to save money. They were also asked whether there was another reason that had not been mentioned, and open-ended responses were coded to see if there was another reason endorsed by a substantial number of people. The only new reason mentioned was the belief that e-cigarettes were healthier than regular cigarettes. After endorsing as many reasons as they felt applied, respondents were asked which of the reasons they would say was "most important." Saving money and avoiding cigarette smell were identified as most important by only a handful of respondents. Table 3 shows the percentage of respondents in each of the three usage groups who endorsed each of the other five reasons as most important. For these analyses, the lowest level of usage includes those who used e-cigarettes only once or twice. The most important reason among all users was the hope that e-cigarettes would help them quit smoking (52.6%), followed by the desire to avoid exposing others to tobacco smoke (16.1%). The belief that e-cigarettes are not as harmful to health was next in importance (8%). To use in nonsmoking areas and to cut down on number of cigarettes were each judged as most

Table 2. Adjusted Odds Ratios[a] for Smoking Cessation and Motivation to Quit at Follow-up

Dependent variable	Quit smoking (*n* = 695)[b] Adjusted OR (95% CI)	Decreased likelihood of quitting in one year (*n* = 552) Adjusted OR (95% CI)	Decreased readiness to quit (*n* = 540) Adjusted OR (95% CI)
Gender			
Male	1.50 (0.28–8.10)	0.61 (0.16–2.33)	0.53 (0.13–2.13)
Female	1.00 (ref)	1.00 (ref)	1.00 (ref)
Age group (y)			
18–30	15.40 (1.42–167.53)	1.45 (0.18–11.48)	3.90 (0.69–22.04)
31–49	4.27 (0.44–41.62)	2.20 (0.57–8.58)	6.45 (1.52–27.35)
50–65	1.00 (ref)	1.00 (ref)	1.00 (ref)
Race/ethnicity			
Minority	0.16 (0.03–0.95)	0.59 (0.12–2.90)	2.28 (0.57–9.07)
White non-Hispanic	1.00 (ref)	1.00 (ref)	1.00 (ref)
Education			
≥ BA	8.84 (1.62–48.29)	2.96 (0.78–11.17)	2.05 (0.43–9.81)
< BA	1.00 (ref)	1.00 (ref)	1.00 (ref)
Heavy smoker			
Yes	0.22 (0.04–1.39)	1.74 (0.54–5.61)	2.12 (0.59–7.67)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)
Electronic cigarette use[c]			
Intensive use	6.07 (1.11–33.18)	1.15 (0.18–7.52)	4.51 (0.57–35.52)
Intermittent	0.31 (0.04–2.80)	6.04 (1.50–24.38)	2.41 (0.56–10.28)
Non-use/trial	1.00 (ref)	1.00 (ref)	1.00 (ref)

OR = odds ratio; CI = confidence interval.

[a]All listed variables were included in models.

[b]*N*s are unweighted.

[c]Non-use/trial = never used or used one or two times; intermittent use = used more than twice but not daily for 1+ months; intensive use = used daily for 1+ months.

important by only 4–6 percent of respondents. Chi-squared analyses indicated that reasons for using e-cigarettes did not differ significantly among three usage groups.

Reasons for Giving up Use of E-Cigarettes and Continuing to Smoke

Those who had used e-cigarettes in the past and were no longer using them at follow-up, but were still smoking combustible cigarettes were asked to rate the level of importance of 10 different potential reasons for stopping. Three of the reasons not deemed important by many respondents included having a negative physical reaction; not being able to find them in stores; and having friends or family disapprove of e-cigarette use. Table 3 shows the proportion of respondents in each of the three usage groups who rated the remaining seven reasons as "very important." (These reasons were not mutually exclusive; one could rate multiple reasons as very important.) The greatest number of former users (36.3%) reported that they stopped using e-cigarettes because they "didn't feel enough like smoking cigarettes." This reason did not differ among usage groups. Between 19% and 24% of respondents endorsed as "very important" the taste, the feeling that it was bad for their health, the expense, and the fact that they did not work well (either broke, or lost battery charge too rapidly). Approximately 10%–12% were put off by the look or feel of the e-cigarette (e.g., being too large and heavy in the hand) and by not getting enough vapor. Some these reasons for giving up on e-cigarettes differed according to level of usage. As Table 3 shows, those who used e-cigarettes only once or twice were significantly more likely than higher level users to say the taste, the expense and the look and feel of the device were very important reasons in their not continuing with them. Intermittent users were more likely than intensive users to say that they did not get enough vapor, but this difference did not reach the .05 level of significance.

Discussion

Results of this study demonstrate that intensive use of e-cigarettes is significantly associated with a higher rate of quitting smoking relative to smokers who never tried e-cigarettes or merely used them once or twice. To use e-cigarettes daily for a month or more suggests that the user has made a commitment to the new product, and it is among these users that we see a significantly increased rate of sustained abstinence. In contrast, intermittent use, which may reflect experimentation or temporary substitution of e-cigarettes for tobacco cigarettes in order to cope with periodic environmental demands, is not associated with cessation at a rate greater than non-use. This finding underlines the need for more focus on detailed measures of patterns of e-cigarette use, a concern that has been identified by other researchers.[20] We do not consider our differentiation between intermittent and intensive e-cigarette users ideal. It is somewhat arbitrary, and although it does capture a difference in extent of use, the intermittent category is quite heterogeneous, and includes individuals who have used e-cigarettes for less than 1 month as well as those who used for more than 6 months. Further efforts to characterize both duration and frequency of use over extended time periods may help us better understand the conditions under which e-cigarette use will facilitate smoking cessation.

We consider the association between intermittent e-cigarette use and the lowering of expectations about quitting in the future only a suggestive finding, worthy of further research. It is puzzling that the association was found for only one of two measures of changes in motivation that were highly correlated with each other. We do

Table 3. Reasons for Starting and Quitting Electronic Cigarette Use by Level of Use

	Triers[a] (*n* = 163) % (CI)[b]	Intermittent use (*n* = 219) % (CI)	Intensive use (*n* = 111) % (CI)	Total (*N* = 493) % (CI)	*p*
Most important reason for starting e-cigarette use					
Use where smoking is not allowed	5.0 (1.9, 12.7)	8.6 (2.5, 25.9)	2.4 (0.5, 10.1)	5.6 (2.5, 12.2)	.33
To avoid exposing others to tobacco smoke	12.0 (3.3, 35.1)	28.1 (5.0, 74.2)	4.4 (0.6, 25.2)	16.1 (4.2, 45.7)	.21
To cut down on smoking	0.6 (0.2, 1.3)	5.8 (1.5, 19.8)	5.9 (1.2, 23.5)	4.5 (1.7, 10.9)	.33
To quit smoking	46.5 (25.0, 69.4)	46.0 (20.4, 73.8)	65.9 (38.8, 85.5)	52.6 (35.1, 69.6)	.49
Health	8.1 (2.1, 26.4)	1.8 (0.4, 6.8)	15.8 (4.8, 41.1)	8.0 (3.5, 17.3)	.08
	Triers[a] (*n* = 138) % (CI)	Intermittent use (*n* = 73) % (CI)	Intensive use (*n* = 16) % (CI)	Total (*N* = 227) % (CI)	*p*
Very important reasons for stopping e-cigarette use[c]					
Taste	35.0 (16.7, 59.1)	8.1 (2.4, 24.5)	0.3 (0, 2.7)	23.9 (12.1, 41.9)	.01
Did not feel like tobacco cigarettes	28.2 (12.7, 51.5)	52.8 (22.2, 81.5)	21.1 (2.2, 76.1)	36.3 (20.9, 55)	.30
Bad for health	29.3 (12.3, 55.2)	16.7 (4.0, 49.1)	1.3 (0.2, 9.4)	23.5 (11.3, 42.7)	.32
Did not like look/feel	17.5 (4.7, 47.9)	0.0 (0, 0.2)	0.5 (0, 5.6)	10.6 (2.8, 33.1)	.00
Did not give enough vapor	6.2 (2.4, 15.1)	23.2 (5.9, 59.2)	0.7 (0.1, 4.5)	11.8 (4.5, 27.5)	.07
Too expensive	33.9 (14.9, 60.1)	5.9 (0.9, 31.0)	0.2 (0, 2.4)	22.5 (10.2, 42.6)	.02
Did not work well	22.3 (8.7, 46.1)	12.3 (2.2, 47.3)	18.6 (1.7, 74.8)	18.7 (8.4, 36.3)	.71

CI = confidence interval.

[a]Triers = used one or two times; intermittent use = used more than twice but not daily for 1+ months; intensive use = used daily for 1+ months.

[b]Ns are unweighted, percentages are weighted. CI = 95% confidence interval.

[c]Questions asked only of former e-cigarette users who were smoking at follow-up.

note that other researchers have observed an increase in motivation to quit among smokers introduced to e-cigarettes in a pilot study.[22] It is also important to note that the causal link between levels of e-cigarette use and changes in quitting motivation is far from clear. A reduction in motivation could lead to less intense e-cigarette use.

In spite of the differential association with cessation, we did not see significant differences in the reasons for using e-cigarettes among respondents in the three different intensity levels. The most important reason mentioned by respondents in every group was to help with quitting smoking. Although 66% of those using intensively endorsed quitting as the most important reason versus 46% in the other two groups, this difference did not reach statistical significance. It is also of interest that protecting others from tobacco smoke exposure was the second most frequent reason for use among intermittent users and those who used once or twice, but not intensive users. This is consistent with the notion that those who did not progress to extended daily use of e-cigarettes were using them for reasons other than the desire to quit smoking.

The reasons given for not continuing to use e-cigarettes among respondents who were still smoking at follow-up provides some insight into characteristics of the products that some smokers find problematic. Some of those reasons (taste, volume of vapor, faulty operation of the device, the look, and feel) may be addressed by future evolution of the product if the regulatory environment is supportive of this innovation.[1] The concern that it may be "bad for health" as reported by 29% of the low level users who were still smoking is something that clear communication from health agencies could correct by clarifying that although we do not have sufficient knowledge of the impact of long-term use, it is generally agreed that continuing to smoke cigarettes is more harmful to health that switching to e-cigarettes.[7] One-third of

continuing smokers who only tried e-cigarettes once or twice did not continue because they were "too expensive." Decision makers should take this into consideration when considering whether or not these products should be taxed as heavily as cigarettes.

Limitations

There are some limitations to the current research, and interpretation of results must be tempered with caution. Most importantly, this is an observational study, and although we have controlled for some covariates, we cannot assure that resulting associations are not due to unmeasured differences in the groups that chose to use e-cigarettes with different intensities. The potential for selection bias means that, as in any observational study, the direction of causality cannot be established with certainty. Moreover, some respondents to the baseline survey did not wish to participate in the second survey, and some were not traceable. The 50% retention rate leaves room for unknown biases.

The sample, being limited to two metropolitan areas, is not a national sample, which may restrict generalizability to the United States as a whole. Nevertheless, there are a number of ways in which this study improves on those in the literature. First, it is a representative, probability sample and therefore reflects how e-cigarettes are being used and with what effect in the population at large, and not in groups with special affinities for e-cigarettes or samples of internet panels that may be affected by unknown biases, especially if the panel was convened from smoking cessation websites or e-cigarette discussion groups. Second, we have followed a group of smokers prospectively over a period of two to three years when awareness of e-cigarettes was high. To our knowledge, this is the first study to have done so. Third, we have used 1 month point prevalence abstinence

as the major outcome variable, which is a rigorous standard for cessation. Although the absence of a biological validation of abstinence is a limitation, this is very common in large scale population surveys.

The finding of a six-fold increase in the likelihood of cessation among smokers who used e-cigarettes daily for at least 1 month compared to those who never used them or used them less intensively provides support for those who see these novel products as a potential boon to public health. What is needed now is a more probing look at the underlying reasons for different patterns of use, including initial expectations for the product, the characteristics of the product chosen, and how experience with the product impacts motivation to quit. This type of research can result in improvements in e-cigarette design and instructions for use to maximize effectiveness as a tool for smoking cessation.

Declaration of Interests

None declared.

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