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Smokers who have used e-cigarettes in the past are less likely to quit successfully in the future: a population-based study.

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Smokers who have used e-cigarettes in the past are less likely to quit successfully in the future: a population-based study.

Abstract

Objectives: To examine whether smokers who used e-cigarettes are more likely to quit after one year when compared to smokers who had never used e-cigarettes.

Methods: California smokers (n=1000) were surveyed at two time points one year apart. Logistic regression analyses were conducted to determine whether history of e-cigarette use at baseline predicted quitting behavior at follow-up while adjusting for demographics and smoking behavior at baseline.

Results: Compared to smokers who never used e-cigarettes, those smokers who ever used e-cigarettes were less likely to decrease cigarette consumption (OR 0.62; 95% CI 0.37, 1.01), and significantly less likely to quit for 30 days or more at follow up (OR 0.34; 95% CI 0.16 ,0.75). Ever e-cigarette users were

more likely to report a quit attempt, although this did not reach statistical significance (OR 1.39; 95% CI 0.84, 2.31).

Conclusions: smokers who used e-cigarettes were less likely to decrease cigarette consumption or have a prolonged quit after one-year. This requires further population studies to assess whether smokers who use e-cigarettes are risking more nicotine dependence and less likelihood of quitting.

Introduction

The Use of Electronic Cigarettes (E-cigarettes), also known as the Electronic Nicotine Delivery System (ENDS) and other more recent names such as Personal Vaporizer or Vaping Cigarette, is a very recent and rapidly expanding phenomenon. These labels refer to a battery-operated device that electronically heats a liquid (sometime referred to as “E-Juice”) containing nicotine and propylene glycol, plus flavors to create cigarette-like smoke that is inhaled by the smoker (commonly known as “vaper”). This has become a very controversial issue among health professionals, policy makers, vapers and the general public. According to the Surgeon General’s recent recommendations, e-cigarettes need to be regulated, and their use in the population closely monitored, especially given the doubling of use among youth within just one year (between 2011 and 2012)(1).

The main controversy surrounding the use of e-cigarettes is whether they are of benefit to smokers as an alternative to cigarettes and to reduce harm or whether they cause more harm to the society by introducing and propagating new forms of nicotine addiction (2). At this time there is a scarcity of data to help guide decisions regarding the potential harm vs benefit of e-cigarettes, a situation that has led to claims and counter claims by opponents and proponents of e-cigarette use (3). If smokers who use e-cigarettes quit traditional cigarettes and use e-cigarettes to maintain their nicotine addiction (but without the degree of exposure to known carcinogens by products of tobacco combustion), then this may be a viable harm reduction strategy that can become a powerful tool for tobacco control. Most of the evidence that users and proponents of the e-cigarettes employ have been until recently anecdotal

and not scientifically validated. Studies on this topic are starting to populate the literature more recently. One of the first studies was a pilot study funded by the manufacturers of an e-cigarette brand from Italy and included 40 smokers who were given e-cigarettes and followed up for 24 weeks. The authors reported a 22.5% rate of sustained abstinence from cigarettes among e-cigarette users, a rate comparable to effects of nicotine replacement therapy in experimental settings (4). However, this was underpowered because of small number of participants. A more recent and larger 3-arm trial of e-cigarette use from New Zealand randomized participants to use e-cigarettes (nicotine or placebo) or nicotine patches to quit smoking. Abstinence rates at six-month follow up were low across conditions (4.1-7.8%) with nicotine e-cigarette showing the highest abstinence and placebo e-cigarette the lowest (5), but no significant differences emerged. In addition to its low statistical power, a potential methodological bias was generated because those in the e-cigarette arm of the trial were mailed the device and cartridges while those in the patch arm of the trial were mailed a voucher (thus requiring that they obtain the nicotine patches). The difference in dose of nicotine and type of e-cigarettes is an additional major limiting factor in interpreting these results across different studies.

Population-based studies of e-cigarette users and their smoking cessation habits are needed to inform our understanding of the effects of e-cigarette use in relation to quitting cigarette smoking. An earlier study of a convenience sample of 81 ever users of e-cigarettes concluded that most were using them to quit smoking (6) but provided no clear indication of how successful they were in their quitting behavior. A larger follow up survey of e-cigarette users by the same authors indicated that almost all (96%) former smokers agreed that e-cigarettes helped them quit smoking and 57.7% of current smokers believed e-cigarettes will help them quit or avoid relapsing (7). However, these studies are biased towards self-selected current users without any comparison groups and the actual influence on quitting among ever users vs never is unknown.

Our aim in this study was to prospectively assess the influence of ever using e-cigarettes compared to never using them on abstinence and smoking habits among smokers in the general population. Given that previous data suggest smokers mostly use e-cigarettes to quit smoking, we hypothesized that smokers in the general population who tried or use e-cigarettes are more likely to succeed in quitting than smokers who never used them, after controlling for level of addiction, quitting intentions, and smoking behavior.

Methods

Data for this study were drawn from the California Smokers Cohort Follow up (CSC), a longitudinal survey designed to investigate factors that predict cigarette cessation behaviors among California current and former smokers. The study was comprised of a baseline survey to establish a cohort of current and former smokers, and a follow-up survey to determine changes in smoking behaviors including reduced consumption, quit attempts, , and duration of abstinence. The baseline survey was conducted from July 26, 2011 to April 29, 2012. The follow up survey conducted from November 6, 2012 to January 16, 2013. The baseline survey interviewed by telephone 4,350 residents of California aged 18-59 who had smoked at least 100 cigarettes during their lifetime. The follow-up consisted of 1,745 interviews with the original respondents, of whom 1000 were smokers at baseline. These 1000 baseline smokers were examined in this study. Interviews for both waves of the study were conducted via landline and cell phone and administered in English and Spanish.

For the purpose of validating the current CSC study, we compared study findings regarding e-cigarette use and population characteristics with data from our separate cross-sectional California Longitudinal Smokers Survey (CLSS), which is a representative sample of smokers who participated in the 2009 California Health Interview Survey. The California Health Interview Survey is biannual population-

based random sample (random digit dial telephone interview) of California residents that consists of the same survey questionnaire used for the CSC. The CLSS follow up telephone interview began in July, 2011, concluded in December, 2011 and recruited smokers who were identified as smokers in CHIS and agreed to be followed up (8). In total, 1718 current smokers were weighted to the age, gender, geographic place of residence, and ethnicity of the population of adult California smokers as previously described (8, 9).

Tobacco Use and E-Cigarette Use History

Survey questions and data collection procedures were identical for the baseline and follow up CSC. Current smokers were those who reported smoking at least 100 cigarettes in their lifetime and smoked cigarettes on at least some days at the time of survey. Smoking status was categorized according to reported smoking frequency: either every day (daily) or some days (non-daily).

All participants were asked if they had heard about electronic cigarettes or e-cigarettes. If they answered “Yes” then they were asked the following:

”What describes you best regarding your use of e-cigarettes: you have used e-cigarettes, you might use e-cigarettes, or you will never use e-cigarettes?”

Independent predictors of tobacco behavior

Nicotine Dependence: Smokers were asked how soon after they awake they smoke their first cigarette with responses categorized into those who smoked within 30 minutes of waking up, representing more addicted smokers, and those who smoked after 30 minutes or more from waking up, representing less addicted smokers. We used this cut-off categorization (30 minutes or less vs more than 30 minutes) to overcome small numbers if using smaller categories and to represent the median value for the number of minutes smokers from the representative CLSS reported smoking their first cigarette after waking up.

Intentions to Quit: Smokers were asked to choose one of 4 options as their future intentions for quitting: never expect to quit, might quit in the future but not in the next 6 months, will quit in the next 6 months or will quit in the next month. To increase the stability of the regression model for the purpose of this study we combined responders who said they never expect to quit or might quit but not in the next 6 months as one category “no current intention to quit” and smokers who endorsed intentions to quit either in the next 1 or 6 months as those “intending to quit in the next 6 months.”

Socio-demographic Characteristics: Demographics were also included in the model such as sex, age (18-44, 45-59 years), years of education (less than or equal to 12 years, 13-15 years, and 16 years or more), and ethnicity (Hispanic, Non-Hispanic White, and all others)

Outcome variables

We chose three smoking behavior variables as outcomes in relation to e-cigarette use: Quit attempts, reduction in the number of cigarettes smoked, and current abstinence from cigarette use.

Reduction in the number of cigarettes smoked was dichotomized according to whether a smoker decreased the monthly number of cigarettes at follow up compared to baseline by 20% or more. We included monthly number of cigarettes smoked rather than daily number of cigarettes to accommodate non-daily smokers.

Quit Attempts. Self-reported quit attempts were assessed by response to the question at follow up: “During the past 12 months, have you quit smoking intentionally for one day or longer?”

Current abstinence. Those reporting duration of abstinence of one month or longer were considered currently abstinent. The one month duration was calculated by subtracting the date of the follow up interview from the date of the start of their most recent quit attempt that lasted one day or longer.

Statistical Analyses

Crude odds ratios (OR), adjusted odds ratios (AOR) and their 95% Confidence Intervals (CI) were calculated using logistic regression analyses separately for each of the three different outcomes (quit attempt; reduction of cigarette smoking by 20% or more abstained from smoking for one month or more), with the outcome event being “Yes”. The main predictor was the use of e-cigarettes which for the purposes of the current study was categorized as those who reported: 1) “will never use e-cigarettes” at baseline and were considered the reference group in the regression models; and 2) “have used e-cigarettes” as a response at baseline. Those who report “might use e-cigarettes” at both time points were excluded from analyses as they did not represent a definitive group of users or never users and might overlap with both. We also excluded from analyses smokers who were inconsistent in their reporting of e-cigarettes at follow up compared to baseline (for example they reported they used e-cigarettes at baseline but reported never using them at follow up) or reported never hearing about e-cigarettes (n=334). The multivariate logistic regression model included as covariates age, gender, education, ethnicity, smoking status, intention to quit, and time to first cigarette.

All analyses were performed using SAS software, Version 9.3 of the SAS System for Windows 7, Copyright, SAS Institute Inc.

For the CLSS comparison data that we used, all parameter estimates reported were weighted to be representative of the population of adult smokers in California. Weighted frequencies, standard deviations (SD), and standard errors (SE) were calculated by the paired unit jackknife method (JK2), using 80 jackknife samples (5).

Results

The CSC population demographics and responses to the e-cigarette question are presented in Table 1. More than a third ($34.1\% \pm 1.5$) reported ever using e-cigarettes, $28.9\% \pm 1.46$ said they will never use e-cigarettes, and $28.2\% \pm 1.45$ said they might use e-cigarettes in the future. Overall, only $8.9\% \pm 0.92$ of smokers in our study sample had not heard about e-cigarettes. A third of our participants were in the youngest age category of 18-44 years, we had slightly more females ($52.2\% \pm 1.58$) and a majority were Non-Hispanic White ($72.6\% \pm 1.4$). The large majority were daily rather than non-daily smokers (83.7% vs 16.3%), and is consistent with the time to first cigarette measure where close to two thirds of the smokers ($60.8\% \pm 1.56$) smoked their first cigarette within 30 minutes of waking up. About $41.9\% \pm 1.57$ indicated they were thinking of quitting in the next 6 months. At the one year follow up, $40.7\% \pm 1.65$ reported making at least one quit attempt in the past year, $33.6\% \pm 1.6$ reported decreasing cigarette consumption by 20% or more in the past year, and $9.4\% \pm 0.92$ reported abstinence of at least one month duration.

To compare independent predictors of ever using e-cigarettes in this convenience sample of smokers with the representative CLSS sample, we carried out multivariable analyses for the same variables shown in Table 1 in a logistic regression model with ever using e-cigarettes as the event of interest compared to never using e-cigarettes. We found comparable results in both populations. Female smokers more likely to report ever use of e-cigarettes than males, OR 1.66 (95% CI 1.18-2.35) in the CSC and OR 2.05 (95% CI 1.01-4.16) in the CLSS. For ethnicity, Non-Hispanic Whites were more likely to ever use e-cigarettes in the CSC, 2.8 (95%CI 1.3-6.05) and CLSS, 1.93 (95% CI 1.31-2.84). Daily smokers in both populations were more likely to ever use e-cigarettes; in CSC OR 2.01 (95% CI 1.26-3.22) and CLSS OR 2.25 (95% CI 0.99-5.16). Other variables were not significantly associated with e-cigarette use in either population.

The primary analyses were longitudinal models of the CSC data including e-cigarette use category along with other baseline smoking variables and demographics to predict the three outcomes at follow up. As

shown in Table 2, the direction of the association between using e-cigarettes and making a quit attempt at follow up was positive but did not reach statistical significance (OR 1.39; 95% CI 0.84-2.31) after adjusting for the main covariates in the multivariable logistic regression analyses.

Examination of the smoking reduction outcome is shown in Table 3. Compared with never using e-cigarettes, use of e-cigarettes was associated with a lower likelihood of decreasing cigarette consumption by 20% or more during the one year period, a finding that approached statistical significance (OR 0.62; 95% CI 0.37-1.01).

Table 4 includes the analyses for the logistic regression analyses predicting abstinence (one month or more) at follow up. Smokers ever using e-cigarettes were significantly less likely to be abstinent at the follow up time point (OR 0.34; 95% CI 0.16-0.75) than smokers who will never use e-cigarettes. In the same models, daily smokers were less likely to quit for one month, and those who intended to quit in the next 6 months were significantly more likely to quit for one month or more.

Discussion

The findings of the present study contradicted our primary hypothesis that smokers who had ever used e-cigarettes would more likely be abstinent from smoking cigarettes at one year follow-up than those who stated they would never use these products. In the present sample, a history of e-cigarette use was significantly associated with cessation failure rather than success. The other analyses indicated that e-cigarette ever users were less likely to reduce their cigarette smoking and tended to attempt quitting during the follow-up period.

Our study did not identify whether participants used e-cigarettes for the purpose of quitting, but we do demonstrate that e-cigarette users were more likely to make quit attempts. Their use of e-cigarettes

might be another attempt to assist them in quitting but not leading to an increase in their success in quitting compared to those who never used e-cigarettes. Others have indicated that smokers who use e-cigarettes do so primarily to help them quit or decrease cigarette consumption (7).

There are limited population based observational studies that have produced results in support of e-cigarettes assisting smokers in quitting. In a very recent study from the UK, it was found that smokers who used e-cigarettes in their most recent quit attempt were more likely to be abstinent compared to those not using any assistance or using nicotine replacement therapy (10). However, this was a cross sectional study and there is lack of temporality between reporting e-cigarette use and smoking behavior with quitting behavior. The authors acknowledge the limitation of recall bias and the potential for e-cigarette users to differentially misreport their level of addiction or smoking behavior. Furthermore, the cessation rate among the unaided group in that population was unusually high (approximately 15%) compared to traditional 4-5%. The authors utilize the UK's Smoking Toolkit Study describing it in their above study as a nationally representative sample of smokers (10). However, description of the original study sample clearly indicates it is not; interviewers made a choice to select those who are most likely to be available to participate and the study never reported a response rate (11). Although weighting can be used to approximate representation of the general population it does not overcome the likely bias from enrolling as participants smokers committed to quitting. This selection bias can undermine findings from a cross sectional study given the recall bias. E-cigarettes have been proposed to be more effective for heavily addicted smokers who are less likely to quit through other means(4). Our study avoids some of these selection and recall biases of cross-sectional studies by being prospective and following up the smokers for one year and re-interviewing them for their smoking behavior, a study design suggested by the authors of the above UK study.

Although assessment of e-cigarette use was limited in the present study, we attempted to enhance validity by assessing consistency of e-cigarette use across both time points and excluding inconsistent reports. Our study is among the first prospective investigations to suggest that the profile of e-cigarette users is that of heavy smokers with less likelihood of achieving sustained abstinence compared to those who never try e-cigarettes. These findings are at odds with data from trials and experimental studies that demonstrated the influence of e-cigarettes on quitting behavior to resemble that of nicotine patch or placebos, all generating very low rates of success (5). However, as with conventional cigarettes, clinical trials and experimental studies are generally more favorable to cessation treatment and attempts compared to observational studies. Clinical trials provide valuable information about the efficacy and efficiency of cessation therapy methods, but rarely reflect the true behavior and cessation in the general population. For example, the percentage of successful quitting among smokers participating in a clinical trial is usually 20% or more, while in the general population the annual cessation rate does not exceed 5% (12).

There is much controversy about the usefulness of e-cigarettes as a tobacco cessation tool (3). Only prospective studies can demonstrate such impact. Our prospective study in this population of smokers demonstrated that smokers who experiment with or use e-cigarettes are less likely to be abstinent; therefore the e-cigarette users are not more likely to be successful quitters in the future. We did adjust for the important predictors of cessation such as addiction level, intentions to quit and smoking status, in addition to demographic variables, and the final results were independent of these factors.

Although we adjust for these variables in the multivariate analyses of the CSC prospective analyses, there may be residual confounding from other unmeasured variables related to quitting successfully or the characteristics of our sample. However, we did compare the predictors of use of e-cigarettes in the multivariate analyses for both our population and that from the California representative CLSS

population and they were comparable. This suggests there are no major systematic confounders that we are missing that might explain these results. We also found the covariates in the model related to smoking; such as addiction level and quitting intention were in the expected direction in terms of e-cigarette use at baseline or quitting behavior at follow up, which provides assurances about the internal validity of the model and the variables.

An important limitation in our study is that we did not ask smokers who quit if they tried using e-cigarettes in their last quit attempt that was successful. At the time of planning the survey in 2010 e-cigarettes were still limited in use and not known to be used for quitting purposes. However, our aim in this study was not to determine whether e-cigarettes can be considered an effective quitting aid, but rather to describe the behavior of smokers who are drawn to these products and if they are more likely to become successful quitters. It could be that smokers not trying to quit are the ones who end up using e-cigarettes and therefore explains our finding but we adjusted for intention to quit in the models and the association between e-cigarette use and not being abstinent was consistent and independent of intention to quit. We actually found e-cigarette users were more likely to make quit attempts than non-users, although this did not reach statistical significance. There is the potential that e-cigarette use is increasing the nicotine dose of smokers and their level of addiction making them less capable of quitting, but this needs further studies to address such a hypothesis.

In Conclusion, our study demonstrates for the first time in a population based study in California that e-cigarette users do not appear to abstain successfully, at least within a year. These findings hold after accounting for key influences on cessation outcomes including smoking status and dependence. Given the rapidly growing use of e-cigarettes, these findings are important to generate further studies that specifically look at the role of e-cigarettes as cessation tools among the general population of smokers and address directly the validity of claims regarding cessation efficacy.

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Contributor Statement

WAD conceptualized the present study, conducted literature review, overlooked the data analyses, and drafted the manuscript. ECL conducted the statistical analyses. MGM made major contribution in drafting the manuscript and along with DRS, and CRH contributed to data collection and design of the California Smokers Cohort, the data analysis plan, development of measures, and interpretation of the results. All authors contributed to the article revision and approved the final version of the article.

Human Participant Protection

Ethical approval for the California Smokers Cohort (CSC) was provided by the UCSD Human Subjects Protection Committee.

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