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Prevalence of population smoking cessation by electronic cigarette use status in a national sample of recent smokers

Daniel P. Giovenco[a,*], Cristine D. Delnevo[b]

[a] Columbia University Mailman School of Public Health, Department of Sociomedical Sciences, 722 W. 168th St., New York 10032, NY, USA
[b] Rutgers School of Public Health, Center for Tobacco Studies, 683 Hoes Ln West, Piscataway 08854, NJ, USA

HIGHLIGHTS

- Over half of daily e-cig users in the sample quit smoking in the last 5 years.
- Daily e-cig users were 3 times more likely to be quit than never e-cig users.
- Some day e-cig users were least likely to be quit.
- Some smokers may have quit or are preventing relapse with frequent e-cig use.

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ABSTRACT

Introduction: Amid decreasing rates of cigarette smoking and a rise in e-cigarette use, there is a need to understand population patterns of use to inform tobacco control efforts and evaluate whether e-cigarettes may play a role in tobacco harm reduction.

Methods: This study merged data from the 2014 and 2015 National Health Interview Survey (NHIS) and restricted the sample to recent smokers [i.e., current smokers and former smokers who quit in 2010 or later (n = 15,532)]. Log-binomial regression estimated adjusted prevalence ratios (aPR) for being quit by e-cigarette use status (i.e., daily, some day, former trier, never). All analyses controlled for factors traditionally correlated with smoking cessation.

Results: A quarter of the sample (25.2%) were former smokers. The prevalence of being quit was significantly higher among daily e-cigarette users compared to those who had never used e-cigarettes [52.2% vs. 28.2%, aPR: 3.15 (2.66, 3.73)]. Those who used e-cigarettes on some days were least likely to be former smokers (12.1%). These relationships held even after accounting for making a quit attempt and use of other tobacco products.

Conclusions: Among those with a recent history of smoking, daily e-cigarette use was the strongest correlate of being quit at the time of the survey, suggesting that some smokers may have quit with frequent e-cigarette use or are using the products regularly to prevent smoking relapse. However, the low prevalence of cessation among infrequent e-cigarette users highlights the need to better understand this subgroup, including the individual factors and/or product characteristics that may inhibit cessation.

1. Introduction

Electronic cigarette (e-cigarette) use among U.S. adults has increased substantially since the products entered the mainstream market (Agaku, et al., 2014; Hu, et al., 2016), concurrent with a decline in smoking rates (Jamal, King, Neff, Whitmill, Babb and Graffunder, 2016). Many advocacy groups posit that e-cigarettes and other vaping products are helping smokers quit, citing user testimonials (American Vaping Association, 2017; Consumer Advocates for Smoke Free Alternatives Association, 2017), but questions regarding a clear relationship between e-cigarette use and smoking cessation remain (Glasser, Collins, Pearson, Abudayyeh, Niaura, Abrams and Villanti, 2016). Findings from a few small, randomized controlled trials (Adriaens, Van Gucht, Declerck, and Baeyens, 2014; Bullen, Howe, Laugesen, McRobbie, Parag, Williman and Walker, 2013; Tseng, Ostroff, Campo, Gerard, Kirchner, Rotrosen and Shelley, 2016) and prospective observational studies (Al-Delaimy, Myers, Leas, Strong, and Hofstetter, 2015; Biener and Hargraves, 2014; Brose, Hitchman, Brown, West, and McNeill, 2015; Grana, Popova, and Ling, 2014; Hitchman, Brose, Brown, Robson, and McNeill, 2015; Polosa, et al., 2014) have

* Corresponding author at: 722 W. 168th St., New York 10032, NY, USA.
E-mail address: dg2984@columbia.edu (D.P. Giovenco).

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been mixed. While some have demonstrated positive associations between e-cigarette use and smoking reduction or cessation (Adriaens et al., 2014; Biener and Hargraves, 2014; Bullen et al., 2013; Hitchman et al., 2015; Polosa et al., 2014; Tseng et al., 2016), others have found no evidence that e-cigarettes help smokers quit (Brose et al., 2015; Grana et al., 2014) or that e-cigarette use is associated with reduced cessation (Al-Delaimy et al., 2015). Limitations common to many of these studies include crude categorizations of e-cigarette use (e.g., ever use, at least once in the past 30 days) and a lack of detailed information on device attributes and patterns of use, including frequency. Moreover, non-representative samples and small sample sizes can limit the generalizability of the findings.

In the only known nationally-representative, longitudinal study examining the duration of e-cigarette use and its impact on cessation, Zhuang et al. assessed the odds of quitting smoking among "long-term" e-cigarette users (i.e., reported using e-cigarettes at baseline and at 2-year follow-up) (Zhuang, Cummins, Y Sun, and Zhu, 2016). Compared to short-term and never users, long-term users had a significantly higher likelihood of cessation after adjusting for intention to quit, cigarettes per day, and demographic variables. There was no difference in quit success between short-term and never e-cigarette users. Despite this study's unique focus on the *duration* of e-cigarette use, it did not capture the *frequency* of e-cigarette use and its association with cessation.

National health surveys produce current, representative estimates of smoking cessation and e-cigarette use and can provide additional insight into the association between patterns of e-cigarette use and quitting smoking at the population level. Reports using national data frequently demonstrate that e-cigarette use is highest among current smokers and is relatively low among former and never smokers (King, Patel, Nguyen, and Dube, 2015; McMillen, Gottlieb, Shaefer, Winickoff, and Klein, 2015), leading some to conclude that e-cigarettes encourage dual use and are not associated with smoking cessation. One methodological limitation of these studies (King et al., 2015; McMillen et al., 2015), however, is the aggregation of all "former smokers," regardless of how long ago they quit. Importantly, e-cigarettes could not have played a role in cessation for smokers who quit before the products entered the market. Two recent studies using more precise categories of "former smokers" documented the highest rates of regular e-cigarette use among former smokers who quit in the past year – a rate more than triple that of current smokers (Delnevo, Giovenco, Steinberg, Villanti, Pearson, Niaura and Abrams, 2016; Schoenborn and Gindi, 2014). Furthermore, current use of e-cigarettes is extremely rare among former smokers who quit before e-cigarettes became available and individuals who have never smoked (Delnevo et al., 2016).

This study combines two years of data from the National Health Interview Survey (NHIS) to examine correlates of being quit among U.S. adults who were established smokers in the last 5 years (i.e., current smokers and former smokers who quit in 2010 or later), with a specific focus on e-cigarette use status. By excluding former smokers who quit before e-cigarettes entered the market and employing measures of e-cigarette use frequency, we can more accurately characterize potential relationships between smoking cessation and the use of e-cigarettes. The aims of this study are to: 1) describe patterns of e-cigarette use between smokers who have quit and those who are currently smoking, and 2) examine e-cigarette use as an independent correlate of population smoking cessation after controlling for other factors known to predict quitting (e.g., age, educational attainment, race/ethnicity, health insurance coverage). Based on previous research documenting higher rates of smoking cessation among "long term" e-cigarette users (Zhuang et al., 2016), and a higher prevalence of daily e-cigarette use among recently former smokers (Delnevo et al., 2016; Schoenborn and Gindi, 2014), we hypothesize that daily e-cigarette use will be significantly associated with being quit.

2. Methods

2.1. Data source

The National Health Interview Survey (NHIS) is an annual, cross-sectional household interview survey and is the principal source of information used to monitor the health status of the civilian, non-institutionalized, adult population in the United States. Details about the NHIS methodology are published elsewhere (Parsons et al., 2014). Briefly, NHIS survey data are obtained through a complex, multistage probability design and generate representative estimates of health behaviors, including tobacco use. This study pooled 2014 and 2015 NHIS data and restricted the sample to current smokers and former smokers who quit in 2010 or later. Although e-cigarettes technically entered the U.S. market as early as 2007, they were not widely available in traditional tobacco retailers until after 2010 (Bover Manderski, Giovenco, and Delnevo, 2017; Giovenco, Hammond, Corey, Ambrose, and Delnevo, 2015). Moreover, before 2010, < 40% of Americans had ever heard of e-cigarettes (King et al., 2015). This year was selected as an optimal cut-point since it marks the beginning of the rapid rise in e-cigarette sales, awareness, and use.

2.2. Measures

Consistent with population-level estimates of smoking prevalence (Agaku et al., 2014), current smokers were defined as individuals who have smoked at least 100 cigarettes and currently smoke "every day" or "some days." Former smokers included respondents who have smoked at least 100 cigarettes, currently smoke "not at all," and reported quitting within the last 4 years (in the 2014 dataset) or 5 years (in the 2015 dataset). This definition of "former smoker," referred to hereafter as "being quit" or "smoking cessation," is the study's primary outcome of interest. A total of 15,532 respondents met the inclusion criteria and were included in the final analytic sample.

Participants were asked if they had ever used an e-cigarette and how often they currently use the product. E-cigarette use was categorized as: daily, some days, former trier (i.e., used an e-cigarette at least once but currently uses "not at all") or never user (Delnevo et al., 2016). Participants were considered other tobacco product users if they reported using any of the following tobacco products daily, some days, or rarely: smokeless tobacco, cigars, little cigars, cigarillos, pipes, or hookah. Among current smokers, making a past-year quit attempt was assessed using the question, "*During the past 12 months, have you stopped smoking for more than one day because you were trying to quit smoking*?"

Covariates included gender, age group, race/ethnicity, educational attainment, census region, health insurance status, and serious psychological distress (SPD). Health insurance status was dichotomized as having any form of health insurance (i.e., public or private) or having no health insurance. Repondents were classified as having SPD if they recorded a score > 13 on the Kessler-6 (K6) Scale. The K6 is a series of six Likert-scale items that ask about feelings of sadness, nervousness, restlessness, worthlessness, hopelessness, and feeling like everything is an effort during the past 30 days. Participants respond on a scale from 'None of the Time' (score: 0) to 'All of the time' (score: 4). This scoring system has been validated as a tool to screen for SPD in the general population (Kessler, et al., 2002; Kessler, et al., 2003). Each of the covariates enumerated above have been empirically demonstrated to predict smoking cessation at the population level (Babb, Malarcher, Schauer, Asman and Jamal, 2017) and were included in all analyses to minimize confounding and enable us to examine the independent effect of e-cigarette use status on being quit.

2.3. Statistical analysis

All analyses applied final survey weights provided by the National Center for Health Statistics to adjust for various probabilities of