Electronic nicotine delivery systems: adult use and awareness of the ‘e-cigarette’ in the USA

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ABSTRACT

Background Electronic nicotine delivery systems (ENDS), also referred to as e-cigarettes or e-cigarettes, were introduced into the US market in 2007. Despite concerns regarding the long-term health impact of this product, there is little known about awareness and use of ENDS among adults in the USA.

Methods A consumer-based mail-in survey (ConsumerStyles) was completed by 10,587 adults (≥18 years) in 2009 and 10,328 adults in 2010. Data from these surveys were used to monitor awareness, ever use and past month use of ENDS from 2009 to 2010 and to assess demographic characteristics and tobacco use of ENDS users.

Results In this US sample, awareness of ENDS doubled from 16.4% in 2009 to 32.2% in 2010 and ever use more than quadrupled from 2009 (0.6%) to 2010 (2.7%). Ever use of ENDS was most common among women and those with lower education, although these were not the groups who had heard of ENDS most often. Current smokers and tobacco users were most likely to try ENDS. However, current smokers who had tried ENDS did not say they planned to quit smoking more often than smokers who had never tried them.

Conclusions Given the large increase in awareness and ever use of ENDS during this 1-year period and the unknown impact of ENDS use on cigarette smoking behaviours and long-term health, continued monitoring of these products is needed.

INTRODUCTION

In 2007, electronic nicotine delivery systems (ENDS) also known as the electronic cigarette (e-cigarette) became available on the US market. Advertisements for ENDS claim that they are more cost effective, more amenable to use with indoor smoking restrictions and more socially acceptable compared with traditional cigarettes. ENDS have been marketed as a smoking cessation aid, and although some public health advocates believe that these products may help smokers quit, there is currently no peer reviewed evidence that ENDS promote long-term cessation, and they are not included as a recommended and effective method for smoking cessation by the US Public Health Service. In 2011, the US Food and Drug Administration (FDA) announced plans to regulate ENDS, which do not make therapeutic claims (eg, cessation) as tobacco products.

There are concerns by other public health professionals that use of ENDS may undermine smoke-free indoor air laws, as well as perpetuate the use of nicotine and tobacco-containing products among smokers who might otherwise be motivated to quit. Furthermore, media have emphasised the rapid spread and popularity of these products; yet to date, there has been no US investigation which has examined the usage and awareness of this product in the USA. Using a consumer mail-in survey with rapid data collection in 2009 and 2010, it was therefore our intention to (1) assess the awareness, ever use and past month use of ENDS in a US sample, (2) determine whether both awareness and use increased from 2009 to 2010 and (3) examine characteristics of adult ENDS users.

METHODS

Data were licensed to the Centers for Disease Control from the ConsumerStyles survey, a consumer mail-in survey designed to capture attitudes towards products, usage of media, health knowledge and behaviours. Sampling and data collection were conducted by Synovate, Inc. Consumers were recruited to join a mail panel through a four-page recruitment survey. Random stratified sampling (by region, household income, population density, age and household size) of the consumer panel was used to select a sample with a demographic distribution similar to the US population; the target demographic distribution was determined by US Census Bureau estimates. In exchange for their participation, respondents were offered small monetary incentives. The ConsumerStyles survey was fielded in April to May of 2009 and 2010. In 2009, 21,240 adults were selected, and in 2010, 20,000 adults were selected. Of these adults, 10,587 returned the survey in 2009 (response rate=49.8%) and 10,328 returned the survey in 2010 (response rate=51.6%). Because no individual identifiers were collected by the Styles survey, it was deemed exempt from institutional review board review.

Three survey questions from the 2010 ConsumerStyles and two survey questions from the 2009 ConsumerStyles were used in this analysis. In 2010, respondents were asked:

1. "Which, if any, of the following products have you heard of: Snus, dissolvable tobacco products, electronic cigarettes or e-cigarettes, flavoured little cigars, water pipes, flavoured cigarettes?" (awareness)

2. "Have you ever tried any of the following products, even just one time: Cigars, cigarillos, or little cigars; chewing tobacco, snuff, or dip; snus; dissolvable tobacco products; electronic cigarettes or e-cigarettes; flavoured little cigars; water pipes; clove cigarettes; roll your own cigarettes; flavoured cigarettes?" (ever use)

3. "In the past 30 days, which of the following products have you used at least once: Cigars,
cigars; or little cigars; chewing tobacco, snuff, or dip; snus; dissolvable tobacco products; electronic cigarettes or e-cigarettes; flavoured little cigars; water pipes; clove cigarettes; roll your own cigarettes; flavoured cigarettes" (past month use)

Respondents were able to check as many products as they had heard of, tried and used in the past 30 days. For each question, ENDS were listed as one of these products. In 2009, respondents were asked:

1. “Have you ever heard of any of the following products: Snus, dissolvable tobacco products, electronic cigarettes, flavoured little cigars, nicotine water, flavoured cigarettes?” (awareness)
2. “Have you ever tried any of the following products, even just one time: Snus, dissolvable tobacco products, electronic cigarettes, flavoured little cigars, nicotine water, flavoured cigarettes?” (ever use)

Again, ENDS were listed as one of these products, and respondents were able to check as many products as they had heard of and tried. Because past month use was not included in the 2009 ConsumerStyles, we were unable to compare past month use of ENDS between 2009 and 2010.

Using responses to these survey questions, survey procedures in SAS V9.2 (SAS Institute Inc.) software were used to create weighted percentages and 95% CIs of awareness and ever use of ENDS for 2009 and 2010 and of past month use of ENDS for 2010. In order to create a data set with demographics matching the US population, survey weights were generated based on gender, age, income, race and household size according to Current Population Survey proportions. Z-tests were used to determine if the percentage of adults who heard of ENDS and the percentage of adults who had ever tried ENDS changed from 2009 to 2010 (p<0.05). Because sample size was sufficient in 2010 to examine the demographics of those who had heard of, tried and used ENDS in the past month, estimates from the 2010 survey were stratified by select demographic groups, and unadjusted ORs were calculated to compare awareness, ever use and past month use of ENDS by sex, age group, race, income, educational attainment, region of residence, cigarette smoking status and tobacco use. Current smoking status was separated into three categories: current smoker, former smoker and never-smoker. Current smokers were defined as adults who reported smoking ≥100 cigarettes in their lifetime and currently smoke everyday or some days; former smokers had smoked ≥100 cigarettes in their lifetime but currently do not smoke at all; never-smokers had not smoked 100 cigarettes in their lifetime. Tobacco users were defined as adults who reported current cigarette smoking or using at least one of the following products in the past 30 days: cigars, cigarillos or little cigars; chewing tobacco, snuff or dip; snus; dissolvable tobacco products; flavoured little cigars; water pipes also known as hookahs; clove cigarettes or clove cigars; roll your own cigarettes or flavoured cigarettes. A tobacco user who reported using more than one of these products was considered a user of multiple tobacco products. Non-tobacco users were defined as never- or former smokers who had not used any of these tobacco products in the past 30 days.

Some analyses were subset to include only adults who reported that they had heard of ENDS. Because ENDS have been marketed as a cessation aid, we also compared reported quitting behaviours of current smokers who had tried ENDS with those of smokers who had not. Quitting behaviours we were able to examine include intention to quit smoking and quit attempts in the past year. Intention to quit was defined based on the answer to the question, “What best describes your intentions regarding quitting smoking: Never plan to quit, will quit in the next 7 days, will quit in the next month, will quit in the next 6 months, or will quit in the next year?” A quit attempt in the past 12 months was defined based on the answer to the question, “During the past 12 months, have you stopped smoking for 1 day or longer because you were trying to quit smoking: Yes, No?”

**RESULTS**

Awareness of ENDS approximately doubled from 16.4% in 2009 to 32.2% in 2010 (z=16.6, p<0.01) in this US sample (figure 1). Awareness of ENDS increased among all demographic groups from 2009 to 2010 (p<0.05), but the groups reporting the largest increases in awareness were current smokers (2009: 20.7%; 2010: 49.6%) and adults between 35 and 44 years of age (2009: 16.4%; 2010: 37.1%) (data not shown). The proportion of adults nationally who had tried ENDS more than quadrupled from 2009 (0.6%) to 2010 (2.7%; z=6.6, p<0.01). In 2010, 1.2% of adults (n=115) had used ENDS in the past month. Among the 249 adults who had heard of and tried ENDS, 45.0% had used one in the past month.

In 2010, differences between awareness of ENDS and having tried ENDS were noted. Although men had heard of ENDS more often than women (OR=1.54, 95% CI 1.17 to 1.58), men who had heard of ENDS were less likely than women to try ENDS (OR=0.59, 95% CI 0.40 to 0.86) (table 1). Those with less than high school education were less likely to have heard of ENDS (OR=0.67, 95% CI 0.47 to 0.96); yet they were almost three times more likely to try an ENDS (OR=2.90, 95% CI 1.13 to 7.45) and more than three times as likely to have used an ENDS in the past month than those who earned a college degree or higher education (OR=3.47, 95% CI 1.15 to 10.46). Although no differences in awareness of ENDS were observed by reported income, adults with an income <$15 000 who had heard of ENDS were more likely to try an ENDS than adults earning ≥$60 000 (OR=2.24, 95% CI 1.25 to 4.02). African–Americans and Hispanics were less likely to have heard of ENDS, yet they were just as likely to have tried an ENDS when compared with Caucasians (p=0.05).

Current cigarette smokers were 2.5 times as likely as never-cigarette smokers to have heard of ENDS and were almost six times as likely to have tried and three times as likely to have used ENDS in the past month (OR=2.50, 95% CI 2.09 to 3.00; OR=5.71, 95% CI 5.72 to 8.76 and OR=3.06, 95% CI 1.72 to 5.42, respectively). When we examined overall tobacco use, 45.1% of tobacco users had heard of ENDS whereas one-quarter of non-tobacco users had heard of ENDS (OR=2.06, 95% CI 1.77 to 2.39; OR=2.63, 95% CI 2.09 to 3.32).
Tobacco users were even more likely to try an ENDS and use one in the past month compared with non-tobacco users (OR=5.55, 95% CI 3.80 to 8.11; OR=4.21, 95% CI 2.53 to 7.01, respectively). Those who used multiple tobacco products were most likely to try an ENDS and use one in the past month compared with non-tobacco users (OR=7.17, 95% CI 4.56 to 11.78; OR=7.10, 95% CI 3.89 to 12.96, respectively).

Among current cigarette smokers, those who tried ENDS did not differ significantly from those who had never tried ENDS in their plans to quit smoking or in their attempts to quit smoking within the past year (p=0.05) (figure 2).

**DISCUSSION**

ConsumerStyles is not a population-based probability survey. However, despite this limitation, this data source allows us an indication of the popularity of ENDS in the USA. To our knowledge, this is the first national study of ENDS awareness and use among US adults. Our results indicate a doubling in the proportion of US adults who are aware of these products from 2009 to 2010, and while a low proportion of adults had ever used an ENDS in 2010 (2.7%), this estimate has more than quadrupled since 2009 (0.9%). These findings highlight the need to perform more rigorous surveillance of this product and its effects.
Our results indicate that certain demographic groups were more aware of ENDS than others. Men, young adults, adults with less education, Caucasian and tobacco users were most aware of this product. Due to the modes of advertising for ENDS, it is perhaps unsurprising that younger persons are more aware of these products. ENDS are aggressively advertised on the internet through web pages on Facebook, YouTube.com promotional videos and search engine sites such as Google, Yahoo and MSN, and these internet ads have received a growing audience over the past 2 years. There is also a 'growing presence of e-cigarettes at shopping mall kiosks'. However, our results revealed inconsistent demographic patterns between awareness and use of ENDS; although men and young adults were more aware of ENDS, they did not try this product more often. These inconsistencies may indicate that ENDS do not necessarily appeal to the demographic groups who are more aware of ENDS somehow, perhaps by exposure to ENDS advertising. However, future research is needed to test this theory.

Although we were unable to address cigarette smokers’ and tobacco users’ motivations for using ENDS in this study, this information would be informative for tobacco control. Use of ENDS rather than proven cessation methods may (or may not) have negative health consequences and may (or may not) delay successful quitting. Preliminary research has shown that ENDS users most often use this product to assist them in quitting and that ENDS may help to alleviate the desire to smoke after abstinence; reduce their cigarette consumption and perhaps encourage short periods of smoking abstinence. Despite the possible use as a cessation aid, our results showed no difference in the intentions to quit of ENDS users compared with non-users, suggesting that current smokers who use ENDS are no more motivated to quit than non-users of ENDS. Furthermore, our findings indicate that ENDS may not encourage quit attempts by smokers. Nevertheless, more research on the long-term individual and population impact of this product on quitting is needed.

ENDS may also impact the initiation of tobacco use. One in 28 never-smokers in our sample had tried ENDS. As mentioned above, ENDS are currently available through the internet and shopping mall kiosks, and these locations make ENDS available to younger users. Although the sale of tobacco products to minors is banned in all 50 states in the USA, only five states (New Hampshire, Arizona, Oregon, Minnesota and New Jersey) ban the sale of ENDS to minors (<18 years). ENDS resemble traditional cigarettes and could potentially be used as a starter product in establishing nicotine addiction and promoting and maintaining cigarette smoking, while thwarting efforts to reduce the social acceptability of smoking. Although we were unable to examine ENDS use among adolescents, our results do indicate that young adults are more aware of ENDS than older adults. Therefore, in addition to monitoring efforts among adults, future studies should consider monitoring awareness and use of this product among adolescents.

It is too soon to determine the long-term health effects of ENDS; however, preliminary studies have observed the presence of glycerin, genotoxins, known carcinogens and diethylene glycol in some ENDS, which can be harmful to humans. Specifically, diethylene glycol has been found a cartridge of ENDS manufactured in China. Diethylene glycol has caused mass poisoning and deaths in the past when substituted for propylene glycol. Other studies have shown that ENDS brands vary in terms of chemical delivery and their ability to suppress nicotine withdrawal symptoms, and many ENDS users are concerned with the toxicity of these products. Additional studies have shown that ENDS require more suction than traditional cigarettes to deliver product, which makes dosing non-uniform over time and may also be harmful to the user’s health. Considering the increasing awareness and ever use highlighted in our study, research is warranted to establish the health consequences and population impact of ENDS; findings from this research would be used to better inform the public of any identified health consequences. Unless they make therapeutic claims (e.g., cessation), ENDS are considered tobacco

Figure 2: Comparison of intention to quit smoking and past year quit attempts among US smokers (adults who reported having smoked 100 cigarettes in their lifetime and currently smoke everyday or on some days) who have tried an electronic nicotine delivery system (ENDS) and smokers who have not—ConsumerStyles 2010.
products. Although current FDA jurisdiction over tobacco products is limited to cigarettes, smokeless tobacco products and roll your own tobacco, FDA has stated its intent to assert jurisdiction over all tobacco products.\(^6\)

Finally, should ENDS increase in popularity, it would be crucial for public health researchers to evaluate their impact on compliance with smoke-free policies in workplaces, restaurants and bars. Currently, 25 states and the District of Columbia have comprehensive policies,\(^12\) as do a number of local US jurisdictions. The US Department of Transportation has proposed banning the use of ENDS on airplanes,\(^13\) and although some states, including New York, have considered banning the use of ENDS in public places,\(^20\) no state or locality has yet enacted such a policy. Since use of ENDS in places with smoke-free policies may give the appearance of smoking traditional cigarettes, this behavior could ultimately undermine smoke-free policies, by giving the appearance that smoking is acceptable, and make enforcing these policies more difficult.

As previously mentioned, there are limitations that should be noted when considering our results. First, survey questions slightly differed between 2009 and 2010. In 2010, the prompt for e-cigarette was added to the ENDS option in the survey. It is possible that this prompt made some respondents more readily recognize this product in 2010, which could partly contribute to the increase in awareness and use from 2009 to 2010. Second, ConsumerStyles is a mail-in survey, thus persons in the USA without a mailing address may be underrepresented. Third, response rate of the 2009 ConsumerStyles was 49.8% and 2010 ConsumerStyles was 51.6% which indicates the opportunity for non-response bias. Fourth, all estimates in this study are based on self-reported use of ENDS and may be subject to reporting bias; although previous studies have demonstrated high validity of estimates of self-reported use of some tobacco products, such as cigarettes,\(^21\) smokeless tobacco and snus,\(^22\) we cannot be certain respondents accurately reported use of ENDS. Despite these limitations, estimates obtained from the 2009 to 2010 ConsumerStyles on smoking prevalence are consistent with those of large national household surveys like the 2009 National Household Interview Survey (NHIS), suggesting strong reliability of these estimates (2009 ConsumerStyles: 19.6%; 2009 NHIS: 20.6%; 2010 ConsumerStyles: 18.2%; 2010 NHIS: 19.4%).\(^23\)\(^24\)

In conclusion, our findings indicate that ever use of ENDS has increased from 2009 to 2010. Because usage may continue to increase, appropriate public health surveillance of ENDS is necessary. It is crucial that future research evaluate what impact this usage has on smoking cessation, initiation, users’ health and compliance with public non-smoking policies.

**References**

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