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Gender differences influence overweight smokers' experimentation with electronic nicotine delivery systems

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Abstract

Introduction—Overweight and obese tobacco users possess increased risk of cancer, diabetes, heart disease and chronic tobacco-related disease. Efforts to prevent tobacco-related health risk in this comorbid population would be informed by better understanding and monitoring of trends in the concurrent use of electronic nicotine delivery systems (ENDS) among smokers in the US marketplace.

Method—The California Longitudinal Smokers Study (CLSS) established a cohort of current cigarette smokers in 2011 who were surveyed for tobacco use and health behavior at baseline and again in 2012 at follow-up.

Results—We observed a large increase in reported experimentation with ENDS. As hypothesized, overweight or obese smokers were more likely to report experimentation with ENDS, an increase that was also observed among women. Experimentation with ENDS was not associated with a reduction in use of cigarettes or a decrease in cigarette dependence in this high risk population of smokers.

Conclusions—Continued surveillance of this vulnerable population is needed to better understand how experimentation with new ENDS products may impact health, facilitate switching to non-combustible tobacco or facilitate persistent cigarette dependence.

Keywords

Electronic cigarettes; Electronic nicotine delivery system; Overweight; Obese; Tobacco products

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Contributors

Drs Strong, Myers, and Linke helped to design the study with significant input from Mr Leas and Drs Hofstetter, Edland and Al-Delaimy. Mr Leas, Drs Hofstetter and Al-Delaimy helped to write and edit the manuscript. Dr. Edland participated in guiding data analyses and statistical procedures conducted by Dr. Strong.

Conflict of interest

No authors have any conflict of interest.

1. Introduction

Tobacco use and obesity are the leading causes of morbidity and mortality worldwide (Haslam & James, 2005; Mokdad et al., 2003). Rates of obesity are particularly high among heavier smokers (Chiolero, Faeh, Paccaud, & Cornuz, 2008) and 37–65% of smokers seeking cessation treatment are overweight or obese (Bush et al., 2008). Weight loss and tobacco cessation have been a focus of public health efforts to decrease risk for diabetes, heart disease, lung disease, cancer, and chronic illness in vulnerable populations of overweight or obese smokers. As new nicotine and tobacco products enter the marketplace, attention to products that may appeal to this high risk population is heightened. Electronic nicotine delivery devices (ENDS) have seen a dramatic increase in the US (Kasza et al., 2011; Yamin, Bitton, & Bates, 2010), have rapidly captured consumer interest since 2008 (Ayers, Ribisl, & Brownstein, 2011; King, Alam, Promoff, Arrazola, & Dube, 2013; Zhu et al., 2013) and have generated a multibillion dollar industry. Among smokers in the US, estimates of experimentation with ENDS range from 11.4% in 2010 (Pearson, Richardson, Niaura, Vallone, & Abrams, 2012), 21.2% in 2011 (Kasza et al., 2011), and 32.18% in 2012 (Zhu et al., 2013). Experimentation among smokers has been concentrated among youth and non-Hispanic whites (Kasza et al., 2011; Pearson et al., 2012; Zhu et al., 2013) though aggressive marketing efforts seek to expand markets (de Andrade, Hastings, Angus, Dixon, & Purves, 2013). While the significance of ENDS in supporting cessation and serious concerns about ENDS sustaining nicotine dependence continue to be debated (Etter, 2012; Henningfield & Zaatari, 2010; IOM, 2012) attention to trends in product use in vulnerable populations of overweight or obese smokers is needed to better understand the potential impact in populations with disproportionate tobacco-related disease.

ENDS may have a particular appeal to overweight or obese smokers seeking alternative means of nicotine self-administration to manage appetite and weight concerns that may interfere with cessation (French & Jeffery, 1995). Nicotine intake has been associated with decreased appetite (Jessen, Buemann, Toubro, Skovgaard, & Astrup, 2005; Mineur et al., 2011), increased metabolic expenditure (Chiolero et al., 2008; Collins, Cornelius, Vogel, Walker, & Stamford, 1994; Hofstetter, Schutz, Jequier, & Wahren, 1986; Perkins et al., 1991) and decreased body weight (Bamia, Trichopoulou, Lenas, & Trichopoulos, 2004). Many tobacco users endorse the belief that nicotine is effective in weight control (Potter, Pederson, Chan, Aubut, & Koval, 2004). However, the potential acute weight-regulating effects of nicotine may not be available to chronic tobacco users. Among regular smokers, acute nicotine intake has been associated with increased hunger and increased caloric intake during meals (Perkins et al., 1992). In several population studies, heavier smoking has been positively associated with higher BodyMass Index (BMI) (Chiolero et al., 2008; John, Hanke, Rumpf, & Thyrian, 2005; Mackay, Gray, & Pell, 2013; Rasky, Stronegger, & Freidl, 1996). Although there has been mixed objective support for tobacco use in managing weight, concerns about weight remain a powerful motive predictive of tobacco use initiation (Potter et al., 2004), persistent nicotine dependence and a barrier to cessation (Jeffery, Hennrikus, Lando, Murray, & Liu, 2000; Meyers et al., 1997; Ockene et al., 2000).

Tobacco industry has long promoted products associated with themes targeting weight control, including suggestions for substitution of tobacco for sweets, and use of packaging

(Pierce et al., 2010) to appeal to weight-concerned women (USDHS, 2001). Themes of weight control are readily apparent in marketing materials for ENDS products. Emerging products highlight effective delivery of nicotine with hundreds of flavors including many sweets that may appeal to broad tastes (de Andrade et al., 2013; Grana & Ling, 2014) or directly include descriptions of appetite control and weight loss. Concerns about gaining weight when quitting smoking are common, particularly among women (Klesges & Klesges, 1988; Pirie, Murray, & Luepker, 1991). The potential inclusion of weight control messages and broadened flavorings may make these ENDS products particularly appealing to women and overweight or obese smokers interested in cessation or reduction in their tobacco use.

We hypothesize that experimentation with ENDS will be more common among overweight or obese smokers than their normal weight counterparts. We also hypothesized that given more frequent weight concerns among women when considering making changes in tobacco use, the effect of weight status on the likelihood of experimenting with ENDS would be stronger among women than men. Hypotheses were tested within the California Longitudinal Smokers Study (CLSS) that assessed tobacco and ENDS use in a cohort assessed in 2011 and again in 2012. Primary hypotheses will be followed by exploration of whether a relationship between levels of weight concerns at the initial assessment and ENDS experimentation over time differed by weight status. Finally, we examined whether experimentation with ENDS was consistent with concurrent patterns of reduction in cigarette consumption or cigarette dependence with consideration for demographic characteristics and mental health concerns associated with weight status and known to influence both experimentation with ENDS and tobacco use.

2. Method

2.1. California Longitudinal Smokers Study

The data used in the present study are from the 2011 California Longitudinal Smokers Survey (CLSS). The CLSS is a follow-back survey of smokers who participated in the 2009 California Health Interview Survey (CHIS 2009), a population-based random sample of California residents. CHIS 2009 data collection spanned from December 27th, 2009, through May 26th, 2010 (Edwards, et al., 2011). The CLSS re-contact began in July 2011 and concluded in April 2012 and smokers were contacted again during a follow-up period that lasted from November 6, 2012 and January 16, 2013. Of the 1745 eligible smokers from the 2010–11 survey cohort, responders to CLSS included 1000 adults aged 18 years or older who reported current cigarette smoking in 2010–11 and completed a follow-up survey in 2012–13. Analyses in the current study were limited to the 1000 current smokers from this sample who were identified and agreed to be followed in the longitudinal component of the study.

2.2. Measures

2.2.1. Demographic characteristics—Survey questions included age of the respondent, coded 18–24, 25–44, and 45–59. Ethnic/racial status was coded for Non-Hispanic white or other ethnicity/racial group. Smokers provided self-reported height and weight which were used to compute Body Mass Index, acknowledging that self-reported weight may result in

overestimation of height, underestimation of weight, and thereby result in an underestimation of BMI in population surveys (Gorber, Tremblay, Moher, & Gorber, 2007). Smokers were classified as normal weight when BMI was <25 or overweight or obese when BMI was ≥ 25.

2.2.2. Smoking characteristics—The survey instrument for the CLSS included detailed information on the frequency and quantity of cigarette smoking. Frequency was assessed with the question “On how many of the past 30 days did you smoke cigarettes?” Quantity was assessed with the question “During the past 30 days, on the days that you *did* smoke, about how many cigarettes did you usually smoke?”. Cigarette dependence was assessed using the Heaviness of Smoking Index (HSI) which sums categories of current cigarettes per day (0 = 0–10; 1 = 11–20; 2 = 20–30; 3 = 31+) and the “time to first cigarette” (TTFC) question “How soon after you awake in the morning do you usually smoke your first cigarette?” (0 for ‘> 60 min’, 1 for ‘31–60 min’, 2 for ‘6–30 min’, and 3 for ‘≤ 5 min’). The HSI is a reliable index of cigarette dependence over time (Borland, Yong, O’Connor, Hyland, & Thompson, 2010) and was scaled among current smokers and quitters with higher scores reflecting more dependence.

2.2.3. Anxiety and depression symptoms—Patient Health Questionnaire for Depression and Anxiety (PHQ-4; (Kroenke, Spitzer, Williams, & Lowe, 2009). The survey poses the overall question: “Over the past 2 weeks have you been bothered by these problems?” The two clusters of anxiety symptoms it assesses are: 1) feeling nervous, anxious, or on edge; and 2) not being able to stop or control worrying. The two clusters of depression symptoms it assesses are: 1) feeling down, depressed, or hopeless; and 2) little interest or pleasure in doing things. Participants chose between the following four options for each of the four items: 1) not at all; 2) several days; 3) more days than not; and 4) nearly every day. Total scores on the PHQ-4 were used to elaborate on combined risks associated with symptoms of these disorders.

2.2.4. Weight concerns—The survey included two tobacco-related weight concern questions to examine. Respondents were asked: “How concerned are you that you may gain weight if you quit smoking?” Response options ranged from ‘not at all concerned’, ‘somewhat concerned’, or ‘very concerned’ and were scaled from 0 to 2. Respondents were also asked: “Please tell me if any of these reasons are true for you...you’re still smoking because smoking helps you control your weight. Is this a reason why you don’t quit smoking?” Responses to this question are ‘Yes’ or ‘No’.

2.2.5. Electronic nicotine delivery system (ENDS) experimentation—Respondents were asked about experimentation with e-cigarettes using the following text: “Electronic cigarettes, also known as ecigarettes, are devices that look like cigarettes and contain nicotine, but do not produce smoke. Some brands are The Safe Cig, Green Smoke, and Blu. What describes you best regarding your use of e-cigarettes...” Smokers were coded as having experimented with e-cigarettes if they responded ‘You have used e-cigarettes.’ All other responses (e.g. ‘you might use e-cigarettes’ or ‘you will never use e-cigarettes’) were coded as not having experimented with ENDS.

2.3. Analytic plan

Maximum likelihood estimation of generalized linear mixed effects models (GLMM) were used to estimate reports of experimentation with ENDS at the 2011 and 2012 assessments. Planned covariates with known associations to cigarette and ENDS use (Kasza et al., 2011; Pearson et al., 2012) included age, education, racial/ethnic group, level of cigarette dependence, frequency of cigarette smoking (daily/nondaily), level of mental health problems (Cummins, Zhu, Tedeschi, Gamst, & Myers, 2014) and the linear effect of time. We examined whether gender and overweight or obese status at the 2011 assessment was associated with differences in reports of ENDS experimentation over assessments. The statistical significance of interaction terms (time * weight status; time * gender; weight status * gender) was examined as a set along with covariates, and all lower-order terms. We also explored whether a relationship between level of weight concerns at the initial assessment and ENDS experimentation over time differed by weight status (weight concern * weight status). Finally, we explored the potential impact of ENDS product use on cigarette smoking. We sought to understand whether ENDS use among overweight or obese smokers was related to a significant reduction in cigarette consumption or if ENDS use was related to a reduction in levels of cigarette dependence. We used generalized linear and linear mixed effects models to examine time-varying associations of ENDS use with rates of smoking reduction and levels of cigarette dependence over time among overweight or obese smokers.

3. Results

3.1. Participants

Table 1 lists characteristics of the demographic, smoking, and weight characteristics of the CLSS participants who were smoking in 2011 and were approached for the 2012 survey (n = 1000). Among current smokers, 51.5% of women (n = 269/522) and 63.6% of men (n = 304/478) were classified as overweight or obese (BMI ≥ 25).

3.2. Experimentation with ENDS

Among smokers, 20.9% of women and 26.5% of men reported having experimented with ENDS at the 2010 survey. By the 2012 survey, 36.0% of women and 32.0% of men reported having experimented with ENDS. Fig. 1 presents the percentage of women and men smokers who reported using ENDS at the 2011 and 2012 surveys by weight status. With adjustment for planned covariates for age, ethnic/racial group, education, level of nicotine dependence, frequency of smoking and level of anxiety/depression, we observed significant increases in rates of experimentation with ENDS over time ($\beta=1.13$, $SE=0.16$, $p < 0.001$), an effect that was significantly stronger among overweight/obese smokers relative to their normal weight counterparts (Year*Weight Status) and stronger among women than men (Year*Gender). Table 2 lists the individual effects from the planned analysis with a GLMM. Although women were less likely than men to report experimenting in 2011 ($\beta = -0.77$, $SE=0.42$), women's reports of experimenting increased more rapidly than men through 2012 ($\beta = 1.23$, $SE = 0.38$, $p = 0.001$). We also observed significantly greater increase in experimentation among overweight or obese smokers relative to their normal weight counterparts ($\beta = 0.91$, $SE = 0.36$, $p = 0.01$). These interaction effects were both significant statistically and reflected an additive likelihood of ENDS experimentation for

women who were also overweight or obese. Experimentation with ENDS increased from 22.7% in 2011, to 41.3 % in 2012 among overweight or obese women smokers.

3.3. Weight concerns

In exploratory regression models with planned covariates mirroring primary outcomes, overweight or obese smokers reported greater concern ‘That you may gain weight if you quit smoking’ ($\beta=0.31$, $SE=0.06$, $p<0.0001$) than their normal weight counterparts. Agreement with the statement that they do not quit smoking because ‘Smoking helps you control your weight’ ($\beta=-0.18$, $SE=0.18$, $p=0.31$) was not significantly different for overweight or obese and normal weight smokers. Average ratings of concern with weight gain upon cessation were 0.92 ($SD=0.87$) and 0.66 ($SD=0.84$) among overweight or obese and normal smokers, respectively. Rates of agreement with the belief that decisions not to quit are motivated by weight control were 21.8% among overweight or obese and 20.0% among normal weight smokers.

We examined the relationship between these two weight-related concerns and experimentation with ENDS using the primary outcome models described above with planned covariates. Weight-related concern from 2011 was evaluated in the primary outcome models describing rates of experimentation with ENDS over time. Neither expectancies that smoking helps control weight ($\beta=-0.26$, $SE=0.35$, $p=0.46$) nor concern with weight gain upon quitting ($\beta=0.19$, $SE=0.36$, $p=0.60$) were related to experimentation with ENDS over the two assessments. Interaction terms (weight status * weight concern questions) also did not support a differential relationship between agreement with smoking helps control weight ($\beta=0.38$, $SE=0.33$, $p=0.25$) nor concerns about weight upon quitting ($\beta=0.36$, $SE=0.80$, $p=0.65$) and ENDS experimentation among overweight or obese smokers relative to normal weight smokers.

3.4. Smoking reductions and cigarette dependence

In GLMM with planned covariates mirroring primary outcomes, we did not observe significant increases in rates of reported reductions in smoking over assessments among smokers reporting concurrent experimentation with ENDS ($b=0.20$, $SE=0.15$, $p=0.19$). Evaluation of the interaction of initial weight status with concurrent experimentation with ENDS did not support a relationship between experimentation with ENDS and a reduction in cigarettes during the evaluation period ($\beta=-0.08$, $SE=0.30$, $p=0.79$). Linear mixed effects models of level of HSI in 2011 and 2012, including all remaining planned covariates, did not support a significant association with the time-varying indicator of ENDS experimentation ($\beta=-0.05$, $SE=0.05$, $p=0.28$) or the interaction of ENDS experimentation and weight status ($\beta=-0.01$, $SE=0.09$, $p=0.88$).

4. Discussion

In this analysis of longitudinal data from the California Longitudinal Smokers Study (CLSS) we examined changes in reports of experimentation in use of ENDS in a high-risk subgroup of overweight and obese smokers. We found that overweight or obese smokers and women had a greater increase in ENDS experimentation than other smokers across this one-year

period. In this sample, increased experimentation among overweight or obese women was pronounced, rising from 22.7% in 2011, to 41.3% in 2012. Neither expectancies that smoking helps control weight nor concern with weight gain upon quitting were related to experimentation with ENDS over the two assessments. Experimentation with ENDS among overweight or obese smokers was not related to reductions in consumption of cigarettes or changes in cigarette dependence. These findings suggest increases in use of new and emerging tobacco products in a vulnerable population that carries a disproportionate burden of tobacco-related disease and no significant change in tobacco use or improved rate of cessation.

Rapidly escalating competition among ENDS products has generated marketing strategies that promote weight control and product characteristics such as flavorings that may appeal to at-risk populations of overweight or obese tobacco users. The present findings of greater increases in experimentation among overweight and obese smokers may reflect the effectiveness of these marketing efforts. ENDS marketing efforts that promote product characteristics using tools that have been disallowed for tobacco products may lead to further increases in experimentation and/or uptake among overweight/obese smokers. This assertion is supported by evidence of rapidly increasing advertising expenditures for ENDS (Health, 2014).

The present findings mirror previous studies documenting steady increases in ENDS use in the US among current cigarette smokers, with 11.4% in 2010 (Pearson et al., 2012) 16% in 2011 (Kasza et al., 2011) and 27% in 2012 (Zhu et al., 2013). Our findings of rapid increase in rate of ENDS experimentation among women contrasts previous studies finding of no gender differences (Kasza et al., 2011; King et al., 2013; Pearson et al., 2012). However, a recent US national survey of current cigarette smokers suggested women were more likely than men to have experimented with ENDS (Zhu et al., 2013). New product features such as flavorings may encourage sustained nicotine intake by appealing to taste sensitivities (Bartoshuk, Duffy, Hayes, Moskowitz, & Snyder, 2006) or by leveraging the appeal of ENDS for example, to control appetite without cigarettes or sweetened food (Scientific Committee on Emerging and Newly Identified Health Risks, 2010; World Health Organization, 2007). These features may be of particular appeal to women.

We did not observe a concordant decrease in cigarette consumption or change in cigarette dependence among overweight or obese smokers with ENDS experimentation. Although suggestive of ENDS use alongside cigarette consumption in this cohort, we were unable to assess the frequency of ENDS use to determine the potential for ENDS as a substitute for cigarettes.

At this time the consequences of a shift to use of ENDS by current cigarette users is unknown. The potential of ENDS to reduce the significant harm from persistent cigarette smoking has been met with concerns. Beliefs of reduced harm from ENDS may translate to sustained nicotine dependence in part by adding an appealing alternative mode of nicotine intake that would complement rather than replace continued cigarette consumption. As such, attention to patterns of ENDS use and their impact on cigarette smoking is particularly important in disproportionately impacted subgroups such as overweight and obese smokers.

This cohort study has several limitations including reliance on self-reported variables (i.e., experimentation with ENDS, smoking patterns, height and weight). Given the exploratory data collection, the survey was not able to provide details about reasons for experimentation, ratings of the appeal of broad product characteristics (i.e., flavors) or elaborated descriptions of use patterns (i.e. quantity or frequency). The hypotheses that guided this investigation were exploratory and greater understanding of ENDS use is needed to better identify mechanisms leading to increased initiation of ENDS among overweight or obese smokers. As with all cohort studies, generalizability may be compromised by attrition.

Being overweight or obese and using tobacco may act synergistically to promote disease progression (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003) increased morbidity and higher mortality. We observed significant increases in experimentation with ENDS among overweight or obese smokers. Although clear understanding of the harmfulness of ENDS product characteristics remains an active area of research, rapid increases in experimentation may suggest careful monitoring of use given the appeal of ENDS products within this high-risk co-morbid population. Attention to ENDS uptake and effects on cigarette consumption within vulnerable populations is needed to evaluate the net public health impact of these emerging tobacco products.

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HIGHLIGHTS

- We observed a large increase in reported experimentation with ENDS from 2011 to 2012.
- Overweight or obese smokers were more likely to report experimentation with ENDS.
- Experimentation with ENDS was not associated with a reduction in use of cigarettes or a decrease in cigarette dependence.

Fig. 1.

Increase in the percentage of cigarette smokers who experimented with electronic cigarettes in 2011 and 2012 was larger for overweight/obese smokers relative to normal weight smokers and among women relative to men. Error bars reflect 95% confidence intervals for each percentage.

Table 1

California Longitudinal Smokers Study participant characteristics (n= 1000).

Characteristics	n	California smokers (%)
Age (years)		
18–24	45	4.5%
25–44	257	25.7%
45–64	698	69.8%
Gender		
Male	478	47.8%
Female	522	52.2%
Race		
Non-Hispanic white	726	72.6%
All others	274	27.4%
Education		
High school or less	348	34.8%
Some college	652	65.2%
Heaviness of smoking (HIS)		
0	403	40.3%
1	357	35.7%
2	146	14.6%
3–4	66	6.6%
Missing	28	2.8%
Smoking frequency		
Daily	837	83.7%
Non-daily	163	16.3%
PHQ-4		
Mean	–	3.42
SD	–	3.38
Missing	54	5.4%
Weight status		
Normal weight (BMI < 25)	390	39.0%
Overweight/obese (BMI ≥ 25)	553	55.3%
Missing	37	3.7%

Table 2

Generalized linear mixed effects logistic regression model estimates of association between gender and weight status on cigarette smokers' reports of experimentation with electronic cigarettes across 2011 and 2012 assessments.

Variable	Beta	Std. error	z value	p
Year	0.58	0.39	1.47	0.142
Female	-1.28	0.84	-1.53	0.127
Overweight/obese	-0.22	0.86	-0.26	0.797
Year * female	1.23	0.38	3.24	0.001
Year * overweight/obese	0.91	0.37	2.49	0.013

Note: model includes planned covariates for age, ethnic/racial group, education, level of cigarette dependence, frequency of smoking, and level of anxiety/depressive symptoms.