

Title: Trends in awareness, use of, and beliefs about electronic cigarette and snus among a longitudinal cohort of US Midwest young adults

Authors:

Kelvin Choi, PhD, MPH

Institution: Division of Intramural Research, National Institute on Minority Health and Health Disparities

Address: 9000 Rockville Pike, Building 3 RW05, Bethesda, MD 20892, USA

Email: kelvin.choi@nih.gov

Jessica Bestrashniy, PhD

Institutions: Woolcock Institute of Medical Research; Tuberculosis Centre of Research Excellence

Addresses: 431 Glebe Point Road, Glebe, NSW 2037, Australia; Building 93, RPA Hospital,

Missenden Road, Camperdown, Sydney 2050, Australia

Jean Forster, PhD, MPH

Institution: Division of Epidemiology and Community Health, University of Minnesota

Address: 1300 South Second Street, Suite 300, Minneapolis, MN 55454, USA

ABSTRACT

Introduction: Few longitudinal studies have examined how awareness, use of, and beliefs about electronic cigarettes (e-cigarettes) and snus change over time. We assessed these trends in a cohort of young adults from the US Midwest.

Methods: Data were from the Minnesota Adolescent Community Cohort (MACC) Study, collected annually during 2010-2013 when participants were 21-29 years old (n=2622). Participants were asked if they had heard of and ever used e-cigarettes and snus, and the number of days they used these products in the past 30 days. Beliefs about whether these products are less harmful than cigarettes, less addictive than cigarettes, and could help people quit smoking were assessed. Repeated measures multiple linear and logistic regression models, adjusting for demographics, peer smoking and smoking status, were used to assess trends.

Results: Compared to 2010-2011, participants in 2012-2013 were five times more likely to be aware of e-cigarettes, report ever used them, and report using them in the past 30-days. Increases in e-cigarette use were observed in all smoking status. Participants were also increasingly likely to believe that e-cigarettes are less harmful than combustible cigarettes and could help people quit smoking. There was only a modest increase in awareness of and ever using snus, as well as believing snus is less harmful than combustible cigarettes. These trends did not differ by smoking status.

Conclusions: The increasingly favorable beliefs about e-cigarettes may explain the increasing prevalence of their use particularly among young adults, both among smokers and nonsmokers.

IMPLICATIONS

Awareness and use of e-cigarettes has increased substantially over the past few years, and positive beliefs of e-cigarettes have also become more prevalent among young adults. Meanwhile, little changes in awareness, use of, and beliefs about snus among young adults. Given the potential of these products to have both positive and negative impact on public health depending on who use them and how they are used, strategically communicating the risks associated with e-cigarettes and snus use may help minimize the burden of tobacco use at the population level.

INTRODUCTION

Electronic cigarettes (e-cigarettes) and snus are a novel product that have been recently introduced into the US marketplace. E-cigarettes could potentially either reduce or increase the population burden caused by smoking. [1] Studies have found that e-cigarettes contain lower levels of toxicants compared to combustible cigarettes, [2] and e-cigarettes have been promoted as cessation aids by their manufacturers. [3, 4] If smokers switch completely from smoking combustible cigarettes to e-cigarettes, they could be reducing their risks of developing smoking-related illnesses. However, despite many users claiming to use e-cigarettes to quit or reduce smoking, [5-9] a recent meta-analysis showed that in population-based studies, smokers who use e-cigarettes were less likely than those who do not use e-cigarettes to be successful in quitting smoking. [10] On the other hand, a randomized controlled trial showed that smoking cessation rates were statistically indistinguishable between those who were randomized into using e-cigarettes and those randomized into using nicotine replacement therapy in assisting smoking cessation. [11] Meanwhile, e-cigarettes could increase the population burden caused by tobacco use if e-cigarette use leads to combustible cigarette smoking. Several US studies suggest that e-cigarette use is associated with subsequent combustible cigarette smoking among youth. [12-15]

Awareness and use of e-cigarettes in the US is increasing. The proportion of US adults (ages 18 years or above) who are aware of e-cigarettes increased from 40.9% in 2010 to 79.7% in 2013, and the proportion of US adults ever using e-cigarettes increased from 3.3% in 2010 to 8.5% in 2013. [16] In 2012-2013, among US adults who had ever used e-cigarettes, 29.8% reported any current use of e-cigarettes. [17] The beliefs about e-cigarettes also appear to be overall positive, with 50.7% of US adults believing that e-cigarettes are less harmful than combustible cigarettes in 2012-2013. [18]

Snus has also been proposed as a product that may reduce the population burden of tobacco use. Snus use has been associated with the decline in cigarette smoking in Sweden, [19] suggesting the potential of snus to be a harm reduction product. However, these observations have not been replicated in the US. For example, snus advertisements in the US rarely feature harm reduction or smoking cessation. [20] Additionally, while a study in Sweden found that snus use is not associated with smoking initiation, [21] while our previous research

showed that snus use predicted subsequent combustible cigarette smoking in a cohort of US Midwest young adult non-smokers. [22] Snus sold in the US also seems to be different from that in Sweden. Previous studies found that Swedish snus and US snus are different in their pH, moisture content, tobacco-specific nitrosamines, and other chemical compositions. [23, 24] Although the prevalence of snus use is not as high as e-cigarettes, among those US adults who had ever used snus, 15.9% reported any current use of snus in 2012-2013. [17] Beliefs about snus were also less favorable than of e-cigarettes. In 2009, only 4.5% of US adults who had heard of snus thought that snus is less harmful than combustible cigarettes. [25]

Our understanding of e-cigarette and snus is limited in the following ways. First, previous studies that examined e-cigarette and snus harm-related beliefs have only focused on their harm relative to combustible cigarettes. [18, 25, 26] They did not examine beliefs about these products related to their addictiveness and abilities to assist smoking cessation. Second, no studies to date have examined the trends in e-cigarette and snus-related beliefs using a longitudinal cohort study. Tan and colleagues attempted to examine e-cigarette harm-related beliefs over time by aligning the estimates from a few studies conducted between 2010 and 2013. [18] However, because of the differences in sampling frames and survey modes across these studies, it was difficult to determine if e-cigarette harm-related beliefs has changed over time. Third, some of these studies only include combustible cigarette smokers, [26] and therefore the trend in e-cigarette harm-related beliefs among nonsmokers is largely unknown.

In light of these limitations, we aimed to assess the trends in awareness and use of, and beliefs about e-cigarettes and snus among a cohort of young adults (aged 21-29) from the US Midwest. We focused on young adults because studies have shown that young adults are more likely to have tried e-cigarettes and snus, [7, 16] and to view them as less harmful than combustible cigarettes. [6, 25-27] Furthermore, young adults are still developing their tobacco use behaviors. [28, 29] Therefore, it is important to monitor the trends in awareness, use of, and beliefs about these novel tobacco products, especially since our previous work showed that positive beliefs of e-cigarettes (e.g., less harmful than cigarettes, helping people quit smoking) predicted subsequent experimentation with e-cigarettes among smokers and non-smokers alike. [30]

METHODS

Study Population

The Minnesota Adolescent Community Cohort (MACC) study is a population-based cohort study that began in 2000. The purpose of the study was to examine the development of tobacco use behaviors during adolescence and emerging adulthood. Sampling, recruitment, and data collection methods have been described in detail elsewhere. [31] Briefly, Minnesota was divided into 126 unique geopolitical units (GPUs), to reflect geographic, political, and tobacco control environments. Sixty GPUs were randomly selected for participant recruitment. In addition, five GPUs from four comparison states (North and South Dakota, Michigan, and Kansas) were selected due to their demographic similarities with Minnesota. To ensure equal age distribution, a combination of probability (random digit dialing) and quota sampling was used to sample one adolescent per household among eligible households (i.e., having at least one individual aged 12 to 16 years) from the selected GPUs. Clearwater Research, Inc. conducted sampling and recruitment.

A total of 3636 participants in Minnesota and 605 participants in comparison states were enrolled in 2000-2001 (recruitment rate of 58.5%). An additional cohort of 585 12-year-old participants from Minnesota were recruited in 2001-2002 from the 60 Minnesota GPUs using the same probability and quota sampling (recruitment rate of 63.6%), which brought the total study sample size to 4826. Telephone surveys that included questions about tobacco use and attitudes towards tobacco were completed every six months through 2007-2008, and then annually from 2008 to 2013. Monetary incentives (\$25) were provided for participation. The present study includes data collected in the 2010-2011, 2011-2012 and 2012-2013 data collection cycles (response rates were 69.1%, 67.6%, 64.4%, respectively). Compared to those who responded in these data collection cycles, individuals who did not respond were likely to be male, race/ethnic minorities, and younger (Chi-square $p < 0.05$). This study was approved by the University of Minnesota Institutional Review Board.

Measures

At each cycle of data collection, we assessed awareness and use of e-cigarettes and snus by asking the participants if they had ever heard of these products, ever used these products, and the number of days they used these products in the 30 days prior to the survey. Participants who were aware of e-cigarettes were also

asked about their beliefs related to e-cigarettes using a 5-point Likert-scale where they rated their levels of agreement with the following statements (strongly agree to strongly disagree): e-cigarettes can help people stop smoking cigarettes; e-cigarettes are less harmful than cigarettes; and e-cigarettes are less addictive than cigarettes. Similarly, participants who were aware of snus were asked to rate their level of agreement with the following statements using the same 5-point Likert scale: snus can help people stop smoking cigarettes; snus is less harmful than cigarettes; and snus is less addictive than cigarettes. Responses were later dichotomized where “strongly agree” and “somewhat agree” were categorized as “agree” and “neither agree nor disagree”, “somewhat disagree”, and “strongly disagree” were classified as “other.”

We collected information on covariates found to be associated with e-cigarette and snus awareness and use in previous studies. [27, 32] These included age, gender, race/ethnicity, peer smoking (number of friends out of four closest who smoke cigarettes), education (high school or less, more than high school but less than four-year college, four-year college or more), and smoking status (nonsmoker: <100 lifetime cigarettes; former smoker: smoked ≥ 100 cigarettes but none in the past 30 days; current smoker: smoked ≥ 100 cigarettes in their lifetime and smoked at least once in the past 30 days). Information on education, peer smoking, and smoking status were collected in every cycle.

Statistical Analysis

To assess the trends in awareness and use of and beliefs about e-cigarettes and snus, we employed repeated measures generalized linear models for dichotomous outcomes (i.e., awareness, ever used, past-30-day use, and beliefs) and repeated measures general linear models for a continuous outcome (i.e., number of days used in the 30 days prior to data collection). Data collection years (2010-2011, 2011-2012, and 2012-2013) were entered into the model as categorical variables, using 2010-2011 as the reference year, while adjusting for time-invariant demographics (e.g., race/ethnicity, gender) and time-variant covariates (e.g., education, peer smoking, and smoking status). We explored whether the trends in awareness, use, and beliefs varied by demographics, peer smoking, and smoking status by including interaction terms between these variables and data collection year. All analyses were conducted in SAS® version 9.3 (SAS Institute Inc.: Cary, NC) using PROC GLIMMIX and PROC MIXED to account for clustered sampling.

RESULTS

Table 1 presents the characteristics of the study sample at each data collection cycle. Demographic characteristics did not differ by data collection cycle ($p>0.05$), but number of peers who smoke and reported smoking status differed significantly by data collection cycle ($p<0.05$). Increasing proportions of the sample became aware of e-cigarettes, had ever used e-cigarettes, and had used e-cigarettes in the past 30 days during 2010-2013 ($p<0.05$). Increases in proportions of the sample ever using e-cigarettes and using e-cigarettes in the past 30-day across data collection cycle were observed in all smoking statuses ($p<0.05$). Number of days used e-cigarettes in the past 30 days also slightly increased ($p<0.05$). Also, among those who were aware of e-cigarettes, an increasing proportion believed that e-cigarettes help people quit smoking, are less harmful than cigarettes, and are less addictive than cigarettes ($p<0.05$). Regarding snus, there were slight increases in the proportion of the sample that became aware of snus and had ever used snus. There was a slight decrease in past 30-day use of snus, while the number of days used snus in the past 30-days remained stable. Among those who were aware of snus, the proportion of the sample believing snus helps people quit smoking and is less harmful than cigarettes slightly increased over time. However, none of these changes were statistically significant over time ($p>0.05$). The proportion of the sample believing snus is less addictive than cigarettes slightly decreased over time ($p<0.05$).

Table 2 shows the adjusted time effect on e-cigarette measures from multiple logistic and linear regression models. Compared to 2010-2011, young adults in the sample were over two times more likely and over five times more likely to have heard of, have ever used, and have used e-cigarettes in the past 30 days in 2011-2012 and 2012-2013, respectively, after controlling for demographics, peer smoking, and smoking status ($p<0.05$). Compared to 2010-2011, the number of days using e-cigarettes in the past 30 days did not increase in 2011-2012, but did increase in 2012-2013 by 0.19 days ($p<0.05$). However, among those who reported using e-cigarettes in the past 30-days, the number of days using e-cigarettes remained stable at around 4-5 days. Compared to 2010-2011, young adults in the sample were increasing likely to agree that e-cigarettes help people quit smoking and are less harmful than cigarettes over time ($p<0.05$), while no clear trend was

shown in agreeing e-cigarettes as less addictive than cigarettes. There were no interactions between these e-cigarette measures and demographics or smoking status ($p>0.05$).

Table 3 shows the adjusted time effect on snus measures from multiple logistic and linear regression models. Compared to 2010-2011, young adults in our sample were slightly more likely to be aware of snus, and were slight more likely to have ever used snus in 2011-2012 and 2012-2013 ($p<0.05$). The magnitudes of these increases were smaller than those of e-cigarettes. There were no significant changes in the proportion of young adults in our sample who reported using snus in the past 30 days, and in the number of days using snus in the past 30 days over time ($p>0.05$). However, there was a significant interaction between race/ethnicity and year of data collection regarding number of days using snus in the past 30 days ($p=0.0017$; Figure 1). Furthermore, among those who had used snus during the 30 days prior to data collection, the number of days using snus increased from 4.80 days in 2010-2011 to 8.21 days in 2012-2013 ($p<0.05$; Table 2). Among those who had heard of snus, young adults in our sample were more likely to agree that snus is less harmful than cigarettes in 2012-2013 when compared to 2010-2011 ($p<0.05$).

DISCUSSION

The prevalence of e-cigarette use has increased in the US in recent years, especially among young adults. [16, 33] Our findings from following a cohort of young adults from the US Midwest on awareness and use of e-cigarettes are consistent with these previous reports. We also observed that young adults in our sample were increasingly likely over time to believe that e-cigarettes are less harmful than cigarettes and can help people quit smoking. These increasing trends in positive beliefs about e-cigarettes may explain the increasing prevalence of e-cigarette use. Young adults who believed that e-cigarettes are less harmful than cigarettes and can help people quit smoking, compared to those who did not share those beliefs, were more likely to subsequently experiment with e-cigarettes; this was true among smokers and nonsmokers alike. [30] Thus, with the increasing trends in positive beliefs related to e-cigarettes among young adults, we would expect an increasing trend in prevalence of e-cigarette use in this population. It is important to note that trends in use of and beliefs about e-cigarettes did not vary significantly by smoking status, supporting the conclusion from a previous study that e-cigarette use increases in both adult smokers and nonsmokers. [33]

In contrast, awareness and ever use of snus, and believing snus as less harmful than cigarettes only showed slight increases in our sample during the observation period. This may indicate that while the product is novel, young adults have not overcome their initial rejection of the product. A previous qualitative study found that although young adults found snus to be convenient and modern, they also expressed snus to be gross and distasteful. [34] Young adults who participated in that study also were skeptical about whether snus could help smokers quit smoking. Nonetheless, it is noteworthy that among those who reported using snus in the past 30-days, there was a significant increase in the number of days used. Further analysis showed that, among current smokers, number of days using snus in the past 30 days was not associated with number of days smoked in the past 30 days ($p=0.51$). Thus, this increase may represent more frequent dual use of cigarettes and snus during the past 30-days. It is unclear why the trends in number of days using snus in the past 30 days differ by race/ethnicity. The sudden decline in the number of days using snus among race/ethnic minority young adults could be due to Minnesota cigarette and smokeless tobacco tax increases in 2013. Given most of the snus users are also cigarette smokers, [27] racial/ethnic minority young adults may be more likely than non-Hispanic White young adults to reserve their financial resources for cigarettes and reduce snus use, given racial/ethnic minorities are found to be more price-sensitive than non-Hispanic Whites. [35]

An additional reason for the divergence between the awareness and use of and beliefs about e-cigarettes and snus may be the differences between the industries' marketing efforts. US magazine advertising expenditure data showed that e-cigarette companies spent US\$1 million to advertise their product in magazines in 2010, and rapidly increased to US\$85 million by 2014. [36] E-cigarette advertisements also often feature messages related to harm reduction and/or smoking cessation. [4, 20] In contrast, after spending US\$62 million in 2010 to advertise snus in US magazines, tobacco companies spent only US\$2-5 million per year between 2011 and 2014 to promote snus in magazines. [36] Additionally, in the US, it was uncommon for snus advertisements to feature messages related to harm reduction and/or smoking cessation, but to feature flavors and price promotions. [20]

While it is likely that e-cigarettes and snus are less harmful than cigarettes, [19, 37] communicating these messages to the population, especially among young adults, could be challenging. On one hand, the overall population burden of tobacco use could be reduced if smokers completely switch to e-cigarettes or snus, and reduced health risk has been cited as one of the top reasons for using these products among smokers. [38] However, e-cigarette and snus use has not been shown to be associated with smoking cessation or reduction in our sample of young adults (data not shown), or other population-based studies. [10] On the other hand, positive beliefs of e-cigarettes and snus can promote e-cigarette and snus use among non-tobacco users, [30] and subsequently promote cigarette use. [12-15] Additional research is needed to craft effective messages to convey harm of e-cigarettes and snus that would promote complete replacement of cigarettes with e-cigarettes or snus among smokers who cannot quit, and to prevent non-tobacco users from starting tobacco use with these products.

One limitation of the present study is attrition, which may introduce bias to our findings. It is likely that the estimated prevalence presented may not be representative of all young adults in the US Midwest. However, the trends in e-cigarette use in our sample mirror that of a national serial cross-section study conducted during the same observation period. [33] Furthermore, when we repeated our analyses using only data from participants who had completed all three cycles of data collection, and found only minimal changes in association estimates. This provides us confidence on the validity of the trends we observed. The US Midwest sample in this study also limits our ability to generalize the findings to young adults in other US regions. We do not have data for 2014 and forward, which may be more relevant in a rapidly changing tobacco use environment. However, we believe our data provide an important historical point of reference for future comparison, especially related to beliefs about e-cigarettes and snus. Data from the 2014 US National Health Interview Survey showed that among young adults (aged 18-24 years), 21.6% had ever used e-cigarettes and 5.1% used e-cigarette every day or some days. [39], which were higher than our estimates based on the 2012-2013 data collection. Another US national study found that in 2015, 45.5% of 18-24 year-olds and 36.8% of 25-34 year-olds believed that e-cigarettes are less harmful than cigarettes. [40] These estimates are higher than those we estimated in 2012-2013. We did not identify recent national data on snus use and perceptions. A

strength of the present study is its longitudinal design, which allowed us to assess within-person changes over time, and provide additional statistical power to test interactions compared to serial cross-sectional studies.

In conclusion, we observed rapid increases in awareness and use of, and positive beliefs about e-cigarettes, but modest increases in these measures of snus among our US Midwest young adult sample. It is important that subsequent studies measure additional beliefs about these two products beyond relative harm to cigarettes, so that we can gain a deeper understanding of how various beliefs related to these products change over time. Strategically conveying the harm of these tobacco products to different subpopulations may be needed to maximize the risk-to-benefit ratio of increasing use of these products at the population level.

FUNDING

This work was supported by the National Cancer Institute (R01 CA86191; J. Forster, Principal Investigator). Dr. Choi's effort on this analysis was supported by the Division of Intramural Research, National Institute on Minority Health and Health Disparities, National Institutes of Health. The data were collected when Dr. Choi was at the University of Minnesota.

DECLARATION OF INTERESTS

None to report.

REFERENCES:

- [1] Abrams DB. Promise and peril of e-cigarettes: can disruptive technology make cigarettes obsolete? *JAMA* 2014;**311**(2):135-136.
- [2] Cahn Z, Siegel M. Electronic cigarettes as a harm reduction strategy for tobacco control: a step forward or a repeat of past mistakes? *J Public Health Policy* 2011;**32**(1):16-31.
- [3] Cobb NK, Brookover J, Cobb CO. Forensic analysis of online marketing for electronic nicotine delivery systems. *Tob Control* 2013.
- [4] Grana RA, Ling PM. "Smoking revolution": a content analysis of electronic cigarette retail websites. *Am J Prev Med* 2014;**46**(4):395-403.

- [5] Etter JF. Electronic cigarettes: a survey of users. *BMC Public Health* 2010;**10**:231.
- [6] Adkison SE, O'Connor RJ, Bansal-Travers M, *et al*. Electronic nicotine delivery systems: international tobacco control four-country survey. *Am J Prev Med* 2013;**44**(3):207-215.
- [7] Zhu SH, Gamst A, Lee M, *et al*. The use and perception of electronic cigarettes and snus among the U.S. population. *PloS one* 2013;**8**(10):e79332.
- [8] Vickerman KA, Carpenter KM, Altman T, *et al*. Use of electronic cigarettes among state tobacco cessation quitline callers. *Nicotine Tob Res* 2013;**15**(10):1787-1791.
- [9] Pepper JK, Ribisl KM, Emery SL, *et al*. Reasons for starting and stopping electronic cigarette use. *Int J Environ Res Public Health* 2014;**11**(10):10345-10361.
- [10] Kalkhoran S, Glantz SA. E-cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med* 2016;**4**(2):116-128.
- [11] Bullen C, Howe C, Laugesen M, *et al*. Electronic cigarettes for smoking cessation: a randomised controlled trial. *Lancet* 2013;**382**(9905):1629-1637.
- [12] Leventhal AM, Strong DR, Kirkpatrick MG, *et al*. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA* 2015;**314**(7):700-707.
- [13] Primack BA, Soneji S, Stoolmiller M, *et al*. Progression to traditional cigarette smoking after electronic cigarette use among US adolescents and young adults. *JAMA Pediatr* 2015;**169**(11):1018-1023.
- [14] Wills TA, Knight R, Sargent JD, *et al*. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii. *Tob Control* 2016.
- [15] Barrington-Trimis JL, Urman R, Berhane K, *et al*. E-Cigarettes and future cigarette use. *Pediatrics* 2016;**138**(1).
- [16] King BA, Patel R, Nguyen KH, *et al*. Trends in awareness and use of electronic cigarettes among US adults, 2010-2013. *Nicotine Tob Res* 2015;**17**(2):219-227.
- [17] Agaku IT, King BA, Husten CG, *et al*. Tobacco product use among adults — United States, 2012–2013. *MMWR* 2014;**63**(25):542-547.
- [18] Tan AS, Bigman CA. E-cigarette awareness and perceived harmfulness: prevalence and associations with smoking-cessation outcomes. *Am J Prev Med* 2014;**47**(2):141-149.

- [19] Foulds J, Ramstrom L, Burke M, *et al.* Effect of smokeless tobacco (snus) on smoking and public health in Sweden. *Tob Control* 2003;**12**(4):349-359.
- [20] Richardson A, Ganz O, Vallone D. Tobacco on the web: surveillance and characterisation of online tobacco and e-cigarette advertising. *Tob control* 2015;**24**(4):341-347.
- [21] Ramstrom LM, Foulds J. Role of snus in initiation and cessation of tobacco smoking in Sweden. *Tob Control* 2006;**15**(3):210-214.
- [22] Taylor N, Choi K, Forster J. Snus use and smoking behaviors: preliminary findings from a prospective cohort study among US Midwest young adults. *Am J Public Health* 2015;**105**(4):683-685.
- [23] Foulds J, Furberg H. Is low-nicotine Marlboro snus really snus? *Harm Reduct J* 2008;**5**:9.
- [24] Borgerding MF, Bodnar JA, Curtin GM, *et al.* The chemical composition of smokeless tobacco: a survey of products sold in the United States in 2006 and 2007. *Regul Toxicol Pharmacol* 2012;**64**(3):367-387.
- [25] Regan AK, Dube SR, Arrazola R. Smokeless and flavored tobacco products in the U.S.: 2009 Styles survey results. *Am J Prev Med* 2012;**42**(1):29-36.
- [26] Pearson JL, Richardson A, Niaura RS, *et al.* E-cigarette awareness, use, and harm perceptions in US adults. *Am J Public Health* 2012;**102**(9):1758-1766.
- [27] Choi K, Forster J. Awareness, perceptions, and use of snus among young adults from the upper Midwest region of the USA. *Tob Control* 2013;**22**(6):412-417.
- [28] U.S. Department of Health and Human Services. The health consequences of smoking -- 50 years of progress. a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health 2014.
- [29] U.S. Department of Health and Human Services. Preventing tobacco use among youth and young adults: a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health 2012.
- [30] Choi K, Forster JL. Beliefs and experimentation with electronic cigarettes: a prospective analysis among young adults. *Am J Prev Med* 2014;**46**(2):175-178.

- [31] Forster J, Chen V, Perry C, *et al.* The Minnesota Adolescent Community Cohort Study: design and baseline results. *Prev Sci* 2011;**12**(2):201-210.
- [32] Choi K, Forster J. Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young US Midwestern adults. *Am J Public Health* 2013;**103**(3):556-561.
- [33] McMillen RC, Gottlieb MA, Shaefer RM, *et al.* Trends in Electronic Cigarette Use Among U.S. Adults: Use is Increasing in Both Smokers and Nonsmokers. *Nicotine Tob Res* 2014;**17**(10):1195-1202.
- [34] Choi K, Fabian L, Mottey N, *et al.* Young adults' favorable perception of snus, dissolvable tobacco products and electronic cigarettes: findings from a focus groups study. *Am J Public Health* 2012;**102**(11):2088-2093.
- [35] Thomas S, Fayter D, Misso K, *et al.* Population tobacco control interventions and their effects on social inequalities in smoking: systematic review. *Tob Control* 2008;**17**(4):230-237.
- [36] El-Toukhy SM, Choi K. Magazine hyped: Trends in tobacco advertising and readership characteristics, 2010-2014. *Prev Med* 2016;**91**:132-137.
- [37] McNeill A, Brose LS, Calder R, *et al.* E-cigarettes: an evidence update. London, UK: Public Health England 2015.
- [38] Rutten LJ, Blake KD, Agunwamba AA, *et al.* Use of e-cigarettes among current smokers: associations among reasons for use, quit intentions, and current tobacco use. *Nicotine Tob Res* 2015;**17**(10):1228-1234.
- [39] Schoenborn CA, Gindi RM. Electronic cigarette use among adults: United States, 2014. *NCHS data brief*. Hyattsville, MD: National Center for Health Statistics 2014.
- [40] Majeed BA, Weaver SR, Gregory KR, *et al.* Changing perceptions of harm of e-cigarettes among U.S. adults, 2012–2015. *Am J Prev Med* 2016.

Table 1. Sample characteristics, Minnesota Adolescent Community Cohort Study, 2010-2013.

Characteristics	2010-2011 (n=2622)	2011-2012 (n=2550)	2012-2013 (n=2420)
Age (years)*	24.0 (1.7)	25.0 (1.7)	26.0 (1.7)
Gender			
Male	1240 (47.3%)	1214 (47.6%)	1133 (46.8%)
Female	1382 (52.7%)	1336 (52.4%)	1287 (53.2%)
Race/ethnicity			
Non-Hispanic White	2345 (89.4%)	2276 (89.3%)	2177 (90.0%)
Other	277 (10.6%)	274 (10.7%)	243 (10.0%)
Education			
4-year college	1555 (59.4%)	1516 (59.6%)	1444 (59.8%)
>High school but not 4-year college	654 (25.0%)	642 (25.2%)	647 (26.8%)
≤High school	409 (15.6%)	387 (15.2%)	323 (13.4%)
Number of peers who smoke§	1.0 (1.2)	1.0 (1.2)	0.9 (1.2)
Smoking status§			
Non-smoker	1672 (63.8%)	1608 (63.1%)	1556 (64.3%)
Former smoker	316 (12.1%)	337 (13.2%)	362 (15.0%)
Current smoker	632 (24.1%)	603 (23.7%)	502 (20.7%)
Heard of e-cigarettes§	1834 (70.0%)	2179 (85.5%)	2211 (91.4%)
Ever used e-cigarettes§	184 (7.0%)	284 (11.1%)	376 (15.5%)
Among non-smokers§	20 (1.2%)	40 (2.5%)	55 (3.5%)
Among former smoker§	23 (7.3%)	43 (12.8%)	74 (20.4%)
Among Current smoker§	140 (22.2%)	201 (33.3%)	247 (49.2%)
Used e-cigarettes in the past 30 days§	31 (1.2%)	54 (2.1%)	98 (4.1%)
Among non-smokers§	2 (0.1%)	9 (0.6%)	13 (0.8%)
Among former smoker§	1 (0.3%)	3 (0.9%)	12 (3.3%)
Among Current smoker§	27 (4.3%)	42 (7.0%)	73 (14.5%)
Days used e-cigarettes in the past 30 days§	0.0 (0.8)	0.1 (1.1)	0.2 (2.0)
Agreed that e-cigarettes help people quit smoking#§	816 (44.5%)	1087 (49.9%)	1206 (54.6%)
Agreed that e-cigarettes are less harmful than cigarettes#§	971 (52.9%)	1288 (59.1%)	1333 (60.3%)
Agreed that e-cigarettes are less addictive than cigarettes#§	486 (26.5%)	653 (30.0%)	619 (28.0%)
Heard of snus	1700 (64.8%)	1721 (67.5%)	1628 (67.3%)
Ever used snus	383 (14.6%)	388 (15.2%)	385 (15.9%)
Among non-smokers	118 (7.1%)	124 (7.7%)	136 (8.7%)
Among former smoker	61 (19.3%)	72 (21.4%)	91 (25.1%)
Among Current smoker	203 (32.1%)	192 (31.8%)	158 (31.5%)
Used snus in the past 30 days	84 (3.2%)	63 (2.5%)	57 (2.4%)
Among non-smokers	29 (1.7%)	23 (1.4%)	24 (1.5%)
Among former smoker	14 (4.4%)	9 (2.7%)	10 (2.8%)
Among Current smoker	40 (6.3%)	31 (5.1%)	23 (4.6%)
Days used snus in the past 30 days	0.2 (2.2)	0.2 (2.0)	0.2 (1.98)
Agreed that snus helps people quit smoking#	279 (16.4%)	307 (17.8%)	300 (18.4%)
Agreed that snus is less harmful than cigarettes#	295 (17.4%)	294 (17.1%)	308 (18.9%)
Agreed that snus is less addictive than cigarettes#§	194 (11.4%)	197 (11.5%)	143 (8.8%)

Note: *Means and standard deviations are provided for continuous variables. #Only those who had heard of the products were asked about their perceptions of the product. §Significant difference over time in bivariate analysis.

Table 2. Changes in awareness, use, and perceptions of e-cigarettes, Minnesota Adolescent Community Cohort Study, 2010-2013.

	Year		
	2010-2011	2011-2012	2012-2013
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Heard of e-cigarettes	1.00	2.88 (2.46, 3.37)	5.57 (4.55, 6.82)
Ever used e-cigarettes	1.00	2.26 (1.77, 2.88)	5.12 (3.92, 6.69)
Past-30-day use of e-cigarettes	1.00	2.12 (1.32, 3.39)	5.41 (3.38, 8.66)
Agreed that e-cigarettes help people quit smoking	1.00	1.28 (1.11, 1.48)	1.58 (1.34, 1.86)
Agreed that e-cigarettes are less harmful than cigarettes	1.00	1.35 (1.17, 1.56)	1.45 (1.23, 1.70)
Agreed that e-cigarettes are less addictive than cigarettes	1.00	1.18 (1.01, 1.37)	1.08 (0.91, 1.28)
	Adjusted mean (95% CI)	Adjusted mean (95% CI)	Adjusted mean (95% CI)
Days used e-cigarettes in the past 30 days	0.06 (0.01, 0.11)	0.10 (0.05, 0.16)	0.25 (0.16, 0.33)
Days used e-cigarettes in the past 30 days among past-30-day e-cigarette users	4.33 (0.81, 7.86)	4.17 (1.28, 7.06)	5.32 (2.51, 8.12)

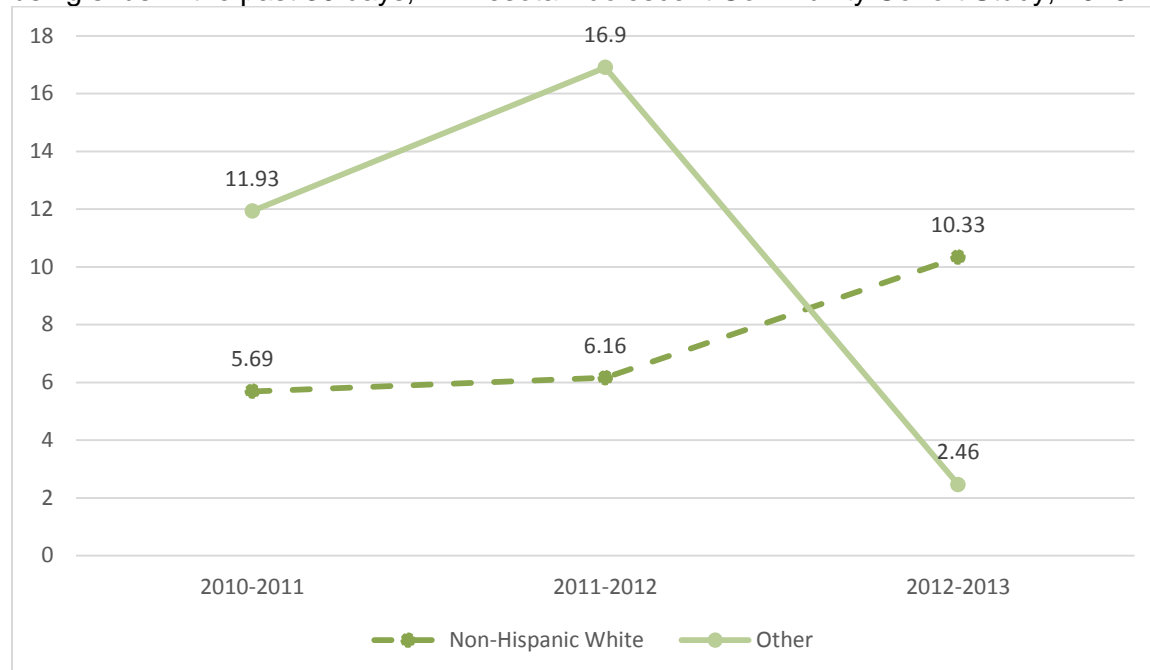
Adjusted for age, gender, race/ethnicity, education, number of peers who smoke, and smoking status. Bolded estimates are statistically significant ($p < 0.05$).

Table 3. Changes in awareness, use, and perceptions of snus, Minnesota Adolescent Community Cohort Study, 2010-2013.

	Year		
	2010-2011	2011-2012	2012-2013
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Heard of snus	1.00	1.26 (1.09, 1.46)	1.34 (1.13, 1.58)
Ever used snus	1.00	1.21 (0.97, 1.49)	1.51 (1.19, 1.94)
Used snus in the past 30 days	1.00	0.88 (0.61, 1.27)	1.01 (0.66, 1.54)
Agreed that snus help people quit smoking	1.00	1.04 (0.85, 1.27)	0.99 (0.79, 1.25)
Agreed that snus is less harmful than cigarettes	1.00	1.04 (0.85, 1.26)	1.27 (1.03, 1.58)
Agreed that snus is less addictive than cigarettes	1.00	1.13 (0.90, 1.43)	0.95 (0.73, 1.24)
	Adjusted mean (95% CI)	Adjusted mean (95% CI)	Adjusted mean (95% CI)
Days used snus in the past 30 days	0.07 (0.16, 0.42)	0.32 (0.20, 0.44)	0.38 (0.25, 0.50)
Days used snus in the past 30 days among past-30-day snus users	4.80 (0.34, 9.26)	7.35 (3.03, 11.66)	8.21 (3.85, 12.57)

Adjusted for age, gender, race/ethnicity, education, number of peers who smoke, and smoking status. Bolded estimates are statistically significant ($p < 0.05$).

Figure 1. Days used snus in the past 30 days by race/ethnicity over time among those reported using snus in the past 30 days, Minnesota Adolescent Community Cohort Study, 2010-2013.



Adjusted for age, gender, education, smoking status, and number of peers who smoke. Interaction between race/ethnicity and year is statistically significant ($p=0.0017$).