



# E-cigarette use among US adolescents: secondhand smoke at home matters

Xiao Zhang · Jia Pu

Received: 30 June 2015 / Revised: 28 December 2015 / Accepted: 29 December 2015 / Published online: 18 January 2016  
© Swiss School of Public Health (SSPH+) 2016

## Abstract

**Objectives** To examine the association of family smoking status and exposure to secondhand smoke (SHS) at home with the use of electronic cigarettes among US adolescents, in particular the mediation effect of SHS on the association between family smoking status and electronic cigarette use.

**Methods** Data from the 2013 National Youth Tobacco Survey were used and logistic regressions were conducted to model electronic cigarettes use. The mediation effect of SHS was tested using the Sobel-Goodman mediation test.

**Results** Overall, 8.1 % of the US adolescents reported ever use of e-cigarettes. Among both the overall population and never-cigarette smokers, adolescents living in smoker households were significantly more likely to report ever use of e-cigarettes ( $p < 0.05$ ). However, the associations were attenuated after including SHS exposure at home during the past 7 days. SHS exposure at home was positively associated with ever use of e-cigarettes, adjusting for family smoking status ( $p < 0.05$ ).

**Conclusions** The association between smoking habits of the family and e-cigarette use was mediated through SHS exposure. The promotion of smoke-free home rules may help prevent the uptake of e-cigarettes among teenagers.

**Keywords** Electronic cigarettes · Secondhand smoke exposure · Adolescents

## Introduction

Electronic cigarettes (e-cigarettes) are battery-powered devices that vaporize e-liquid containing nicotine, flavorings and other chemicals. Introduced into the US market in 2007, e-cigarettes have been gaining popularity. It is estimated that in 2013, 8 of 10 adults were aware of e-cigarettes and 1 in 10 had used the devices at least once (King et al. 2014). Use of e-cigarettes has also risen rapidly among US adolescents. Between 2013 and 2014, the prevalence of e-cigarette use during past 30 days increased from 4.5 to 13.4 % among high school students, and from 1.1 to 3.9 % among middle school students (Centers for Diseases Control and Prevention 2015). Although e-cigarettes are marketed as tools that help with smoking cessation (Grana and Ling 2014), existing evidence is unsupportive of this claim (Adkison et al. 2013; Vickerman et al. 2013) and even suggests that e-cigarettes may cause nicotine addiction among youth (Lee et al. 2014; Dutra and Glantz 2014).

Past studies indicate that a number of characteristics at the individual and household levels predict e-cigarette use among adolescents including age, sex, race/ethnicity, and use of other tobacco products. In general, e-cigarette use is more likely to be reported by youth who are older, male, non-Hispanic white, and who use conventional cigarettes or hookah (Lee et al. 2014; Dutra and Glantz 2014; Barnett et al. 2015). Living with someone who smokes cigarettes was also positively associated with e-cigarette use, regardless of the cigarette smoking status of the adolescent (Cardenas et al. 2015). It is speculated that the increased

---

This article is part of the special issue “Electronic Cigarettes and Public Health”.

---

X. Zhang (✉)  
UW Carbone Cancer Center, University of Wisconsin-Madison,  
Madison, WI, USA  
e-mail: xzhang86@wisc.edu

J. Pu  
Mathematica Policy Research, Oakland, CA, USA

likelihood was attributed to hearing about or having access to the devices at home since e-cigarette users also tend to be current cigarette smokers (Cardenas et al. 2015; Choi and Forster 2013). On the other hand, the effect of family members' smoking habits on e-cigarette use among children may be mediated through exposure to secondhand smoke (SHS). Previous research has found that SHS exposure at home is a mediator between parental smoking and smoking initiation among children, probably because SHS conveys a pro-tobacco message and/or has a direct physical additive impact (Wang et al. 2011). Similarly, SHS exposure can mediate the effect of family smoking status on e-cigarette use in children. However, no study has examined this pathway.

This current study used data from the 2013 National Youth Tobacco Survey (NYTS) to investigate the association of family smoking status and exposure to secondhand smoke at home, the primary source of SHS exposure among children (Committee on Environmental Health-Health et al. 2009), with the use of e-cigarettes among adolescents in the US. We also tested the hypothesis that SHS exposure at home mediates the association between family smoking status and e-cigarettes use among teens.

## Methods

### Study sample

This cross-sectional study used 2013 NYTS data, which is the most recent wave available. The NYTS is a school-based, self-report survey designed to investigate tobacco-related beliefs, attitudes, behaviors and exposure to pro- and anti-tobacco influences among public middle and high school students. The survey employs a multistage sampling design to produce a nationally representative sample of US students from public and private schools in grades 6–12. Detailed information about the survey has been published by the US Centers for Disease Control and Prevention (Arrazola et al. 2014). In 2013, 250 schools were selected and 187 agreed to participate in the survey. A total of 18,406 students completed the survey, yielding an overall response rate of 67.8 %. Participants who were less than 11 years old or 19 years old or older (1.2 % of the study sample) were excluded from the study so that the final sample included 18,092 students.

### Measures

#### *Sociodemographic characteristics*

The survey collected information on adolescents' age, sex, race and ethnicity.

#### *Ever cigarette smoking*

Adolescents were asked "Have you ever tried cigarette smoking, even one or two puffs?" Those who answered 'yes' were classified as ever cigarette smokers and those who answer 'no' as never-smokers.

#### *E-cigarette use*

In this study, we refer to e-cigarettes use as *ever* use of e-cigarettes. A student was classified as "ever used e-cigarettes" if he/she reported "e-cigarettes" to the question: "Which of the following tobacco products have you ever tried, even just one time?"

#### *Family smoking status*

Participants were inquired "Does anyone who lives with you now...?" and those who reported "smoked cigarettes" were coded as living in family with one or more smokers.

#### *Secondhand smoke exposure at home*

Exposure to SHS at home was measured by the question "During the past 7 days, on how many days did someone smoke tobacco products in your home while you were there?" Adolescents who answered 1 or more days were considered exposed to SHS at home.

#### Statistical analysis

We computed descriptive statistics to depict the prevalence of e-cigarette use. We estimated multiple logistic regression models to examine the association of family smoking status and SHS exposure at home with e-cigarette use, adjusting for sociodemographic factors. We estimated two models. Model 1 included only family smoking status and in model 2 SHS exposure during the past 7 days was added. The mediation effect of SHS exposure on the association between family smoking status and e-cigarette use among adolescents was examined by the Sobel-Goodman mediation test (Sobel 1982). Because SHS may have a different impact on participants who do not currently smoke conventional cigarettes, analysis was conducted in the overall sample and then in never-smokers. Fully adjusted analyses incorporated weights provided by the NYTS to account for the complex sampling design and non-response in population estimates. All analyses were performed using STATA/SE 13.1 (StataCorp LP, College Station, TX).

## Results

Participant characteristics are described in Table 1. Overall, 8.1 % of the 2013 NYTS participants reported ever use of e-cigarettes, 29.8 % reported living with other smokers, and 23.9 % reported exposure to SHS at home during the past 7 days. Most participants (74.8 %) had never smoked any cigarettes. Compared to the overall sample, never-smokers had a lower prevalence of e-cigarette use (1.4 %), living with other smokers (23.9 %) and exposure to SHS at home during the past 7 days (16.5 %).

After controlling for age, sex, and race/ethnicity, participants living in households with one or more smokers were significantly more likely to report ever use of e-cigarettes [Model 1, odds ratio (OR) 1.45, 95 % CI 1.27–1.66, Table 2]. However, this association was attenuated after including SHS exposure at home during the past 7 days in Model 2 (Model 2, OR 1.27, 95 % CI 1.08–1.48). The formal test for mediation effects indicated that the association between family smoking status and e-cigarette use was partly mediated by SHS exposure at home (Sobel-Goodman test:  $p < 0.001$ ). Similar results were obtained in the subgroup analysis among never-smokers. Living with other smokers was significantly associated with e-cigarette use among never-smokers (Model 1, OR 1.90, 95 % CI 1.37–2.61), but this association was no longer statistically significant after adjusting for SHS exposure status (Model 2, OR 1.34, 95 % CI 0.89–2.03). Likewise, the Sobel-Goodman test confirmed the mediation effect of SHS exposure at home ( $p < 0.001$ ). There was a statistically significant association between SHS exposure and ever use

of e-cigarettes in both the overall sample (OR 1.37, 95 % CI 1.17–1.61) and the sample restricted to never-smokers (OR 2.10, 95 % CI 1.70–2.60).

## Discussion

This is the first study to examine the association between SHS exposure at home and e-cigarette use, and the mediating effects of SHS exposure in the association between family smoking status and e-cigarette use among adolescents. Concordant with previous research, adolescents from households with one or more smokers (including those who had never smoked conventional cigarettes) were more likely to use e-cigarettes (Cardenas et al. 2015). In addition, SHS exposure at home was a significant predictor of e-cigarette use. However, the impact of family smoking status on e-cigarette use among children was attenuated after adjustment for SHS exposure at home, suggesting that the relationship was mediated through SHS exposure.

The harmful effects of SHS exposure on the physical health of children have been well documented (US Department of Health and Human Services 2007). Those exposed to SHS are at increased risk of sudden infant death syndrome, acute respiratory symptoms, ear infections, and more severe asthma. SHS exposure may also increase the likelihood of smoking initiation among children (Wang et al. 2011). In the current context wherein the overall health effects of e-cigarettes remain understudied (Bhatnagar et al. 2014), this current study complements previous research on the harm of SHS exposure among children by providing evidence on the association between SHS exposure at home and e-cigarette use among adolescents. Research is needed to examine the impact of, and possible mechanisms underpinning, the association between SHS and exposure e-cigarettes.

If future studies using prospective designs find that SHS exposure at home triggers e-cigarette use among adolescents, our findings underscore the need for maintaining homes smoke-free. Although the prevalence of homes with smoke-free rules has risen over time in the US (Zhang et al. 2012), 40 % of households with one or more smokers and with underage children had not adopted voluntary smoke-free home rules by 2010–2011 (Zhang et al. 2015). Tobacco control and prevention efforts are warranted to continue to promote the adoption of voluntary smoke-free home rules. Intervention programs should emphasize strict enforcement to voluntary smoke-free rules at home. In our sample, 12.8 % of youth who reported having a smoke-free home were exposed to SHS at home during the past 7 days (data not shown).

This study has limitations. First, the design was cross-sectional, which precludes establishing the temporal

**Table 1** Characteristics of middle and high school students in 2013 in the USA ( $n = 18,092$ )

	Overall %	Never-smokers %
Age, years		
11–14	49.1	56.6
15–18	50.9	43.3
Sex		
Female	51.3	50.0
Male	48.8	50.0
Race/ethnicity		
Non-Hispanic White	56.9	58.3
Non-Hispanic Black	15.9	16.0
Hispanic	21.9	20.1
Other	5.3	5.7
Ever cigarette smoker	25.2	NA
Ever used e-cigarettes	8.1	1.4
Family with one or more smokers	29.8	23.9
SHS exposure at home in past 7 days	23.9	16.5

**Table 2** The association of family smoking status and exposure to secondhand smoke (SHS) at home with the use of e-cigarettes among USA middle and high school students in 2013 ( $n = 18,092$ )

	Overall		Never-smokers	
	Model 1 AOR (95 % CI)	Model 2 AOR (95 % CI)	Model 1 AOR (95 % CI)	Model 2 AOR (95 % CI)
Family with one or more smokers				
No	Ref	Ref	Ref	Ref
Yes	1.45 (1.27–1.66)	1.27 (1.08–1.48)	1.90 (1.37–2.61)	1.34 (0.89–2.03)
Age, years				
11–14	Ref	Ref	Ref	Ref
15–18	1.65 (1.42–1.92)	1.65 (1.41–1.93)	1.90 (1.38–2.61)	2.01 (1.32–2.53)
Sex				
Female	Ref	Ref	Ref	Ref
Male	1.39 (1.22–1.59)	1.37 (1.19–1.56)	1.44 (1.05–1.97)	1.38 (1.00–1.90)
Race/ethnicity				
Non-Hispanic White	Ref	Ref	Ref	Ref
Non-Hispanic Black	0.35 (0.29–0.43)	0.36 (0.29–0.44)	0.98 (0.64–1.50)	0.95 (0.61–1.47)
Hispanic	0.61 (0.52–0.71)	0.62 (0.53–0.72)	1.22 (0.84–1.79)	1.28 (0.87–1.89)
Other	0.57 (0.41–0.77)	0.61 (0.44–0.83)	0.65 (0.31–1.34)	0.70 (0.34–1.45)
Cigarette smoking status			NA	NA
Never	Ref	Ref		
Ever	22.7 (19.0–27.1)	21.6 (18.0–26.0)		
SHS exposure at home in past 7 days	NA		NA	
No		Ref		Ref
Yes		1.37 (1.17–1.61)		2.10 (1.70–2.60)

AOR adjusted odds ratio, CI confidence interval

relationship of the observed associations. Second, we focused on *ever* use of e-cigarettes as the outcome because the prevalence of current e-cigarette use was relatively low (2.8 %), which contributed to temporality challenges. Research with longitudinal study designs is needed to establish the temporal relationship and examine causation. Finally, all the data were based on self-report, which could be subject to information bias.

In conclusion, exposure to SHS at home is associated with e-cigarette use among US adolescents, regardless of family smoking status. The association between smoking habits of the family and e-cigarette use was mediated through SHS exposure. Promotion of smoke-free home rules may help prevent the uptake of e-cigarettes among adolescents.

## References

- Adkison SE, O'Connor RJ, Bansal-Travers M et al (2013) Electronic nicotine delivery systems: international tobacco control four-country survey. *Am J Prev Med* 44:207–215. doi:10.1016/j.amepre.2012.10.018
- Arrazola RA, Neff LJ, Kennedy SM et al (2014) Tobacco use among middle and high school students—United States, 2013. *MMWR Morb Mortal Wkly Rep* 63:1021–1026
- Barnett TE, Soule EK, Forrest JR et al (2015) Adolescent electronic cigarette use: associations with conventional cigarette and hookah smoking. *Am J Prev Med*. doi:10.1016/j.amepre.2015.02.013
- Bhatnagar A, Whitsel LP, Ribisl KM et al (2014) Electronic cigarettes: a policy statement from the American Heart Association. *Circulation* 130:1418–1436. doi:10.1161/CIR.0000000000000107
- Cardenas VM, Breen PJ, Compadre CM et al (2015) The smoking habits of the family influence the uptake of e-cigarettes in US children. *Ann Epidemiol* 25:60–62. doi:10.1016/j.annepidem.2014.09.013
- Centers for Diseases Control and Prevention (2015) E-cigarette use triples among middle and high school students in just one year. <http://www.cdc.gov/media/releases/2015/p0416-e-cigarette-use.html>. Accessed 1 Jan 2016
- Choi K, Forster J (2013) Characteristics associated with awareness, perceptions, and use of electronic nicotine delivery systems among young US Midwestern adults. *Am J Public Health* 103:556–561. doi:10.2105/AJPH.2012.300947
- Committee on Environmental HealthHealth, Committee on Substance Abuse, Committee on Adolescence, Committee on Native American Child (2009) From the American Academy of Pediatrics: policy statement—tobacco use: a pediatric disease. *Pediatrics* 124:1474–1487. doi:10.1542/peds.2009-2114
- Dutra LM, Glantz SA (2014) E-cigarettes and conventional cigarette use among US adolescents: a cross-sectional study. *JAMA Pediatr* 168:610–617. doi:10.1001/jamapediatrics.2013.5488
- Grana RA, Ling PM (2014) “Smoking revolution”: a content analysis of electronic cigarette retail websites. *Am J Prev Med* 46:395–403. doi:10.1016/j.amepre.2013.12.010

- King BA, Patel R, Nguyen K, Dube SR (2014). Trends in awareness and use of electronic cigarettes among US adults, 2010–2013. *Nicotine Tob Res*: ntu191
- Lee S, Grana RA, Glantz SA (2014) Electronic cigarette use among Korean adolescents: a cross-sectional study of market penetration, dual use, and relationship to quit attempts and former smoking. *J Adolesc Heal Off Publ Soc Adolesc Med* 54:684–690. doi:10.1016/j.jadohealth.2013.11.003
- Sobel ME (1982) Asymptotic confidence intervals for indirect effects in structural equation models. *Sociol Methodol* 13(1982):290–312
- US Department of Health and Human Services (2007) The health consequences of involuntary exposure to tobacco smoke: a report of the surgeon general. <http://www.surgeongeneral.gov/library/secondhandsmoke/report/index.html>. Accessed 4 Oct 2011
- Vickerman KA, Carpenter KM, Altman T et al (2013) Use of electronic cigarettes among state tobacco cessation quitline callers. *Nicotine Tob Res Off J Soc Res Nicotine Tob* 15:1787–1791. doi:10.1093/ntr/ntt061
- Wang MP, Ho SY, Lam TH (2011) Parental smoking, exposure to secondhand smoke at home, and smoking initiation among young children. *Nicotine Tob Res Off J Soc Res Nicotine Tob* 13:827–832. doi:10.1093/ntr/ntr083
- Zhang X, Martinez-Donate AP, Kuo D et al (2012) Trends in home smoking bans in the USA, 1995–2007: prevalence, discrepancies and disparities. *Tob Control* 21:330–336. doi:10.1136/tc.2011.043802
- Zhang X, Martinez-Donate A, Rhoads N (2015) Parental practices and attitudes related to smoke-free rules in homes, cars, and outdoor playgrounds in US households with underage children and smokers, 2010–2011. *Prev Chronic Dis*. doi:10.5888/pcd12.140553