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Recall of E-cigarette Advertisements and Adolescent E-cigarette Use

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Abstract

Objective—We examined the impact of e-cigarette advertising on e-cigarette use behaviors among youth over time.

Methods—At baseline, 3907 students participated in a youth tobacco surveillance study from 2014–2015 and 2488 students completed a 6-month follow-up. Weighted logistic regression models investigated the recall of e-cigarette advertisements (TV/radio/billboards/retail/Internet) as a risk factor for e-cigarette perceived harm, use, and susceptibility.

Results—The odds of ever e-cigarette use was 3 times higher (AOR=2.99; 95% CI, 1.50–5.97) at 6-month follow-up among e-cigarette never-users who recalled e-cigarette advertisements in retail stores at baseline, compared to those who did not. Likewise, the odds of current e-cigarette use and susceptibility to e-cigarette use at 6-month follow-up were 2.03 (95% CI, 1.11–3.72) and 1.77 (95% CI, 1.20–2.61), respectively. Additionally, recall of e-cigarette advertisements on the Internet at baseline was significantly related to current use (AOR=2.17; 95% CI, 1.05–4.48) and susceptibility to use e-cigarettes (AOR=1.72; 95% CI, 1.15–2.58) at 6-month follow-up.

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Human Subjects Statement

The University of Texas Health Science Center Internal Review Board HSC-SPH-15-1010 approved this study.

Conflict of Interest Statement

No conflicts declared.

Conclusions—Recall of e-cigarette advertisements at point-of-sale and on the Internet was significantly associated with adolescent e-cigarette susceptibility and use, which supports the need to minimize adolescent exposure to these advertisements.

Keywords

e-cigarettes; youth use of tobacco alternatives; tobacco use; tobacco advertising

Since their introduction to the United States (US) market in 2007, e-cigarettes have gained popularity, especially among youth.¹ Although commonly marketed for their safety compared to traditional cigarettes, e-cigarettes are not harmless. Nicotine is addictive and known to be harmful to the adolescent brain and cognitive development as well as the central nervous system.^{2–4} Toxic chemicals and carcinogens, like acetaldehyde, formaldehyde, and tobacco-specific nitrosamines, which are common in cigarettes, also have been found in e-cigarettes.^{5,6} Despite these health risks, e-cigarette sales are predicted to exceed \$10 billion in 2017.⁷

As the e-cigarette market proliferates, concern is growing about adolescent e-cigarette use, especially because e-cigarette use has been shown to predict combustible tobacco product use among youth over time.^{8–11} This is worrisome, given the rise in e-cigarette use among youth. During the time period 2011–2015, the National Youth Tobacco Survey (NYTS) revealed exponential increases in both middle (0.6% to 5.3%) and high (1.5% to 16.0%) school students current, or past 30 day, e-cigarette use.¹² By 2015, nearly 3 million middle and high school students nationwide were current e-cigarette users.¹² In Texas, use was even higher in 2014, where 7.9% of middle and 19.1% of high school students reported current e-cigarette use.¹³ A 2013 Connecticut study determined that among students who had never used an e-cigarette, 26% of middle school and 32% of high school students were susceptible to using e-cigarettes in the future.¹⁴ Susceptibility warrants attention with e-cigarettes, as it has been shown to predict cigarette smoking.^{15–18}

Prior to the US Food and Drug Administration (FDA) extending its regulatory authority in 2016 to include e-cigarettes, no federal restrictions for e-cigarette advertising existed.^{19,20} Advertisement spending from e-cigarette companies tripled during 2011–2012, with a large majority of these monies spent on TV advertisements.²¹ During this same period, radio expenditures quadrupled.²¹ During the time period of 2011–2013, TV e-cigarette advertisements increased more than 250% and reached over 24 million adolescents.²² In 2014, 70% of US middle and high school students had seen an e-cigarette advertisement on TV, in a retail store, on the Internet, or in newspapers/magazines.²³ The impact of increased advertising on youth e-cigarette use remains unknown.

The well-documented effects of traditional cigarette advertising on adolescent smoking support the potential negative effect of e-cigarette advertisements on adolescent consumption.²⁴ Tobacco use on TV programs has been shown to increase current tobacco use in adolescents,²⁵ and exposure to advertising at point-of-sale has been linked to cigarette smoking initiation among adolescents in California.²⁶ Advertisements also have been known to increase adolescent susceptibility to use tobacco products, like cigarettes and cigars, in the future.^{26–29} Based on a review of over 200 reports, peer-reviewed journal articles, and

books, the 2012 Surgeon General's Report concluded that cigarette advertisement exposure has led to initiation and continued cigarette smoking among adolescents.²⁴

Literature specific to the impact of advertising on adolescent e-cigarette use is only beginning to emerge.^{30–32} Two studies using 2014 NYTS data found that recall of e-cigarette advertising through TV/movies, Internet, print, and retail was associated with increased *ever* and *current* e-cigarette use among middle and high school students as well as susceptibility to future e-cigarette use among never users.^{30,31} However, both studies were cross-sectional by design, limiting their ability to make causal inferences about the temporal relationship between advertising and adolescent e-cigarette use. Additionally, neither study examined perceived harm, which may be an important potential mediator of the impact of e-cigarette advertising on use, given declarations of health and safety in e-cigarette advertising. The 2012 NYTS determined that two-thirds of adolescents who had ever used e-cigarettes believed them to be less harmful than cigarettes.^{33,34} Furthermore, a 2014 randomized controlled experiment determined that adolescents who viewed 4 e-cigarette TV advertisements had increased odds of perceiving e-cigarettes to be safer and less toxic than conventional cigarettes as well as being susceptible to future e-cigarette use in comparison to a control group.³² However, this experiment measured forced exposure of advertising and was limited to TV advertisements.

The present study extends the limited cross-sectional research^{30–32} on the impact of e-cigarette advertising on adolescent e-cigarette use in 3 important ways. First, in addition to cross-sectional analyses, we utilized longitudinal data with a 6-month follow-up between assessments to investigate recall of e-cigarette advertisements as a risk factor for e-cigarette use behaviors. Second, we added perceived harm to the list of variables to examine. Third, we considered e-cigarette advertising in additional channels, like billboards and radio. Data for this study are drawn from the Texas Adolescent Tobacco Advertising and Marketing Surveillance System (TATAMS), a large-scale, representative study of youth enrolled in middle and high schools in the major metropolitan areas of the state. Texas ranks first across all states in regards to tobacco industry expenditures on advertising.³⁵ Understanding the nature and impact of e-cigarette advertising here will help inform future policy development and regulatory action specific to tobacco control. The purpose of this study was to determine if recall of e-cigarette advertising on TV, radio, billboards, retail stores, and the Internet is related to adolescent perceived harm of e-cigarettes, ever and current e-cigarette use, and susceptibility to use e-cigarettes. We hypothesized that increased exposure to e-cigarette advertisements was associated with lower perceived harm of e-cigarettes and increased e-cigarette ever use, current use, and susceptibility.

METHODS

Study Design

TATAMS is a rapid response surveillance system that follows 6th, 8th, and 10th grade students (12–17 year-olds) enrolled in 79 middle and high schools at baseline in 5 counties surrounding the 4 most populated cities in Texas (Austin, Houston, Dallas-Ft. Worth, San Antonio). TATAMS used a complex sampling design, which is described elsewhere.^{36,37} Baseline and follow-up data were collected from the same cohort of students in 2014–2015,

approximately 6 months apart. At baseline, tablet-based surveys were administered in the classroom; during follow-up, Web-based surveys were implemented outside of the classroom. Both surveys relied on the same format, which included pictures of e-cigarette devices to enhance the validity of related measures.³⁸ All survey measures were adapted from national surveillance studies (eg, PATH, NYTS)^{39,40} and underwent cognitive testing before implementation.

Participants

The sampling frame consists of 461,069 youth residing in the 4 most populated cities within 5 counties in Texas. A total of 3907 students completed the baseline survey (representing a population of $N = 461,069$), and 2488 ($N = 280,911$) of these students completed the follow-up survey 6 months later (weighted retention rate, or the response rate using the sampling weights = 60.8%). Non-response at 6-month follow-up was not related to tobacco or e-cigarette use.^{36,37} The weighted baseline sample consisted of 32.2% sixth graders, 34.7% eighth graders, and 33.1% tenth graders. In addition, 49% were female, while 54.5% of the students were Hispanic, 27.9% non-Hispanic white/other, and 17.6% non-Hispanic black, representing the distribution of the students in the sampling frame.

Measures

Exposures—Five communication channels (TV, radio, billboards, retail stores, and internet) were considered as possible outlets for exposures to e-cigarette advertisements at baseline. Students were asked questions regarding their exposure to TV, radio, and billboard advertisements in a matrix format: “How often do you see or hear any advertisements or promotions for electronic cigarettes, vape pens, or e-hookah on...Television shows (TV or online)? Radio/Internet Radio? Billboards?” Responses of “Never” and “Rarely” were collapsed to indicate low exposure, whereas “Occasionally,” “Frequently,” and “Very Frequently” were collapsed to indicate high exposure, consistent with prior research.^{23,30,41,42} The question on retail stores asked: “When you visited gas stations, convenience stores and/or grocery stores, how often did you see signs marketing electronic cigarettes, vape pens, or e-hookah?” The response of “Never/not that I remember” indicated low exposure, and “Some of the time you were in a store,” “Most of the time you were in a store,” and “Every time you were in a store” were collapsed to indicate high exposure, consistent with previous studies.^{23,30,41,42} All students were asked: “Where do you remember seeing advertisements for electronic cigarettes, vape pens, or e-hookah...?” Students who checked “Internet” were considered exposed to e-cigarette advertisements on the Internet, whereas students who did not check were not exposed. Finally, a continuous index score was created as the sum of the responses from the aforementioned 5 dichotomous exposures, where each student could score between a 0 and 5. This index score measures cumulative exposure to advertising, again consistent with prior research.³⁰

Outcomes—Four outcomes were included in the analyses: perceived harm, ever e-cigarette use, current e-cigarette use, and susceptibility. Perceived harm was measured by asking all students: “How harmful are electronic cigarettes, vape pens, or e-hookah to health?” on a 4-point scale from “Not at all harmful” to “Extremely harmful.” Responses of ‘Not at all harmful’ represented no perceived harm, and responses in the other 3 categories were

collapsed to indicate any perceived harm. Any perceived harm represented the reference category in analyses, as no perceived harm was the risk of interest.

We assessed ever e-cigarette use by asking all students at baseline and e-cigarette never users at 6-month follow-up the following question: “Have you EVER used an electronic cigarette, vape pen, or e-hookah, even one or two puffs?” with response options of ‘Yes’ or ‘No’. Those students who responded ‘Yes’ were considered e-cigarette ever users and those who responded ‘No’ were e-cigarette never users. Students who reported e-cigarette use at either wave were assessed for current e-cigarette use by asking: “DURING THE PAST 30 DAYS, on how many days did you use an electronic cigarette, vape pen, or e-hookah? Please enter the number of days (from 0 to 30 days).” Students who responded with 1 or more days were considered current (ie, past 30 day) e-cigarette users.

Only students who reported never e-cigarette use at either wave were asked the following 3 questions, which were based on established traditional cigarette susceptibility measures.^{15–17} The first question was: “Have you ever been curious about using electronic cigarettes, vape pens, or e-hookahs?” with responses including “Not at all curious,” “A little curious,” “Somewhat curious,” and “Very Curious.” The other 2 questions included: “Do you think you will use any of the following products in the next 12 months?” and “If one of your close friends were to offer you one of the following products, would you use it?” in reference to electronic cigarettes, vape pens, or e-hookahs. The response options for both of these questions were “Definitely not,” “Probably not,” “Probably yes,” and “Definitely yes.” If a student answered “Not at all curious” to the first question and “Definitely not” to the other 2 questions, they were considered non-susceptible. If students selected any other answer than “Not at all curious” or “Definitely not” to any of these 3 questions, they were considered susceptible to e-cigarette use.

Covariates—Four covariates were considered in the analyses: sex, race/ethnicity, grade level, and current other tobacco use. Sex was assessed by whether they were male or female. Two items measuring race/ethnicity asked: “What race or races do you consider yourself to be?” and “Are you Hispanic or Latino/a?” Responses from these 2 questions were collapsed to form 3 race/ethnicity categories (Hispanic, Non-Hispanic white/other, and Non-Hispanic black), as used for the generation of the sampling weights needed for analyses.^{36,37} Grade level was collapsed to a dichotomous variable (6th/8th and 10th) for both ever and current e-cigarette use because there was no new e-cigarette use from baseline to follow-up among 6th grade students.

One variable combined all other tobacco product responses to represent current other tobacco use at baseline, which was determined by asking students who indicated they had ever used any of these products, “DURING THE PAST 30 DAYS, on how many days did you smoke/use cigarettes; little filtered cigars; large cigars/cigarillos; hookah; smokeless tobacco? Please enter the number of days (from 0 to 30 days).” Students who responded 1 or more days to any of these items were considered current other tobacco users.

Statistical Analysis

Because TATAMS used a complex design, all statistical analyses used sampling weights to extrapolate to the population of 6th, 8th, and 10th grade students in 5 counties (Travis, Harris, Dallas, Tarrant, Bexar). Weighted proportions of e-cigarette advertisement recall (TV, radio/online radio, billboards, retail stores, internet, index score) and each of the outcomes (perceived harm, ever e-cigarette use, current e-cigarette use, susceptibility) were estimated by respondents at baseline in comparison to those who responded at both baseline and 6-month follow-up (Table 1). Weighted adjusted logistic regression analyses were used to investigate recall of e-cigarette advertisements as a risk factor for each of the outcomes, separately, in both cross-sectional (Table 2) and longitudinal (Table 3) models. One additional weighted adjusted logistic regression model was used to evaluate the association between susceptibility to e-cigarette use at baseline and ever e-cigarette use at 6-month follow-up. Sampling weights were applied to generalize results to all 6th, 8th, and 10th grade students in the 5 counties surrounding the 4 most populated cities in Texas; to account for the cluster effect of students within schools; and to adjust for non-response bias at follow-up.^{36,37} Baseline data analyses were cross-sectional by design, whereas the analyses that link both surveys were longitudinal. All analyses were performed using STATA 14.0 (College Station, TX).

A list-wise deletion of missing data was performed to compare the analyses of perceived harm of e-cigarettes, current e-cigarette use, and susceptibility to e-cigarette use across waves.⁴³ The final sample sizes for analyses with e-cigarette advertisements and the individual outcomes across both waves were 2223 for perceived harm, 2301 for current use, and 1827 for susceptibility. The outcome of e-cigarette ever use was not able to be compared across waves, because e-cigarette ever users will remain ever users across waves. Data were missing for less than 10% for each variable utilized in the e-cigarette ever use analyses, which allowed for complete case analysis to occur at baseline and follow-up.⁴³ At baseline, 3540 participants had complete data for analyses of ever use of e-cigarettes and 1950 participants had complete data at follow-up.

RESULTS

Among students who completed both assessments, 14.5% believed e-cigarettes not to be harmful at baseline, which decreased to 13.0% at follow-up. At baseline, 18.5% of students had ever used e-cigarettes. By follow-up, 3.0% of students had become new e-cigarette ever users. Among students who completed both surveys, 5.8% reported current e-cigarette use at baseline, which decreased to 3.5% at follow-up. In addition, 31.5% of student never-users who completed both surveys were susceptible to e-cigarette use at baseline, which decreased to 26.0% at follow-up.

Among students who completed both assessments, 47.2% of students recalled seeing e-cigarette advertising on TV, 23.7% on radio/online radio, 42.9% on billboards, 63.0% in retail stores, and 43.5% on the Internet. For the index score, 17.8% of students had no recall of e-cigarette advertising in all 5 channels, whereas 21.0% recalled advertisements in one of the 5 channels, 20.2% in 2, 18.8% in 3, 14.6% in 4, and 7.6% in all 5 channels. Table 1

compares the weighted proportions of e-cigarette advertising exposures between students who completed only baseline and students who completed both assessments.

Perceived Harm

Recall of e-cigarette advertising was not significantly associated with perceived harm at baseline after adjusting for covariates (Table 2, $p > .05$). However, among students who recalled e-cigarette advertising on TV at baseline, the odds of perceiving no harm from e-cigarettes at follow-up was 1.49 times higher compared to those who did not recall these advertisements, after adjusting for covariates (Table 3, $p < .05$).

E-cigarette Ever Use

Among students who recalled advertisements via TV and retail stores, the odds of ever e-cigarette use was 1.60 and 1.51 times higher, respectively, at baseline compared to those who did not recall these advertisements, after adjusting for covariates (Table 2, $p < .05$). The odds of ever e-cigarette use at baseline also increased by 1.14 for each recall of an advertisement, cumulatively, after adjusting for covariates (Table 2, $p < .05$). Among students who recalled retail store advertisements at baseline, the odds of ever e-cigarette use was 2.99 times higher at follow-up compared to those who did not recall retail store advertisements, after adjusting for covariates (Table 3, $p < .05$).

Current E-cigarette Use

Among students who recalled advertisements in retail stores, the odds of current e-cigarette use was 2.21 times higher at baseline compared to those who did not recall retail store advertisements, after adjusting for covariates (Table 2, $p < .05$). Among students who recalled retail store and internet advertisements at baseline, the odds of current e-cigarette use was 2.03 and 2.17 times higher, respectively, at follow-up compared to those who did not recall these advertisements, after adjusting for covariates (Table 3, $p < .05$).

Susceptibility

Across all outlets, at baseline, the odds of being susceptible to e-cigarette use was 1.76–2.79 times higher among students who recalled advertisements compared to those who did not recall these advertisements, after adjusting for covariates (Table 2, $p < .05$). The odds of being susceptible to e-cigarette use at baseline also increased by 1.45 for each recall of an advertisement, cumulatively, after adjusting for covariates (Table 2, $p < .05$). Among students who recalled advertisements via retail stores and the Internet at baseline, the odds of being susceptible to e-cigarette use was 1.77 and 1.72 times higher, respectively, at follow-up compared to those who did not recall these advertisements, after adjusting for covariates (Table 3, $p < .05$). The odds of being susceptible to e-cigarette use at baseline also increased by 1.20 for each recall of an advertisement, cumulatively, after adjusting for covariates (Table 3, $p < .05$). Finally, and importantly, susceptibility to e-cigarette use at baseline also was significantly associated with e-cigarette ever use 6 months later (OR=6.88, 95% CI 3.42–13.81, not shown).

DISCUSSION

This study contributes to the growing body of research on the effects of e-cigarette advertising on young people's e-cigarette use. Most of the literature on e-cigarette advertising to date has utilized samples of young adults^{44–47} and adults^{48,49} who were already traditional cigarette smokers. The literature to date specific to adolescents utilizes exclusively cross-sectional studies^{30,31} and an experimental study limited to TV advertisement exposure;³² however, this study also examined longitudinal relationships. Our findings from these longitudinal analyses underscore the impact that e-cigarette advertising at retail stores can have on increasing adolescent ever e-cigarette use, current e-cigarette use, and susceptibility to use e-cigarettes. In addition, e-cigarette advertising on the Internet also appears to increase current e-cigarette use as well as susceptibility to use e-cigarettes among youth, which may lead to experimentation with e-cigarettes over time.^{15–18}

Analysis of the 2014 NYTS indicated that e-cigarette advertising was seen most often in retail stores, on TV, and on the Internet among middle and high school students.²³ These findings are comparable to findings from our study, which also shows that billboards are another prominent source of advertising. E-cigarette advertising has increased on TV, especially during popular adolescent-oriented TV shows,²² despite banning cigarette advertising on TV decades ago.⁵⁰ Over 90% of adolescents access the Internet daily, such that regulation of Internet advertising also could be an important tool in curbing adolescent e-cigarette use.⁵¹ However, this is challenging, as Internet messages are a mix of tobacco industry-sponsored and user-generated content.^{52,53} More traditional channels of advertising, like billboards or radio, may be easier to regulate in the near future, as advertising for other products, like cigarettes, are banned on them, creating precedence for e-cigarettes. Given our findings specific to students' recall of advertisements at retail stores and its impact on e-cigarette use behaviors, actions to minimize the appeal of these advertisements and adolescent exposure to them seem most warranted. However, regulation of the point-of-sale environment at retail stores has been almost non-existent to date, not only for e-cigarettes, but also for other tobacco products.^{54,55}

The findings specific to susceptibility to e-cigarette use were the most consistent across our analyses. Susceptibility to cigarettes, defined as the lack of a firm commitment not to smoke, is a significant predictor of future cigarette smoking in adolescents;^{15–18} our findings extend this to e-cigarettes as well. In our study, recall of e-cigarette advertisements across all channels were associated with increased susceptibility in cross-sectional analyses. In longitudinal analyses, recall of e-cigarette advertisements via retail stores, the Internet, and the cumulative index score predicted susceptibility. Our cross-sectional results are also consistent with cross-sectional analyses of the 2014 NYTS.³⁰ In that study, e-cigarette advertisements across the Internet, retail stores, and TV/movie channels were associated with susceptibility to e-cigarette use, after adjusting for sex, race/ethnicity, grade, and current other tobacco use.³⁰ In addition, a dose-response relationship was observed between the number of e-cigarette advertisement channels adolescents recalled and the odds of susceptibility; the odds of susceptibility increased by 1.11 with the addition of each e-cigarette advertising channel.³⁰ Our findings suggest an even stronger dose-response relationship, at 1.45 cross-sectionally and 1.20 longitudinally. Given the age of our cohort,

the impact of advertising on susceptibility is notable and warrants further follow-up to examine whether those with increased susceptibility, after exposure to advertising, go on to experiment with e-cigarettes.

Our results for perceived harm were mixed. For perceived harm, no associations were found cross-sectionally; however, recall of TV e-cigarette advertisements was significantly associated with no perceived harm of e-cigarettes longitudinally. The cross-sectional results are perplexing, but it is interesting to note that retail stores and the Internet had the highest odds ratios for associations with no perceived harm and, significantly, for susceptibility to use. These associations may have been developing in these adolescent cohorts, especially because the longitudinal finding on TV advertisements is consistent with our hypotheses. As previous studies indicate, perceived harm typically decreased with advertisement exposure.³² Adolescents may not be aware of the potential risks of using e-cigarettes, which could lead to initiating use. The 2012 NYTS indicated that adolescents perceiving low harm of e-cigarettes were more likely to use e-cigarettes.³³ Furthermore, perceiving e-cigarettes to be less harmful has increased e-cigarette use in never users over time.⁵⁶ More research is necessary to determine the effect of e-cigarette advertising on perceived harm as well as the effect perceived harm has on e-cigarette use in adolescents.

In cross-sectional analyses, recall of TV, retail store, and the index score of e-cigarette advertisements was significantly associated with e-cigarette ever use, whereas recall of retail store advertisements was significantly associated with current e-cigarette use. In the 2014 NYTS, both TV and retail store advertisements were associated with ever e-cigarette use, and retail store advertisements were associated with current e-cigarette use, in support of our findings.^{30,31} Mantey et al³⁰ also determined that each exposure to each channel of e-cigarette advertisements in the 2014 NYTS increased the odds of ever and current e-cigarette use by 1.16 and 1.22, respectively. Our findings for e-cigarette ever use were consistent with these. Additionally, a 2014 online study found that teenagers had positive perspectives of e-cigarettes and increased intentions to try e-cigarettes after viewing TV e-cigarette advertisements.⁵⁷ In the present study, recall of retail store e-cigarette advertisements was associated with both ever and current e-cigarette use in longitudinal analyses. Notably, recall of advertisements in retail stores was the most prevalent form of exposure in our sample, and this high level of exposure may have translated into e-cigarette use 6 months later. Our findings indicate that retail store regulation could be important in preventing e-cigarette use in adolescents.

This study has some limitations. First, the weighted proportion of both current e-cigarette users and susceptible non-users decreased from Wave 1 to Wave 2. This is not reflective of increased use patterns seen over time in nationally representative studies, such as the NYTS.¹² However, this could be due to selection bias from students who did not answer the questions of interest in the TATAMS survey and were removed from analysis. Additionally, the present study uses self-reported variables. Recall of moments is subject to bias as many experiences are not retained in memory and difficult to enumerate, especially for routine actions.⁵⁸ Even though longitudinal data help strengthen causal inference, selection bias cannot be completely removed. Future research on advertising exposures should consider validating self-reported measures with direct observation. However, the present study also

has strengths. The study utilized a large sample of students who were representative of 6th, 8th, and 10th graders living in counties surrounding the 4 largest cities in Texas (Austin, Dallas-Ft. Worth, Houston, San Antonio). The study also was able to analyze the effect of e-cigarette advertisements via multiple locations on e-cigarette use behaviors over time, as previous studies to date have analyzed this effect only cross-sectionally. Currently, these major metropolitan areas are among the fastest growing American cities and represent about 50% of the state's population.⁵⁹ Moreover, as noted above, Texas ranks first across all states in regards to tobacco industry expenditures on advertising,⁶⁰ at a rate that outnumbers its state tobacco prevention spending at 62 to 1.⁶¹ Understanding the impact of e-cigarette advertising will help inform future policy development and regulatory action specific to tobacco control.

IMPLICATIONS FOR TOBACCO REGULATION

As adolescents recall e-cigarette advertisements through various channels, regulation of these advertisements could be essential in adolescent e-cigarette prevention efforts. Because the Deeming Rule does not include governing e-cigarette advertisements beyond the inclusion of a warning label,^{19,20} building the evidence on the effects of e-cigarette advertising is necessary to inform the FDA. The findings from this study support regulation of e-cigarette advertisements across channels; notably, related restrictions on cigarette advertisements provide precedence for such an approach. Regulation of e-cigarette advertising, particularly at point-of-sale and on the Internet, may be most effective in preventing e-cigarette use and susceptibility. However, point-of-sale regulations have not even been enacted for conventional cigarette advertising and the Internet is difficult to regulate.⁵² Despite this difficulty, different approaches, such as preventing e-cigarette company advertising, voluntary bans from social networking sites, filtering e-cigarette youth-oriented content, or including the Internet as part of a comprehensive advertising ban, have been proposed to tackle internet regulation.⁵³ Although regulations for advertising can be difficult to enforce, a ban on e-cigarette advertising in Finland resulted in 10.5% of adolescents recalling an e-cigarette advertisement across any advertising channel,⁶² compared to 79.7% at baseline in the current study. More longitudinal research with more robust measures of advertising exposure is necessary to help build the body of evidence specific to the causal effects of e-cigarette advertising on adolescent e-cigarette use behaviors.

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References

1. Bhatnagar A, Whitsel LP, Ribisl KM, et al. Electronic cigarettes: a policy statement from the American Heart Association. *Circulation*. 2014; 130(16):1418–1436. [PubMed: 25156991]

2. Yuan M, Cross SJ, Loughlin SE, Leslie FM. Nicotine and the adolescent brain. *J Physiol.* 2015; 593(16):3397–3412. [PubMed: 26018031]
3. [Accessed March 25, 2016] US Department of Health and Human Services. Smoking and youth. 2014. Available at: http://www.cdc.gov/tobacco/data_statistics/sgr/50th-anniversary/pdfs/fs_smoking_youth_508.pdf
4. Parrott AC. The psychobiological problems of continued nicotine dependency in e-cigarette ‘vapers’. Commentary: “electronic cigarettes”. *Front Psychiatry.* 2015; 6:123. [PubMed: 26388787]
5. Williams M, Villarreal A, Bozhilov K, et al. Metal and silicate particles including nanoparticles are present in electronic cigarette cartomizer fluid and aerosol. *PLoS One.* 2013; 8(3):e57987. [PubMed: 23526962]
6. Goniewicz ML, Knysak J, Gawron M, et al. Levels of selected carcinogens and toxicants in vapour from electronic cigarettes. *Tob Control.* 2014; 23(2):133–139. [PubMed: 23467656]
7. Herzog, B., Gerberi, J. [Accessed October 27, 2015] E-cigs revolutionizing the tobacco industry. Available at: <http://www.smallcapfinancialwire.com/wp-content/uploads/2013/11/E-Cigs-Revolutionizing-the-Tobacco-Industry-Interactive-Model.pdf>
8. 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. [PubMed: 26348249]
9. 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. [PubMed: 26284721]
10. Wills TA, Sargent JD, Knight R, et al. E-cigarette use and willingness to smoke: a sample of adolescent non-smokers. *Tob Control.* 2015; 0:1–8.
11. Barrington-Trimis JL, Urman R, Berhane K, et al. E-cigarettes and future cigarette use. *Pediatrics.* 2016; 138(1):e20160379. [PubMed: 27296866]
12. Singh T, Arrazola RA, Corey CG, et al. Tobacco use among middle and high school students - United States, 2011–2015. *MMWR Morb Mortal Wkly Rep.* 2016; 65(14):361–367. [PubMed: 27077789]
13. Cooper M, Case KR, Loukas A. E-cigarette use among Texas youth: results from the 2014 Texas Youth Tobacco Survey. *Addict Behav.* 2015; 50:173–177. [PubMed: 26151581]
14. Krishnan-Sarin S, Morean ME, Camenga DR, et al. E-cigarette use among high school and middle school adolescents in Connecticut. *Nicotine Tob Res.* 2015; 17(7):810–818. [PubMed: 25385873]
15. Pierce J, Farkas A, Evans N, Gilpin E. An improved surveillance measure for adolescent smoking. *Tob Control.* 1995; 4(1):S47–S56.
16. Pierce JP, Choi WS, Gilpin EA, et al. Validation of susceptibility as a predictor of which adolescents take up smoking in the United States. *Health Psychol.* 1996; 15(5):355–361. [PubMed: 8891714]
17. Pierce JP, Distefan JM, Kaplan RM, Gilpin EA. The role of curiosity in smoking initiation. *Addict Behav.* 2005; 30(4):685–696. [PubMed: 15833574]
18. Unger JB, Johnson CA, Stoddard JL, et al. Identification of adolescents at risk for smoking initiation: validation of a measure of susceptibility. *Addict Behav.* 1997; 22(1):81–91. [PubMed: 9022874]
19. US Food and Drug Administration. [Accessed December 27, 2016] Deeming Tobacco Products To Be Subject to the Federal Food, Drug, and Cosmetic Act, as Amended by the Family Smoking Prevention and Tobacco Control Act; Regulations Restricting the Sale and Distribution of Tobacco Products and Required Warning Statements for Tobacco Product Packages and Advertisements. Available at: <https://www.federalregister.gov/documents/2016/05/10/2016-10685/deeming-tobacco-products-to-be-subject-to-the-federal-food-drug-and-cosmetic-act-as-amended-by-the>
20. US Food and Drug Administration. [Accessed June 3, 2016] FDA takes significant steps to protect Americans from dangers of tobacco through new regulation. Available at: <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm499234.htm>
21. Kim AE, Arnold KY, Makarenko O. E-cigarette advertising expenditures in the U.S., 2011–2012. *Am J Prev Med.* 2014; 46(4):409–412. [PubMed: 24650844]

22. Duke JC, Lee YO, Kim AE, et al. Exposure to electronic cigarette television advertisements among youth and young adults. *Pediatrics*. 2014; 134(1):e29–e36. [PubMed: 24918224]
23. Singh T, Marynak K, Arrazola RA, et al. Vital signs: exposure to electronic cigarette advertising among middle school and high school students - United States, 2014. *MMWR Morb Mortal Wkly Rep*. 2016; 64(52):1403–1408. [PubMed: 26741522]
24. US Department of Health and Human Services. [Accessed February 18, 2016] Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General. Available at: <http://www.ncbi.nlm.nih.gov/books/NBK99237/>
25. Fulmer EB, Neilands TB, Dube SR, et al. Protobacco media exposure and youth susceptibility to smoking cigarettes, cigarette experimentation, and current tobacco use among US youth. *PLoS One*. 2015; 10(8):e0134734. [PubMed: 26308217]
26. Henriksen L, Schleicher NC, Feighery EC, Fortmann SR. A longitudinal study of exposure to retail cigarette advertising and smoking initiation. *Pediatrics*. 2010; 126(2):232–238. [PubMed: 20643725]
27. Portnoy DB, Wu CC, Tworek C, et al. Youth curiosity about cigarettes, smokeless tobacco, and cigars: prevalence and associations with advertising. *Am J Prev Med*. 2014; 47(2 Suppl 1):S76–S86. [PubMed: 25044199]
28. Hanewinkel R, Isensee B, Sargent JD, Morgenstern M. Cigarette advertising and adolescent smoking. *Am J Prev Med*. 2010; 38(4):359–366. [PubMed: 20307803]
29. Pechmann C, Knight SJ. An experimental investigation of the joint effects of advertising and peers on adolescents' beliefs and intentions about cigarette consumption. *J Consum Res*. 2002; 29(1):5–19.
30. Mantey DS, Cooper MR, Clendennen SL, et al. E-cigarette marketing exposure is associated with e-cigarette use among US youth. *J Adolesc Heal*. 2016; 58(6):686–690.
31. Singh T, Agaku IT, Arrazola RA, et al. Exposure to advertisements and electronic cigarette use among US middle and high school students. *Pediatrics*. 2016; 137(5):e20154155. [PubMed: 27244815]
32. Farrelly MC, Duke JC, Crankshaw EC, et al. A randomized trial of the effect of e-cigarette TV advertisements on intentions to use e-cigarettes. *Am J Prev Med*. 2015; 49(5):686–693. [PubMed: 26163170]
33. Amrock SM, Zakhar J, Zhou S, Weitzman M. Perception of e-cigarette harm and its correlation with use among U.S. adolescents. *Nicotine Tob Res*. 2015; 17(3):330–336. [PubMed: 25125321]
34. Ambrose BK, Rostron BL, Johnson SE, et al. Perceptions of the relative harm of cigarettes and e-cigarettes among U.S. youth. *Am J Prev Med*. 2014; 47(2 Suppl 1):S53–S60. [PubMed: 25044196]
35. [Accessed July 10, 2016] Campaign for Tobacco-Free Kids. State-Specific Estimates of Tobacco Company Marketing Expenditures 1998–2014. Available at: <http://www.tobaccofreekids.org/research/factsheets/pdf/0271.pdf>
36. Pérez A, Harrell MB, Malkani R, et al. Texas adolescent tobacco and marketing surveillance system's design. *Tob Regul Sci*. 2017; 3(2):151–167.
37. Pérez, A., Jackson, CD., Delk, J., et al. Design, sampling weights, reweighting for unit nonresponse, and monitoring of the Texas Adolescent Tobacco and Marketing Surveillance (TATAMS) System. Joint Statistical Meetings. Session 541: Weighting and Design Effects; Seattle, WA (USA). 2015. JSM2015 program book, 222
38. Delk, J., Harrell, M., Tala, F., et al. [Accessed January 3, 2017] Implementation of a computerized tablet-survey in an adolescent large-scale, school-based study. Available at: https://c.ymcdn.com/sites/srnt.site-ym.com/resource/resmgr/Conferences/Past_Annual_Meetings/SRNT_2015_Rapids_WEB.pdf
39. National Institutes of Health, Food and Drug Administration. [Accessed June 23, 2016] Population Assessment of Tobacco and Health (PATH). Available at: <https://pathstudyinfo.nih.gov/UI/HomeMobile.aspx>
40. US Centers for Disease Control and Prevention. [Accessed June 23, 2016] National Youth Tobacco Survey (NYTS). Available at: http://www.cdc.gov/tobacco/data_statistics/surveys/nyts/

41. Agaku IT, Ayo-Yusuf OA. The effect of exposure to pro-tobacco advertising on experimentation with emerging tobacco products among U.S. adolescents. *Health Educ Behav.* 2014; 41(3):275–280. [PubMed: 24347143]
42. Dube SR, Arrazola RA, Lee J, et al. Pro-tobacco influences and susceptibility to smoking cigarettes among middle and high school students – United States, 2011. *J Adolesc Heal.* 2013; 52(5):S45–S51.
43. Williams, R. [Accessed December 27, 2016] Missing Data Part 1: Overview, Traditional Methods. Available at: <http://www3.nd.edu/~rwilliam/stats2/112.pdf>
44. Berg CJ, Stratton E, Schauer GL, et al. Perceived harm, addictiveness, and social acceptability of tobacco products and marijuana among young adults: marijuana, hookah, and electronic cigarettes win. *Subst Use Misuse.* 2015; 50(1):79–89. [PubMed: 25268294]
45. Trumbo CW, Kim S-JS. The effect of electronic cigarette advertising on intended use among college students. *Addict Behav.* 2015; 46:77–81. [PubMed: 25827334]
46. Sanders-Jackson A, Schleicher NC, Fortmann SP, Henriksen L. Effect of warning statements in e-cigarette advertisements: an experiment with young adults in the United States. *Addiction.* 2015; 110(12):2015–2024. [PubMed: 25557128]
47. Pokhrel P, Fagan P, Kehl L, Herzog TA. Receptivity to e-cigarette marketing, harm perceptions, and e-cigarette use. *Am J Health Behav.* 2015; 39(1):121–131. [PubMed: 25290604]
48. Harrington KF, Hull NC, Akindoju O, et al. Electronic cigarette awareness, use history, and expected future use among hospitalized cigarette smokers. *Nicotine Tob Res.* 2014; 16(11):1512–1517. [PubMed: 24827786]
49. Pepper JK, Emery SL, Ribisl KM, et al. Effects of advertisements on smokers' interest in trying e-cigarettes: the roles of product comparison and visual cues. *Tob Control.* 2014; 23:iii31–iii36. [PubMed: 24935896]
50. US Centers for Disease Control and Prevention (CDC). [Accessed March 21, 2016] Smoking and Tobacco Use - Regulation. Available at: http://www.cdc.gov/tobacco/data_statistics/by_topic/policy/regulation/
51. Lenhart, A. [Accessed December 27, 2016] Teens, Social Media and Technology Overview 2015. Pew Research Center. Available at: www.pewinternet.org/2015/04/09/teens-social-media-technology-2015/
52. Forsyth SR, Kennedy C, Malone RE. The effect of the internet on teen and young adult tobacco use: a literature review. *J Pediatr Heal Care.* 2013; 27(5):367–376.
53. Freeman B. New media and tobacco control. *Tob Control.* 2012; 21(2):139–144. [PubMed: 22345236]
54. Rose SW, Barker DC, D'Angelo H, et al. The availability of electronic cigarettes in U.S. retail outlets, 2012: results of two national studies. *Tob Control.* 2014; 23:iii10–iii16. [PubMed: 24935892]
55. Widome R, Brock B, Klein EG, Forster JL. Smokeless tobacco advertising at the point of sale: prevalence, placement, and demographic correlates. *Nicotine Tob Res.* 2012; 14(2):217–223. [PubMed: 22080586]
56. Brose LS, Brown J, Hitchman SC, McNeill A. Perceived relative harm of electronic cigarettes over time and impact on subsequent use. a survey with 1-year and 2-year follow-ups. *Drug Alcohol Depend.* 2015; 157:106–111. [PubMed: 26507173]
57. Duke JC, Allen JA, Eggers ME, et al. Exploring differences in youth perceptions of the effectiveness of electronic cigarette television advertisements. *Nicotine Tob Res.* 2016; 18(5):1382–1386. [PubMed: 26706908]
58. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. *Annu Rev Clin Psychol.* 2008; 4:1–32. [PubMed: 18509902]
59. United States Census Bureau. Four Texas Metro Areas Add More Than 400,000 People in the Last Year, Census Bureau Reports. 2016. Release Number: CB16-43
60. Sly DF, Hopkins RS, Trapido E, Ray S. Influence of a counteradvertising media campaign on initiation of smoking: the Florida “Truth” campaign. *Am J Public Health.* 2001; 91(2):233–238. [PubMed: 11211631]

61. Campaign for Tobacco-Free Kids. [Accessed July 10, 2016] State Tobacco Prevention Spending vs. Tobacco Company Marketing. Available at: http://www.tobaccofreekids.org/content/what_we_do/state_local_issues/settlement/FY2016/StateTobaccoPreventionSpendingvsTobCoMarketing12-4-15.pdf
62. Kinnunen JM, Ollila H, El-Amin SE-T, et al. Awareness and determinants of electronic cigarette use among Finnish adolescents in 2013: a population-based study. *Tob Control*. 2015; 24(e4):e264–e270. [PubMed: 24827977]

Table 1

Weighted Proportion of Recall of E-cigarette Advertisement by Students that Complete Only Wave 1 (n = 3907) and Students that Completed Both Wave 1 and Wave 2 (n = 2488)

	Only Wave 1 n (%) (N^a = 461,069; n = 3907)	Both Wave 1 and Wave 2 n (%) (N^a = 280,911; n = 2488)
E-cigarette Advertisements		
TV	1725 (45.1)	1105 (47.2)
Radio/Online Radio	789 (23.3)	515 (23.7)
Billboards	1492 (40.7)	969 (42.9)
Retail Stores	2177 (61.8)	1418 (63.0)
Internet	1668 (40.0)	1144 (43.5)
Index Score		
0	809 (20.3)	476 (17.8)
1	834 (20.9)	535 (21.0)
2	784 (20.2)	502 (20.2)
3	708 (18.2)	455 (18.8)
4	535 (14.0)	353 (14.6)
5	237 (6.4)	167 (7.6)

Note.

^aThe weighted N's generalize back to the entire population of youth in the 4 cities in 5 counties where youth were sampled for this study.

Table 2

Association between Exposure to E-cigarette Advertisements at Baseline and No Perceived Harm of E-cigarettes, E-cigarette Ever Use, Current E-cigarette Use, and Susceptibility to E-cigarette use at Baseline among TATAMS Adolescents after Adjusting for Covariates (2014–2015)

	No Perceived Harm ^a OR (95% CI) N = 2223 ^b	Ever Use ^a OR (95% CI) N = 3540 ^c	Current Use ^a OR (95% CI) N = 2301 ^d	Susceptibility ^a OR (95% CI) N=1827 ^e
TV	0.84 (0.63–1.13)	1.60 (1.15–2.24)	1.13 (0.66–1.94)	1.97 (1.45–2.68)
Radio	0.74 (0.49–1.11)	1.07 (0.75–1.53)	1.03 (0.56–1.90)	1.76 (1.02–3.04)
Billboards	0.74 (0.51–1.09)	1.12 (0.87–1.45)	1.07 (0.61–1.88)	1.98 (1.37–2.86)
Retail Stores	1.00 (0.65–1.54)	1.51 (1.07–2.15)	2.21 (1.17–4.19)	1.97 (1.41–2.74)
Internet	1.30 (0.88–1.93)	1.24 (0.92–1.69)	1.20 (0.70–2.07)	2.79 (1.80–4.33)
Index Score ^f	0.95 (0.85–1.07)	1.14 (1.04–1.25)	1.12 (0.92–1.35)	1.45 (1.25–1.69)

Note.

Bolded indicates statistical significance, $p < .05$

^a Adjusted for sex, race/ethnicity, grade level, and current other tobacco use.

^b This sample generalizes back to a population (N) of 246, 555 youth in the 4 cities in 5 counties where youth were sampled for this study.

^c This sample generalizes back to a population (N) of 409,558 youth in the 4 cities in 5 counties where youth were sampled for this study.

^d This sample generalizes back to a population (N) of 255,336 youth in the 4 cities in 5 counties where youth were sampled for this study.

^e This sample generalizes back to a population (N) of 197,644 youth in the 4 cities in 5 counties where youth were sampled for this study.

^f The index score is the sum of the 5 dichotomous exposure responses and ranges between 0 and 5.

Table 3

Association between Exposure to E-cigarette Advertisements at Baseline and No Perceived Harm of E-cigarettes, E-cigarette Ever Use, Current E-cigarette Use, or Susceptibility to E-cigarette use at 6-month Follow-up among TATAMS Adolescents after Adjusting for Covariates (2014–2015)^a

	No Perceived Harm ^b OR (95% CI) N = 2223 ^f	Ever Use ^c OR (95% CI) N = 1950 ^g	Current Use ^d OR (95% CI) N = 2301 ^h	Susceptibility ^e OR (95% CI) N = 1827 ⁱ
TV	1.49 (1.04–2.13)	1.36 (0.58–3.19)	1.09 (0.67–1.79)	1.35 (0.91–1.99)
Radio	1.57 (0.99–2.48)	0.82 (0.31–2.18)	0.95 (0.51–1.79)	1.22 (0.76–1.95)
Billboards	1.19 (0.77–1.86)	1.13 (0.58–2.20)	0.75 (0.42–1.33)	1.15 (0.75–1.76)
Retail Stores	0.93 (0.65–1.34)	2.99 (1.50–5.97)	2.03 (1.11–3.72)	1.77 (1.20–2.61)
Internet	0.76 (0.52–1.12)	1.26 (0.60–2.65)	2.17 (1.05–4.48)	1.72 (1.15–2.58)
Index Score ^j	1.07 (0.95–1.20)	1.16 (0.98–1.37)	1.12 (0.98–1.28)	1.20 (1.04–1.38)

Note.

Bolded indicates statistical significance, $p < .05$

^aThe measures of exposures were from baseline, while the outcomes were from 6-month follow-up.

^bAdjusted for sex, race/ethnicity, grade level, current other tobacco use, and perceived harm in Wave 1.

^cAdjusted for sex, race/ethnicity, grade level, and current other tobacco use.

^dAdjusted for sex, race/ethnicity, grade level, current other tobacco use, and current e-cigarette use in Wave 1.

^eAdjusted for sex, race/ethnicity, grade level, current other tobacco use, and susceptibility to e-cigarette use in Wave 1.

^fThis sample generalizes back to a population (N) of 246,555 youth in the 4 cities in 5 counties where youth were sampled for this study.

^gThis sample generalizes back to a population (N) of 210,681 youth in the 4 cities in 5 counties where youth were sampled for this study.

^hThis sample generalizes back to a population (N) of 255,336 youth in the 4 cities in 5 counties where youth were sampled for this study.

ⁱThis sample generalizes back to a population (N) of 197,644 youth in the 4 cities in 5 counties where youth were sampled for this study.

^jThe index score is the sum of the 5 dichotomous exposure responses and ranges between 0 and 5.