The impact of outdoor advertising on adolescent tobacco use: Exposures at home and school

Hayes Forum 2018

Brittney Keller-Hamilton, MPH[1]

INTRODUCTION

Tobacco use remains prevalent among adolescents in the United States (US). An estimated 7.2% of middle school students and 20.2% of high school students reported current use of at least one product in 2016.[1] The balance of tobacco products used by adolescents has changed in the past five years. Decreases in use of traditional products, like cigarettes and cigars, have been offset by increases in use of electronic cigarettes (e-cigarettes) and hookah; in fact, e-cigarettes have become the most-used product for middle and high school students.[1] The prevalence of smokeless tobacco use has remained largely unchanged among middle school students and has decreased among high school students, although it remains most popular among male adolescents.[1]

Use of any tobacco product during adolescence is unsafe. Exposure to nicotine alters adolescent brain development, and adolescents are particularly susceptible to nicotine addiction.[2] An estimated 90% of adult cigarette smokers initiated use during adolescence.[3] Thus, because nicotine addiction begins early, adolescence represents a critical window for preventing tobacco use.

The tobacco industry pours billions of dollars into marketing their products every year,[4–6] and exposure to tobacco marketing is particularly influential on adolescent tobacco use behaviors.[3] Indeed, high densities of tobacco retailers around adolescents' homes[7,8] and schools[9] are associated with increased risk of adolescent cigarette smoking. Further, adolescents who

[1] Megan E. Roberts, PhD provided guidance for the study design and analyses. Dr. Roberts and Amy K. Ferketich, PhD both provided helpful feedback on this manuscript.

frequently visit retailers with heavy tobacco advertising, such as convenience stores, are at increased risk of initiating cigarette use.[10] Less is known about the relationship between retailer density and exposure to tobacco retail advertising around adolescents' homes and schools and use of e-cigarettes and smokeless tobacco (SLT) among adolescents. A few studies have shown that high levels of retailer density[11,12] and combined interior and exterior e-cigarette advertising[11] around schools increases risk of adolescent e-cigarette use, but the association between retailer density or burden of advertising near adolescents' homes and e-cigarette use behaviors has been unexamined. Additionally, to our knowledge, no research has explored the effects of retailer density or advertising burden near homes and schools on risk of SLT use among adolescents. Finally, no published research has examined both the effects of density and exposure to exterior tobacco advertising in the same study.

As the types of tobacco products being used continues to shift among adolescents in the US, identifying risk factors for use of traditional and novel tobacco products is vital. The present study aims to examine how both tobacco retailer density and burden of exterior advertising at tobacco retailers around adolescents' homes and schools relates to risk of initiating cigarette, e-cigarette, or SLT use. Consideration of both retailer density and burden of exterior advertising at tobacco retailers will improve our understanding of adolescent risk factors for use of cigarettes, e-cigarettes, and SLT and provide evidence for tobacco control interventions and policies.

METHODS

Study Participants and Procedures

Male youth ages 11-16 years were recruited via address-based sampling (N=991) and convenience sampling (N=229) methods in 2015 and 2016. Participants lived in Franklin

County, Ohio (N=708) or one of nine Appalachian Ohio counties (N=512) at enrollment. At baseline, participants completed in-person interviews that were a mix of audio computer-assisted self-interview (for tobacco use and other sensitive items) and interviewer-administered items. After baseline, participants completed phone-based follow-up surveys every six months for 1.5 years. Additional details about the study procedures are provided elsewhere.[13] All study activities were approved by The Ohio State University's Institutional Review Board.

Measures

Ever use of cigarettes, e-cigarettes, and SLT (defined as ever trying the product, even once or twice) were ascertained at baseline and follow-up. School names were obtained from the male youth during the baseline interview. Home and school addresses were geocoded with the ggmap package[14] in RStudio version 1.1.383,[15] which uses Google's geocoding capabilities to geocode large batches of addresses. After geocoding, home and school addresses were spatially joined to census tracts with ArcMap version 10.2.2.[16]

Lists of retailers with a cigarette dealer license were obtained from Ohio county auditor offices in 2016. These retailer addresses were also geocoded and spatially joined to census tracts using ArcMap.[16] Counts of retailers in each participant's home and school census tracts were our measures of retailer density.

A random sample of retailers with cigarette dealer licenses (N=212) were audited by trained fieldworkers in 2016; detailed procedures are provided elsewhere.[17] Prior to conducting audits, fieldworkers established an acceptable level of inter-rater reliability (kappa coefficients > 0.6). At each retailer, fieldworkers recorded the total number of small (less than one foot in all dimensions), medium (greater than one foot but less than three feet in all dimensions), and large

(greater than 3 feet in at least one dimension) advertisements for tobacco products on the outside of the building or on the site premise. These counts were used to calculate a weighted sum of exterior advertisements for each retailer; the count of small advertisements was multiplied by 1, the count of medium advertisements was multiplied by 2, and the count of large advertisements was multiplied by 3. These weighted exterior advertising scores varied greatly between retailer types (range of median scores by store type: 0-19). Therefore, we next calculated the median sum of weighted exterior advertising by retailer type (e.g., grocery store, convenience store, gas station, etc.) for each county. These median values were then applied to all retailers of the same type in each county. This step allowed us to essentially extrapolate the advertising scores from our sample of retailers to all retailers in a county. Finally, we summed exterior advertising scores across all retailers in each census tract to provide one measure of total exterior advertising burden in each participant's home and school census tracts.

Statistical Analyses

We completed a survey design-based analysis using fixed effects logistic regression. Information about our survey weighting procedures is provided elsewhere.[13] The dependent variables were incident ever use of cigarettes, e-cigarettes, or SLT by the 1.5-year follow-up survey. Thus, participants who had tried cigarettes, e-cigarettes, or SLT at baseline were excluded from analyses on the respective product. At baseline and follow-up, missing tobacco use responses were imputed using hot deck imputation. Participants missing data for other covariates were excluded from all analyses.

In crude analyses, we used separate models to evaluate the effects of home-tract retailer density, school-tract retailer density, home-tract exterior advertising, and school-tract exterior

advertising on our dependent variables. Retailer density and amount of exterior advertising in home and school census tracts violated the assumption of linearity in our logistic regression models; therefore, these variables were dichotomized for all models, with tracts in the highest 25th percentile being the index, or exposed, group.

In adjusted analyses, we controlled for race/ethnicity (white non-Hispanic, black non-Hispanic, and other race/ethnicity), baseline age, whether the participant lived with an adult tobacco user (yes/no), region (urban or Appalachian), parental education (less than college or college degree), and percent of families below the federal poverty level in the census tract.

All statistical analyses were completed using Stata 14.2.[18]

RESULTS

Study Population

For home-tract analyses, 1000 participants were included for cigarette incidence analyses, 978 were included for e-cigarette incidence analyses, and 1009 were included for SLT incidence analyses. Three participants were excluded from all home-tract analyses because their homes were not able to be geocoded. A total of 124 participants were excluded from school-tract analyses due to their schools not being located within one of our study counties (N=76), they were home-schooled (N=2), or their schools were not able to be geocoded due to a failure in confirming the school's name or address (N=46). Thus, for school-tract analyses, 953 were retained for cigarette models, 933 were retained for e-cigarette models, and 961 were retained for SLT analyses.

An estimated 5.6% of male youth initiated cigarette use over the 1.5 year period; 7.1% initiated e-cigarettes, and 2.4% initiated SLT. Males who initiated cigarettes, e-cigarettes, or SLT

were on average about a half-year older than males who did not initiate use of these products (Table 1). Additionally, tobacco initiators were more likely to have parents who used tobacco and who had not obtained a college degree. SLT initiators were also more likely to be white non-Hispanic and to live in the Appalachia Ohio region.

Effects of Retailer Density and Exterior Advertising on Tobacco Initiation

In crude analyses, living in a census tract with high retailer density or exterior advertising increased odds of cigarette initiation (Table 2). The effects of these predictors on odds of e-cigarette and SLT initiation were not statistically significant. We identified no effects of school-tract exposures on odds of cigarette, e-cigarette, or SLT initiation.

In adjusted analyses, the effect of living in a census tract with high exterior tobacco advertising remained associated with increased odds of cigarette initiation (odds ratio [OR] = 2.27; 95% confidence interval [CI]: 1.11, 4.62). The effects of home-tract retailer density on odds of cigarette initiation were attenuated to marginal significance (OR = 1.94; 95% CI: 0.90, 4.18).

DISCUSSION

We identified that living in census tracts with high counts of tobacco retailers and a high concentration of exterior tobacco advertising increased odds of cigarette initiation among adolescent males living in urban or Appalachian Ohio. After controlling for potential confounders of this association, the concentration of home census tract-level exterior advertising remained associated with increased odds of cigarette initiation. We found no association between

home or school census tract retailer density or exterior advertising burden on odds of e-cigarette or SLT initiation.

Our results are in line with prior studies demonstrating the effects of retailer density around adolescents' homes on risk of cigarette use. High retailer density has been associated with increased risk of susceptibility to cigarette smoking,[19] lifetime cigarette smoking,[7,20] current cigarette smoking,[8] and reduced readiness to quit smoking[19] among adolescents. One potential reason for these associations is that high retailer density influences adolescents' beliefs, attitudes, and perceived norms related to cigarette use, which in turn increases their likelihood of initiation.[21] Indeed, high tobacco retailer density around adolescents' homes increases perceptions of cigarette availability,[7] decreases perceptions of underage tobacco law enforcement,[7] raises the likelihood that adolescents think smoking is cool,[22] and increases perceived prevalence of adult smoking in their community.[20]

Although no studies to our knowledge have investigated the sole effects of outdoor tobacco advertising at the community level on adolescent tobacco use behaviors (i.e., the effects of outdoor advertising distinct from indoor advertising at the point-of-sale), our results again agree with prior work finding tobacco advertising exposures in the retail environment to be associated with increased risk of adolescent cigarette use.[10] On their own, exterior advertising exposures are important because youth do not need to enter tobacco retailers to see them. The path through which outdoor advertising exposures affect adolescent cigarette use behaviors is likely similar to the path from retailer density to adolescent cigarette use;[21] however, our study identified that exposure to exterior advertising may in fact be an even stronger predictor of cigarette initiation.

While the low rate of SLT initiation may have contributed to our marginally significant findings, the lack of association between retailer density or exterior advertising burden and odds of e-cigarette initiation was unexpected—although it does agree with one recent study that found self-reported exposure to tobacco advertising at the county level was not associated with adolescent e-cigarette use.[23] Though we are aware of no studies that have examined associations between tobacco retailer density around adolescents' *homes* and adolescent e-cigarette use, density of e-cigarette retailers and advertising near adolescents' *schools* has been associated with increased risk of e-cigarette use.[11,12] If the factors contributing to use of marketed tobacco products is relatively similar across products, we would expect to find consistent associations across products. There are a few potential explanations for this inconsistency that are worthy of further exploration. One reason could be that other forms of e-cigarette promotion (e.g., social media or television) are more persuasive to adolescents than exposures in their community. A second reason may be that e-cigarette advertisements at tobacco retailers are more discreet than advertisements for cigarettes or SLT, which was not recorded in our store audit process. Additionally, because e-cigarettes are a newer product, it is possible that it may take more time for exterior advertising exposures for this product to affect adolescent e-cigarette use behaviors. Another reason for our findings may be that our list of cigarette dealer licenses did not contain every e-cigarette retailer, and e-cigarette retailers are not required to be licensed in the state of Ohio. Thus, some e-cigarette retailers were not included in our measures of density or exterior advertising burden. Finally, we must consider that adolescents who initiate e-cigarette use differ from those who initiate use of more traditional tobacco products. If true, this study's results indicate that some tobacco control measures intended to reduce adolescent cigarette use (e.g.,

reduction of retailer density or outdoor advertising bans) may be less effective at reducing adolescent e-cigarette use due to differences in the target audience.

Similar to other studies that found no effects or marginal effects of retailer density around schools on adolescent cigarette smoking,[20,24,25] we also found null results. Our null results may be due to characteristics of our study population. Retailer density around schools has been associated with increased risk of smoking among high school students and in urban areas, but not in rural areas or among middle school students.[9] With the mean age of our population being 14-years-old and nearly a quarter living in Ohio Appalachia, it is possible that we would have detected effects in an older or more urban population.

The following limitations should be considered when interpreting our findings. First, while our focus on incident rather than prevalent tobacco use allows us to make stronger claims about causal relationships, it excluded participants who had already initiated tobacco use by baseline. It is possible that we excluded some youth who may have initiated use due to the tobacco advertising characteristics of their home or school census tracts by the time they enrolled in the study, and this could have biased our results toward the null. Excluding participants due to baseline use or missing data issues may also have left some of our analyses underpowered to detect significant differences. Though it did not limit the quality of our study findings, our decision to use total count of retailers per census tract as our measure of density rather than count of retailers per mile of roadway or per capita within a buffer drawn around adolescents' homes and schools mad our results less directly comparable to prior research. We decided to use total count of retailers per census tract to account for the fact that adolescents have larger activity spaces than within a buffer-zone drawn around their homes.[26] Finally, our results may only generalize to adolescent males who live in Ohio due to our study design.

This study was the first to examine the effects of exterior tobacco advertising around adolescents' homes and schools on risk of cigarette, e-cigarette, and SLT initiation. We identified that increased exterior tobacco advertising around adolescents' homes raises their risk of initiating cigarette use, which has important tobacco control implications. First, this is evidence that decreasing the burden of exterior advertising, either through reduction in retailer density or reduction in store-front advertising, may reduce smoking rates among adolescents—and that this effort should not be limited to areas near schools. In light of recent difficulties in reducing outdoor advertising through federal policy approaches,[27,28] alternative approaches should be considered. One such approach could be placement of graphic or emotive anti-tobacco advertisements on storefronts to draw attention away from tobacco advertisements.[29] Community-based studies examining the effectiveness of this approach are needed. Finally, it is important that implementation of policies that reduce retailer density should also monitor whether there are subsequent increases in store-front advertising at the remaining retailers, which may mitigate the otherwise positive effects of reducing retailer density on adolescent tobacco use outcomes.

Tables

Table 1. Survey-Weighted Characteristics of Tobacco Initiators

	Cigarette initiators	SLT initiators	E-cigarette initiators	All youth in sample
Baseline age (years; mean)	14.5	14.7	14.6	14.0
Race (%)				
White non-Hispanic	62.7	91.7	68.1	70.4
Black non-Hispanic	23.2	1.4	22.5	14.9
Other race/ethnicity	14.2	6.9	9.4	14.7
Parent tobacco use (%)	40.4	39.8	39.3	28.7
Region (%)				
Franklin County	67.9	39.8	77.9	74.4
Appalachia	32.3	60.2	22.2	25.6
Parent education (%)				
Less than college	62.9	46.2	57.1	42.2
College or higher	37.1	53.8	42.9	57.8
Home tract poverty (%, mean)	15.3	12.4	12.4	11.7

Abbreviations: SLT = Smokeless tobacco; E-cig = Electronic cigarette

Table 2. Crude effects of home- and school-tract retailer density and exterior advertising on odds of cigarette, e-cigarette, and SLT initiation*

	Home census tract			School census tract		
	Cigarette initiation	SLT initiation	E-cigarette initiation	Cigarette initiation	SLT initiation	E-cigarette initiation
Retailer density, OR (95% CI) †	2.39 (1.14, 5.02)	2.09 (0.91, 4.81)	0.90 (0.45, 1.82)	1.03 (0.44, 2.40)	0.85 (0.35, 2.03)	0.70 (0.31, 1.57)
Exterior advertising, OR (95% CI)‡	2.71 (1.31, 5.59)	1.86 (0.79, 4.38)	0.94 (0.47, 1.86)	1.78 (0.82, 3.88)	1.49 (0.63, 3.52)	0.95 (0.44, 2.03)

Abbreviations: OR = Odds ratio; CI = Confidence interval; E-cigarette = Electronic cigarette; SLT = Smokeless tobacco

* Fixed effects logistic regression with survey weights was used for all models.

† Reference group was census tracts in the lowest 75th percentile of retailer density.

‡Reference group was census tracts in the lowest 75th percentile of exterior advertising.

References

1. Jamal A, Gentze A, Hu S, et al. Tobacco Use Among Middle and High School Students - United States, 2011-2016. *Morb Mortal Wkly Rep*. 2017;66(23):597-603. doi:10.15585/mmwr.mm6623a1
2. Yuan M, Cross SJ, Loughlin SE, Leslie FM. Nicotine and the adolescent brain. *J Physiol*. 2015;593(16):3397-3412. doi:10.1113/JP270492
3. U.S. Department of Health and Human Services. *Preventing Tobacco Use among Youth and Young Adults*.; 2014. doi:10.1056/NEJMsa1405092
4. Federal Trade Commission. *Federal Trade Commission Cigarette Report for 2014*. Washington, D.C.; 2016. https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-cigarette-report-2014-federal-trade-commission-smokeless-tobacco-report/ftc_cigarette_report_2014.pdf.
5. Federal Trade Commission. *Federal Trade Commission Smokeless Tobacco Report for 2014*. Washington, D.C.; 2016. https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-cigarette-report-2014-federal-trade-commission-smokeless-tobacco-report/ftc_smokeless_tobacco_report_2014.pdf.
6. American Legacy Foundation. *Vaporized: E-Cigarettes, Advertising, and Youth*.; 2014. http://truthinitiative.org/sites/default/files/Vaporized_E-cigarettes_Advertising_and_Youth_May2014.pdf.
7. Lipperman-Kreda S, Grube JW, Friend KB, Mair C. Tobacco Outlet Density, Retailer Cigarette Sales without ID Checks, and Enforcement of Underage Tobacco Laws: Associations with Youths' Cigarette Smoking and Beliefs. *Addiction*. 2016;111(3):525-532. doi:10.1111/add.13179.Tobacco
8. Novak SP, Reardon SF, Raudenbush SW, Buka SL. Retail tobacco outlet density and youth cigarette smoking: A propensity-modeling approach. *Am J Public Health*. 2006;96(4):670-676. doi:10.2105/AJPH.2004.061622
9. McCarthy WJ, Mistry R, Lu Y, Patel M, Zheng H, Dietsch B. Density of tobacco retailers near schools: Effects on tobacco use among students. *Am J Public Health*. 2009;99(11):2006-2013. doi:10.2105/AJPH.2008.145128
10. Henriksen L, Schleicher NC, Feighery EC, Fortmann SP. A longitudinal study of exposure to retail cigarette advertising and smoking initiation. *Pediatrics*. 2010;126(2):232-238. doi:10.1542/peds.2009-3021.A
11. Giovenco DP, Casseus M, Duncan DT, Coups EJ, Lewis MJ, Delnevo CD. Association Between Electronic Cigarette Marketing Near Schools and E-cigarette Use Among Youth. *J Adolesc Heal*. 2016;59(6):627-634. doi:10.1016/j.jadohealth.2016.08.007
12. Bostean G, Crespi CM, Patsornkarn V, McCarthy WJ. E-cigarette use among students and e-cigarette specialty retailer presence near schools. *Heal Place*. 2016;42:129-136. doi:10.5588/ijtld.16.0716.Isoniazid
13. Friedman KL, Roberts ME, Keller-Hamilton B, et al. Attitudes towards tobacco, alcohol, and non-alcoholic beverage advertisement themes among adolescent boys. *Subst Use Misuse*. In press.
14. Kahle D, Wickham H. ggmap: Spatial Visualization with ggplot2. 2013:144-161.
15. RStudio Team. RStudio: Integrated Development for R. 2016. http://www.rstudio.com/.
16. ESRI. ArcGIS Desktop: Release 10. 2011.
17. Roberts ME, Berman ML, Slater MD, Hinton A, Ferketich AK. Point-of-sale tobacco

marketing in rural and urban Ohio: Could the new landscape of Tobacco products widen inequalities? *Prev Med (Baltim)*. 2015;81:232-235. doi:10.1016/j.ypmed.2015.08.024
18. StataCorp. *Stata Statistical Software Version 14.2*. College Station, TX: StataCorp LP; 2015.
19. Mennis J, Mason M. Tobacco outlet density and attitudes towards smoking among urban adolescent smokers. *Subst Abus*. 2016;37(4):521-525. doi:10.1080/08897077.2016.1181135
20. Schleicher NC, Johnson TO, Fortmann SP, Henriksen L. Tobacco outlet density near home and school: Associations with smoking and norms among US teens. *Prev Med (Baltim)*. 2016;91:287-293. doi:10.1016/j.ypmed.2016.08.027.Tobacco
21. Ajzen I, Madden TJ. Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *J Exp Soc Psychol*. 1986;22(5):453-474. doi:10.1016/0022-1031(86)90045-4
22. Loomis BR, Kim AE, Busey AH, Farrelly MC, Willett JG, Juster HR. The density of tobacco retailers and its association with attitudes toward smoking, exposure to point-of-sale tobacco advertising, cigarette purchasing, and smoking among New York youth. *Prev Med (Baltim)*. 2012;55(5):468-474. doi:10.1016/j.ypmed.2012.08.014
23. Pesko MF, Robarts AMT. Adolescent Tobacco Use in Urban Versus Rural Areas of the United States: The Influence of Tobacco Control Policy Environments. *J Adolesc Heal*. 2017;61(1):70-76. doi:10.1016/j.jadohealth.2017.01.019
24. Lipperman-Kreda S, Mair C, Grube JW, Friend KB, Jackson P, Watson D. Density and Proximity of Tobacco Outlets to Homes and Schools: Relations with Youth Cigarette Smoking. *Prev Sci*. 2014;15(5):738-744. doi:10.1007/s11121-013-0442-2
25. Adams ML, Jason LA, Pokorny S, Hunt Y. Exploration of the Link Between Tobacco Retailers in School Neighborhoods and Student Smoking. *J Sch Health*. 2013;83(2):112-118. doi:10.1111/josh.12006
26. Browning CR, Soller B, Jackson AL. Neighborhoods and Adolescent Health-Risk Behavior: An Ecological Network Approach. *Soc Sci Med*. 2015;125:163-172. doi:10.1097/MCA.0000000000000178.Endothelial
27. Gostin L. FDA regulation of tobacco: politics, law, and the public's health. *JAMA*. 2009;302(13):1459-1469.
28. Bayer R, Kelly M. Tobacco control and free speech—an American dilemma. *N Engl J Med*. 2010;362(4):281-283.
29. Meernik C, Jarman K, Wright ST, Klein EG, Goldstein AO, Ranney L. Eye Tracking Outcomes in Tobacco Control Regulation and Communication: A Systematic Review. *Tob Regul Sci*. 2016;2(4):377-403. doi:10.1038/nature15540.Genetic