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Original Investigation

Secondhand Smoke Exposure at Home and/or in a Vehicle: Differences Between Urban and Non-Urban Adolescents in the United States, From 2015 to 2018

Dale S. Mantey PhD, MPA,[1] Onyinye Omega-Njemnobi MBBS, MPH,[1] and Cristina S. Barroso DrPH[2]

[1]University of Texas School of Public Health, Austin, TX 78701, USA [2]University of Tennessee, College of Education, Health, and Human Sciences, Knoxville, TN 37996, USA

Corresponding Author: Dale S. Mantey, PhD, MPA, University of Texas School of Public Health, Dallas, TX 75235, USA. Telephone: (512) 482-6154; Fax: 713-500-3356; E-mail: dale.s.mantey@uth.tmc.edu

Abstract

Introduction: Secondhand smoke exposure during adolescence is linked to increased risk for cigarette smoking susceptibility and initiation. Non-urban youth may encounter a disproportionate number social and environmental risk factors for secondhand smoke exposure. Research is needed to explore geographic disparities in secondhand smoke exposure.

Aims and Methods: Four years of National Youth Tobacco Survey (2015–2018) data were pooled. Participants were 69 249 middle and high school students. Multivariable logistic regression examined the relationship between geographic region and secondhand smoke exposure (1) at home and (2) in a vehicle. A multivariable, multinomial logistic regression examined the relationship between geographic region and number of sources of secondhand smoke exposure (ie, 0, 1 source, 2 sources). Covariates included sex, race/ethnicity, grade level, past 30-day tobacco use, and living with a tobacco user.

Results: From 2015 to 2018, ~28.4% of middle and high school students reported secondhand smoke exposure either at home, in a vehicle, or both. Non-urban youth had greater odds of reporting secondhand smoke exposure at home (Adj OR: 1.26; 95% CI: 1.15 to 1.38) and in a vehicle (Adj OR: 1.50; 95% CI: 1.35 to 1.65), compared with urban youth. Similarly, non-urban youth had greater odds of reporting secondhand smoke exposure via one source (RRR: 1.21; 95% CI: 1.11 to 1.31) and two sources (RRR: 1.61; 95% CI: 1.42 to 1.82), relative to no exposure, than urban youth.

Conclusion: Secondhand smoke exposure at home and/or in a vehicle varies across geographic region. Targeted interventions should be developed and implemented to reduce secondhand smoke exposure among at-risk youth.

Implications: Findings showcase the need to address secondhand smoke exposure in non-urban areas and how it impacts adolescents. Public health interventions and regulatory policies aimed at improving social norms and expanding health infrastructure in rural communities should be designed and implemented in order to prevent and reduce secondhand smoke exposure among non-urban youth.

Introduction

Secondhand smoke contains ~7000 chemicals[1] and has been linked to cancer, heart disease, and stroke.[1] Exposure to secondhand smoke, particularly during adolescence, presents a myriad of unique health concerns. For example, secondhand smoke exposure can cause respiratory illness and infection especially among teens and youth.[1,2] Further, adolescents exposed to secondhand smoke are at increased risk of cigarette smoking experimentation and initiation than those not exposed to secondhand smoke.[3] Given these ramifications, exploring disparities associated with adolescent secondhand smoke exposure is critical to developing public health interventions and regulatory policies tailored to reduce inequities affecting adolescent health.

According to the Social Ecological Model (SEM), multilevel factors (ie, individual, social, environmental, and community level) influence behavior, and the relationship between these multilevel factors serves as a leading determinant of health.[4–6] Research suggests that the concentration of risk factors for adolescent secondhand smoke exposure may vary substantially by geography across each level of the SEM.[7] On the individual level, adolescents outside of urban areas (eg, rural and suburban) frequently report higher prevalence of cigarette smoking.[8–10] As such, non-urban youth are more likely to be current cigarette smokers (ie, individual-level risk factor) and/or have peers and friends who are current cigarette smokers (ie, social-level risk factor).[4–6] Similarly, adult cigarette smoking is significantly greater in non-urban areas,[11–13] reflecting an added social tier risk factor for secondhand smoke exposure among adolescents.

On the community level, differences in cultural norms surrounding tobacco use may also result in geographic disparities in secondhand smoke exposure. A recent study that used nationally representative data found adults in urban areas were significantly more likely to prohibit cigarette smoking in their homes and/or vehicles than adults in non-urban areas.[14] The lack of smoke-free home and vehicle policies is linked to an increased risk for secondhand smoke exposure among youth.[11–13] Geographic differences in cultural norms are further demonstrated by urban areas having stronger regulatory policies protecting adolescents against secondhand smoke exposure. Specifically, non-urban areas have fewer and less comprehensive clean air policies regarding cigarette smoking in public areas (eg, parks and bars/restaurants) and workplaces.[15–19]

Research has consistently demonstrated that adolescents[15,20] and adults[21–25] in non-urban areas report greater rates of secondhand smoke exposure. However, the majority of research on geographic disparities in exposure to secondhand smoke has focused on exposure in areas of public accommodations (eg, bars, restaurants, etc.).[15,21–25] As a result, there is a substantial gap in the literature examining geographic differences in secondhand smoke exposure in more private locations, such as vehicle and home. A prior study of adolescents in Florida found that living in non-urban areas was associated with greater odds of reporting secondhand smoke in a vehicle and/or in the home.[20] To our knowledge, this relationship has not been explored using a nationally representative sample. Research on adolescent secondhand smoke exposure in a vehicle and/or in the home is critically needed given that these locations are subject to substantially fewer regulation and enforcement compared with public accommodations in the United States.[19,26] As such, these areas reflect a categorically different source of secondhand smoke exposure that will require specialized research in efforts to develop and target prevention strategies and intervention.

Study Aims and Hypotheses

This study aims to explore geographic disparities in self-reported exposure to secondhand smoke among a nationally representative sample of middle and high school students, using cross-sectional data collected annually from 2015 to 2018. Specifically, this study will compare self-reported exposure to secondhand smoke at home and/or in a vehicle across urban and non-urban adolescents in the United States.

This study has three hypotheses. First, we hypothesize that non-urban adolescents will have greater odds of self-reported exposure to secondhand smoke at home, relative to urban youth. Second, we hypothesize that non-urban youth will have greater odds of self-reporting exposure to secondhand smoke in a vehicle, relative to urban youth. Third, we hypothesize that non-urban adolescents, compared with urban adolescents, will have greater odds of self-reporting exposure to secondhand smoke via one channel (ie, at home *or* in a vehicle, but not both) and two channels (ie, at home *and* in a vehicle), relative to no secondhand smoke exposure (referent group). Examination of each source of secondhand smoke exposure as well as cumulative sources was deemed necessary given the variance in attitudes and practices regarding smoke-free policies at home and in a vehicle among adults.[27]

Methods

Study Sample and Population

This study pooled and analyzed data from the 2015, 2016, 2017, and 2018 National Youth Tobacco Surveys (NYTS). The NYTS is a stratified, three-stage cluster sample designed to obtain the representative sample of middle and high school students in the United States. The sample procedures of the NYTS are probabilistic and conducted without replacement at all stages. The first stage of sample was to select primary sampling units within each stratum, then schools within each selected primary sampling unit, followed by classes within each selected school. Participation was voluntary and confidential for both students and schools. Extensive details of the sample procedures for the NYTS are available elsewhere.[28]

A sample total of n = 76 447 middle and high school students completed the NYTS surveys included in this study. However, participants with missing data on any variables included in this study were excluded from the sample (n = 7198; 9.8% of total sample). Resulting in a final sample of n = 69 249 middle and high school students from 2015 to 2018.

Study Measures

Geographic Residence

The NYTS survey incorporates geographic residence into the primary sampling unit (PSU) used for data collection. Participants were categorized as non-urban (referent group) if they lived in any area other than one of the 54 largest counties in the United States.[28] Consistent with previous literature[8,29] and in line with the National Center for Health Statistics categories.[30] Participants were categorized as urban if they lived in large central or fringe metro areas or medium metro areas, which constituted the 54 largest counties in the United States (coded as 1).[28] These classifications are described in further detail in the NYTS methodology guides available through the Center for Disease Control and Prevention.[28]

Secondhand Smoke Exposure

There were three outcome variables for this study: (1) self-reported exposure to secondhand smoke at home, (2) self-reported exposure to secondhand smoke in a vehicle, and (3) number of self-reported secondhand smoke exposure sources. For outcome 1, participants were asked the following questions: "During the past 7 days, on how many days did someone smoke tobacco products in your home while you were there?" For outcome 2, "During the past 7 days, on how many days did you ride in a vehicle when someone was smoking a tobacco product?" Both questions had categorical responses that were dichotomized into 0 days (referent outcome) and 1 to 7 days (coded as 1). For outcome 3, a score reflecting responses to both questions was computed to reflect cumulative exposure to secondhand smoke. Participants were categorized as follows: no secondhand smoke exposure (referent), at home or in a vehicle (coded as 1), and at home and in a vehicle (coded as 2).

Covariates

This study controlled for the following sociodemographic factors: biological sex, race/ethnicity, and grade level. Biological sex is a binary variable; males served as the referent group and females served as the comparison group. Race/ethnicity was coded into the following categories: (1) non-Hispanic, white; (2) Hispanic/Latino; (3) non-Hispanic, black; and (4) "other," reflecting non-Hispanic, Asian; non-Hispanic, multiracial; and non-Hispanic, any other race. Grade level was dichotomized into middle school (6th–8th grade) and high school (9th–12th grade). Each of these socio-demographic variables has been found to be associated with differing prevalence of secondhand smoke exposure in the home and/or vehicle.[11]

This study also controlled for past 30-day tobacco use, including e-cigarettes as this is a strong determinant of secondhand smoke exposure.[11–13] Participants were asked to self-report any use (in the past 30 days) of the following tobacco products: combustible cigarettes, electronic cigarettes, cigar products (ie, cigars, cigarillos, or little cigars), hookah, smokeless tobacco, pipe tobacco, snus, bidis, dissolvable tobacco, or roll your own tobacco. Based on these responses, adolescent tobacco use was categorized into the following mutually exclusive groups: none (referent), e-cigarettes only, other tobacco only, both e-cigarettes and other tobacco. This categorization was rooted in the fact that e-cigarettes are the most commonly used tobacco product among adolescents,[31] a sizable portion of adolescent e-cigarette users use multiple tobacco products,[31–33] and perceptions of harm differ significantly across e-cigarettes and other forms of tobacco products among adolescents.[34,35]

Finally, this study controlled for living with anyone that used combustible tobacco products and/or electronic cigarettes (live

Table 1. Descriptive statistics of study sample by urban/non-urban (NYTS, 2015–2018; *n* = 68 630)

	Geographic location			Chi-square test (*p*-value)
	Full sample	Non-urban[a]	Urban[b]	
Percent of sample	100%	50.0% (47.0–53.0)	50.0% (47.0–53.0)	
Sex				.085
Male	50.0% (49.2–50.7)	50.6% (49.7–51.5)	49.3% (48.2–50.5)	
Female	50.0% (49.3–50.8)	49.4% (48.5–50.3)	50.7% (49.6–51.8)	
Grade level[c]				.292
Middle school	43.3% (40.6–46.0)	44.7% (41.0–48.4)	41.8% (37.9–45.8)	
High school	56.7% (54.0–59.5)	55.3% (51.6–59.0)	58.2% (54.2–62.1)	
Race/ethnicity				**<.001**
Non-Hispanic White	53.3% (51.0–55.6)	62.1% (59.4–64.8)	44.5% (41.1–47.9)	
Hispanic/Latino	24.2% (22.5–26.0)	18.6% (16.8–20.5)	29.8% (27.0–32.7)	
Non-Hispanic, Black	12.2% (11.0–13.6)	10.8% (9.2–12.6)	13.7% (11.9–15.7)	
Other[d]	10.3% (9.5–11.1)	8.5% (7.5–9.6)	12.0% (10.9–13.3)	
Tobacco use category[e]				**<.001**
None	84.1% (83.3–84.9)	82.4% (81.2–83.6)	86.1% (85.0–87.1)	
E-cigarettes, only	4.8% (4.4–5.3)	4.8% (4.3–5.5)	4.7% (4.1–5.5)	
Other tobacco, only	5.6% (5.2–6.0)	6.7% (6.0–7.4)	4.5% (4.1–4.9)	
Both	5.4% (5.0–5.8)	6.1% (5.5–6.7)	4.7% (4.2–5.3)	
Live with a tobacco user[f]				.057
No	84.0% (81.7–86.1)	82.0% (78.2–85.2)	86.1% (83.4–88.4)	
Yes	16.0% (13.9–18.3)	18.0% (14.8–21.8)	13.9% (11.6–16.6)	
Year				.994
2015	25.2% (20.1–31.0)	50.7% (39.6–61.7)	49.3% (38.3–60.4)	
2016	25.0% (20.0–30.8)	51.0% (39.8–62.1)	49.0% (37.9–60.2)	
2017	25.1% (19.9–31.1)	48.7% (37.0–60.4)	51.3% (39.6–62.9)	
2018	24.7% (19.9–30.3)	49.7% (39.4–60.0)	50.3% (40.0–60.6)	

Note: Bold indicates statistical significance at $p < .05$.

[a]Participants were categorized as non-urban if they lived in any area other than one of the 54 largest counties in the United States.

[b]Participants were categorized as urban if they lived in one of the 54 largest counties in the United States.

[c]Middle school reflects being in 6th through 8th grade; high school reflects being in 9th through 12th grade.

[d]"Other" is where a response was "Asian, non-Hispanic," "American Indian/Alaska Native, non-Hispanic"; or "native Hawaiian and other Pacific Islanders, non-Hispanic".

[e]Past 30-day use of any of the following: combustible cigarettes, electronic cigarettes, cigars, cigarillos, little cigars, pipe tobacco, bidis, snus, dissolvable, and hookah.

[f]Self-reported living with anyone that using combustible cigarettes, electronic cigarettes, cigar products, hookah, pipe tobacco, and bidis.

Table 2. Association between geographic region and secondhand smoke exposure (NYTS, 2015–2018; *n* = 68 630)

	At home[a]	In a vehicle[b]
	Adj OR (95% confidence interval)	Adj OR (95% confidence interval)
Geographic region[c]		
Urban	1.00 (referent)	1.00 (referent)
Non-urban	**1.26*** (1.15–1.38)**	**1.50*** (1.35–1.65)**
Sex		
Male	1.00 (referent)	1.00 (referent)
Female	**1.19*** (1.13–1.24)**	**1.33*** (1.27–1.40)**
Grade level[d]		
Middle school	1.00 (referent)	1.00 (referent)
High school	**0.92* (0.85–0.99)**	1.04 (0.96–1.13)
Race/ethnicity		
Non-Hispanic White	1.00 (referent)	1.00 (referent)
Hispanic/Latino	**0.88** (0.81–0.95)**	**0.70*** (0.64–0.76)**
Non-Hispanic, Black	1.10 (0.99–1.22)	1.00 (0.91–1.11)
Other[e]	0.98 (0.89–1.07)	**0.81*** (0.73–0.90)**
Tobacco use category[f]		
None	1.00 (referent)	1.00 (referent)
E-cigarettes, only	**1.38*** (1.22–1.57)**	2.33*** (2.06–2.62)
Other tobacco, only	**2.24*** (2.02–2.50)**	3.93*** (3.49–4.44)
Both	**3.68*** (3.20–4.23)**	**8.16*** (7.17–9.29)**
Live with a tobacco user[g]		
No	1.00 (referent)	1.00 (referent)
Yes	**20.94*** (19.50–22.50)**	**7.72*** (7.23–8.26)**
Year		
2015	1.00 (referent)	1.00 (referent)
2016	1.00 (0.88–1.15)	0.97 (0.83–1.14)
2017	0.92 (0.81–1.06)	**0.80* (0.67–0.95)**
2018	0.91 (0.80–1.03)	**0.80** (0.69–0.92)**

Note: Bold indicates statistical significance at $p < .05$.

[a]Self-reporting 1 to 7 days for the following question: "During the past 7 days, on how many days did someone smoke tobacco products in your home while you were there?"

[b]Self-reporting 1 to 7 days for the following question: "During the past 7 days, on how many days did you ride in a vehicle when someone was smoking a tobacco product?"

[c]Participants were categorized as non-urban if they lived in any area other than one of the 54 largest counties in the United States

[d]Middle school reflects being in 6th through 8th grade; high school reflects being in 9th through 12th grade.

[e]"Other" is where a response was "Asian, non-Hispanic," "American Indian/Alaska Native, non-Hispanic"; or "native Hawaiian and other Pacific Islanders, non-Hispanic".

[f]Past 30-day use of any of the following: combustible cigarettes, electronic cigarettes, cigars, cigarillos, little cigars, pipe tobacco, bidis, snus, dissolvable, and hookah.

[g]Self-reported living with anyone that using combustible cigarettes, electronic cigarettes, cigar products, hookah, pipe tobacco, and bidis.

with a tobacco user). Combustible tobacco products include combustible cigarettes, cigar products, hookah, pipe tobacco, and bidis. Electronic cigarettes were included in this variable given that use of these products visually mimic combustible tobacco use.[36,37] Living with anyone that used one or more of these products was coded as a binary variable (ie, 0 = no; 1 = yes). Selection of covariates was informed by Directed Acyclic Graph available in Supplementary Material, Figure 1.

Statistical Analysis

Prior to testing study hypotheses, descriptive statistics were reported for each of the outcome variables. Further, chi-square tests were used to examine the bivariate association between covariates and study outcomes (Tables 1 and 2).

Two multivariate logistic regression models were used to test the first two study hypotheses. First, a multivariate logistic regression model examined the relationship between urban residency and self-reported secondhand smoke exposure at home in the past 7 days. Second, a multivariate logistic regression model examined the relationship between urban residency and self-reported secondhand smoke exposure in a vehicle in the past 7 days (Table 3). A multinomial logistic regression model was used to test the third study hypothesis (Table 4). For this model, exposure to neither source of secondhand smoke served as the referent outcome.

All analyses controlled for biological sex, race/ethnicity, grade level, past 30-day tobacco use, and living with a tobacco user. Further, year of survey was included as the covariate to account for the random intercept of this variable. Data were weighted to be representative of US middle school and high school students and to adjust for nonresponse and probability of selection. All analyses were conducted using STATA 14.2 (College Station, TX).

Results

Descriptive Statistics

The study sample was evenly distributed across urban and non-urban. Non-urban youth were predominately non-Hispanic white (62.1%) and had a greater prevalence of past 30-tobacco use (17.6%; $p < .001$) than their urban counterparts (13.9%). These figures and bivariate comparisons are available in detail in Table 1. Descriptive statistics and bivariate comparisons for each source and cumulative sources of secondhand smoke exposure across study variables are available in Supplementary material, tables.

Study Hypotheses

Table 2 shows non-urban youth had significantly greater odds of secondhand smoke exposure at home (Adj OR: 1.26; 95% CI: 1.15 to 1.38). Similarly, non-urban youth had significantly greater odds of secondhand smoke exposure in a vehicle (Adj OR: 1.50; 95% CI: 1.35 to 1.65). Also living with a tobacco user exponentially increases the odds of second hand smoke exposure at home (Adj OR: 20.94; 95% CI: 19.50 to 22.50) and in a vehicle (Adj OR: 7.72; 95% CI: 7.23 to 8.26).

Table 3 shows non-urban youth had a greater risk of secondhand smoke exposure via one source (RRR: 1.21; 95% CI: 1.11 to 1.31), relative to no secondhand smoke exposure, adjusting for all covariates. Similarly, non-urban youth had a greater relative risk of secondhand smoke exposure via two sources (RRR: 1.61; 95% CI: 1.42 to 1.82), relative to no secondhand smoke exposure, adjusting for all covariates.

Table 3. Association between geographic region and secondhand smoke exposure by number of sources (NYTS, 2015–2018; $n = 68\,630$)

	At home **or** in a vehicle[a] (ie, 1 source)	At home and in a vehicle[b] (ie, 2 sources)
	Relative risk ratio (95% confidence interval)	Relative risk ratio (95% confidence interval)
Geographic region[c]		
Urban	1.00 (referent)	1.00 (referent)
Non-urban	**1.21*** (1.11–1.31)**	**1.61*** (1.42–1.82)**
Sex		
Males	1.00 (referent)	1.00 (referent)
Females	**1.20*** (1.13–1.27)**	**1.39*** (1.31–1.47)**
Grade level[d]		
Middle school	1.00 (referent)	1.00 (referent)
High school	**1.12** (1.04–1.21)**	0.93 (0.84–1.03)
Race/ethnicity		
Non-Hispanic White	1.00 (referent)	1.00 (referent)
Hispanic/Latino	**0.90* (0.83–0.97)**	0.68*** (0.61–0.75)
Non-Hispanic, Black	1.09 (0.99–1.21)	**1.05 (0.92–1.20)**
Other[c]	0.95 (0.86–1.05)	**0.83** (0.74–0.94)**
Tobacco use category[f]		
None	1.00 (referent)	1.00 (referent)
E-cigarettes, only	**2.00*** (1.72–2.32)**	**2.24*** (1.92–2.61)**
Other tobacco, only	**3.16*** (2.78–3.59)**	**4.85*** (4.21–5.59)**
Both	**6.15*** (5.22–7.25)**	**12.73*** (10.65–15.22)**
Live with a tobacco user[g]		
No	1.00 (referent)	1.00 (referent)
Yes	**8.35*** (7.80–8.93)**	**31.34*** (28.51–34.44)**
Year		
2015	1.00 (referent)	1.00 (referent)
2016	1.01 (0.89–1.14)	0.98 (0.81–1.19)
2017	**0.85** (0.74–0.96)**	**0.81* (0.66–0.99)**
2018	0.90 (0.80–1.02)	**0.78** (0.66–0.94)**

Note: Bold indicates statistical significance at $p < .05$.

All participants were asked the following questions: (1) "During the past 7 days, on how many days did someone smoke tobacco products in your home while you were there?" and (2) "During the past 7 days, on how many days did you ride in a vehicle when someone was smoking a tobacco product?"

[a]Self-reporting secondhand hand smoke exposure via only one source (ie, at home or in a vehicle, but not both).

[b]Self-reporting secondhand hand smoke exposure via both sources (ie, both at home and in a vehicle).

[c]Participants were categorized as non-urban if they lived in any area other than one of the 54 largest counties in the United States.

[d]Middle school reflects being in 6th through 8th grade; high school reflects being in 9th through 12th grade.

[e]"Other" is where a response was "Asian, non-Hispanic," "American Indian/Alaska Native, non-Hispanic"; or "native Hawaiian and other Pacific Islanders, non-Hispanic"

[f]Past 30-day use of any of the following: combustible cigarettes, electronic cigarettes, cigars, cigarillos, little cigars, pipe tobacco, bidis, snus, dissolvable, and hookah.

[g]Self-reported living with anyone that using combustible cigarettes, electronic cigarettes, cigar products, hookah, pipe tobacco, and bidis.

Discussion

This study found that youth residing in non-urban areas were more likely to self-report being exposed to secondhand smoke at home as well as in a vehicle from 2015 to 2018. Similarly, this study found that non-urban youth were more likely to be exposed to multiple sources of secondhand smoke (ie, at home and in a vehicle) than urban youth from 2015 to 2018. To the best of our knowledge, this is the first study to explore geographic disparities in second hand smoke exposure to secondhand smoke at home and/or in a vehicle (private locations) among a nationally representative sample of adolescents in the United States, across multiple years. Study findings highlight a disconcerting inequity among non-urban populations particularly as secondhand smoke exposure during adolescence is a strong determinant of subsequent cigarette smoking.[3]

In applying the framework of the SEM, this study builds on previous research exploring disparities in cigarette smoking behaviors among urban and non-urban populations in the United States. Non-urban, youth,[8,29] and adults[9,10,38–40] consistently report greater rates of smoking cigarettes than their urban counterparts in general and across socio-demographic factors (eg, sex and race/ethnicity). Cigarette smoking as a behavioral outcome is influenced by the relationships between multilevel risk factors.[4–6] Previous research suggests that these geographic disparities in smoking prevalence may be due to individual factors (eg, income), environmental (eg, marketing exposure) and regulatory policies (eg, excise taxes and retail licensing) differences across regions.[8,29,38,41,42] Our study finds that secondhand smoke exposure at home and/or in a vehicle is greater among non-urban youth and, as such, it is plausible that this social-level risk factor may contribute to the disproportionately higher smoking prevalence among non-urban adolescents relative to their urban counterparts.[4–6]

This study has several implications for public health. Findings indicate a need to expand educational campaigns aimed at

promoting smoke-free home and vehicle policies particularly in non-urban areas. Negative attitudes toward smoke-free home and/or vehicle polices are common in non-urban areas, relative to urban areas.[18,27,43] However, research has shown that public health interventions designed for non-urban populations can be effective at changing cultural norms (such as perceptions of indoor smoking) and behaviors (such as adoption of smoke-free home and vehicle policies).[7] Thus, public health intervention campaigns aimed toward changing attitudes and behaviors to reduce adolescent exposure to secondhand smoke at home and/or in a vehicle are needed.

Presented findings also indicate the need to expand regulatory policies on federal, state, and local levels in order to prevent and reduce secondhand smoke exposure. On the federal level, a potential area of focus may be federally funded and subsidized multiunit housing. While a 2018 federal rule by the Department of Housing and Urban Development restricts the use of combustible tobacco products in public housing units,[43] these rules do not apply to the Section 8 voucher program which currently serves more than 2 million low-income residents in the United States.[43] On the state and local level, an expansion of smoke-free policies in public places (eg, parks and bars/restaurants) and worksites may address the gap in secondhand smoke exposure. While these policies may not directly impact adolescents, smoke-free home and/or vehicle policies, smoke-free ordinances on the state and local level have been demonstrated to improve smoke-free norms,[44,45] which may ultimately reduce secondhand smoke exposure.[46–48]

This study has a number of limitations. First, this study uses self-reported data, thus all responses are subject to recall bias. Second, the presented data were cross-sectional consequently causal inferences cannot be made. Third, this study included two highly predictive factors of secondhand smoke exposure (ie, current tobacco use and living with tobacco users) as covariates, thus the threat of residual confounding cannot be excluded. Future research using more complex analytics (eg, propensity score matching) with more comprehensive socio-demographic (eg, income status) and behavioral (eg, marijuana use) variables is needed to remove the threat of residual confounding.[49] Fourth, this study did not explore frequency of secondhand smoke exposure (ie, number of days per week) and was unable to examine variances in source of secondhand smoke exposure (from parents, siblings, etc.). Finally, geographic regions in the United States are complex; however, this research was limited to exploring geography as a binary variable (ie, urban/non-urban). Future research is needed to investigate beyond the preliminary nature of our study and comprehensively examines the nuances of geographic disparities.

Despite these limitations, presented findings showcase the need to address secondhand smoke exposure in non-urban areas. Public health interventions and regulatory policies aimed at improving knowledge, social norms, and expanding health infrastructure, particularly in rural communities, should be designed and implemented in order to prevent and reduce secondhand smoke exposure among youth.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Disclaimer

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Declaration of Interests

None declared.

References

1. US Department of Health and Human Services. *The health consequences of smoking—50 years of progress: a report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease; 2014.
2. US Department of Health and Human Services. *A report of the surgeon general: how tobacco smoke causes disease: what it means to you*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention. National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2010. p. 978.
3. Okoli CT, Kodet J. A systematic review of secondhand tobacco smoke exposure and smoking behaviors: Smoking status, susceptibility, initiation, dependence, and cessation. *Addict Behav.* 2015;47:22–32.
4. Corbett KK. Susceptibility of youth to tobacco: a social ecological framework for prevention. *Respir Physiol.* 2001;128(1):103–118.
5. Connell CM, Gilreath TD, Aklin WM, Brex RA. Social-ecological influences on patterns of substance use among non-metropolitan high school students. *Am J Commun Psychol.* 2010;45(1–2):36–48.
6. Wen M, Van Duker H, Olson LM. Social contexts of regular smoking in adolescence: towards a multidimensional ecological model. *J Adolesc.* 2009;32(3):671–692.
7. Williamson M, Elbaum M, Pearson M, et al. *Advancing Tobacco Prevention and Control in Rural America*. National Network of Public Health Institutes; 2019.
8. Wiggins AT, Huntington-Moskos L, Rayens EA, et al. Tobacco use among rural and urban US middle and high school students: National Youth Tobacco Survey, 2011-2016. *J Rural Health.* 2020;36(1):48–54.
9. Doogan NJ, Roberts ME, Wewers ME, et al. A growing geographic disparity: rural and urban cigarette smoking trends in the United States. *Prev Med.* 2017;104:79–85.
10. Nighbor TD, Doogan NJ, Roberts ME, et al. Smoking prevalence and trends among a U.S. national sample of women of reproductive age in rural versus urban settings. *PLoS One.* 2018;13(11):e0207818.
11. Agaku IT, Odani S, King BA, Armour BS. Prevalence and correlates of secondhand smoke exposure in the home and in a vehicle among youth in the United States. *Prev Med.* 2019;126:105745.
12. Agaku IT, Singh T, Rolle I, Olalekan AY, King BA. Prevalence and determinants of secondhand smoke exposure among middle and high school students. *Pediatrics.* 2016;137(2):e20151985.
13. Gentzke AS, Wang TW, Marynak KL, Trivers KF, King BA. Exposure to secondhand smoke and secondhand E-cigarette aerosol among middle and high school students. *Prev Chronic Dis.* 2019;16:E42.
14. Stillman FA, Tanenbaum E, Wewers ME, et al. Variations in support for secondhand smoke restrictions across diverse rural regions of the United States. *Prev Med.* 2018;116:157–165.
15. Vander Weg MW, Cunningham CL, Howren MB, Cai X. Tobacco use and exposure in rural areas: Findings from the Behavioral Risk Factor Surveillance System. *Addict Behav.* 2011;36(3):231–236.

16. Hood NE, Bernat DH, Ferketich AK, Danesh D, Klein EG. Community characteristics associated with smokefree park policies in the United States. *Nicotine Tob Res*. 2014;16(6):828–835.
17. Huang J, King BA, Babb SD, Xu X, Hallett C, Hopkins M. Sociodemographic disparities in local smoke-free law coverage in 10 States. *Am J Public Health*. 2015;105(9):1806–1813.
18. Buettner-Schmidt K, Miller DR, Maack B. Disparities in rural tobacco use, smoke-free policies, and tobacco taxes. *Western J Nurs Res*. 2019;41(8):1184–1202.
19. Hafez AY, Gonzalez M, Kulik MC, Vijayaraghavan M, Glantz SA. Uneven access to smoke-free laws and policies and its effect on health equity in the United States: 2000-2019. *Am J Public Health*. 2019;109(11):1568–1575.
20. Bayly JE, Bernat D, Porter L, O'Dare K, Choi K. Prevalence and characteristics of secondhand smoke and secondhand vapour exposure among youth. *Tob Control*. 2019;28(3):305–310.
21. Schmidt LM, Reidmohr AA, Helgerson SD, Harwell TS. Secondhand smoke exposure and smoke-free policy support among public housing authority residents in rural and tribal settings. *J Commun Health*. 2016;41(6):1116–1121.
22. Lee K, Hwang Y, Hahn EJ, Bratset H, Robertson H, Rayens MK. Secondhand smoke exposure is associated with smoke-free laws but not urban/rural status. *J Air Waste Manag Assoc*. 2015;65(5):624–627.
23. Buettner-Schmidt K, Lobo ML, Travers MJ, Boursaw B. Tobacco smoke exposure and impact of smoking legislation on rural and non-rural hospitality venues in North Dakota. *Res Nurs Health*. 2015;38(4):268–277.
24. Buettner-Schmidt K, Boursaw B, Lobo ML. Place and policy: Secondhand smoke exposure in bars and restaurants. *Nurs Res*. 2018;67(4):324–330.
25. Buettner-Schmidt K, Boursaw B, Lobo ML, Travers MJ. Tobacco smoke pollution in hospitality venues before and after passage of statewide smoke-free legislation. *Public Health Nurs*. 2017;34(2):166–175.
26. Weisman S. *Kids, Cars and Cigarettes: Policy Options for Smoke-Free Vehicles*. St. Paul, MN: Public Health Law Center. 2010.
27. McMillen R, Wilson K, Tanski S, Klein JD, Winickoff JP. Adult attitudes and practices regarding smoking restrictions and child tobacco smoke exposure: 2000 to 2015. *Pediatrics*. 2018;141(suppl 1):S21–S29.
28. U.S. Department of Health and Human Services, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. *National Youth Tobacco Survey: Methodology Report*. 2018.
29. 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 Health*. 2017;61(1):70–76.
30. Statistics NCfH. *NCHS urban-rural classification scheme for counties*. Updated; 2017. https://www.cdc.gov/nchs/data_access/urban_rural.htm
31. Wang TW, Gentzke AS, Creamer MR, et al. Tobacco product use and associated factors among middle and high school students - United States, 2019. *MMWR Surveill Summ*. 2019;68(12):1–22.
32. Mantey DS, Omega-Njemnobi O, Montgomery L. Flavored tobacco use is associated with dual and poly tobacco use among adolescents. *Addict Behav*. 2019;93:269–273.
33. Mantey DS, Creamer MR, Pasch KE, Perry CL. Marketing exposure recall is associated with past 30-day single, dual, polytobacco use among US adolescents. *Nicotine Tob Res*. 2018;20(suppl_1):S55–S61.
34. Strong DR, Messer K, White M, et al. Youth perception of harm and addictiveness of tobacco products: Findings from the population assessment of tobacco and health study (Wave 1). *Addict Behav*. 2019;92:128–135.
35. Mattingly DT, Tompkins LK, Rai J, Sears CG, Walker KL, Hart JL. Tobacco use and harm perceptions among Appalachian youth. *Prev Med Rep*. 2020;18:101089.
36. Pepper JK, Emery SL, Ribisl KM, Southwell BG, Brewer NT. Effects of advertisements on smokers' interest in trying e-cigarettes: the roles of product comparison and visual cues. *Tob Control*. 2014;23(suppl 3):iii31–iii36.
37. de Andrade M, Hastings G, Angus K. Promotion of electronic cigarettes: tobacco marketing reinvented? *BMJ*. 2013;347:f7473.
38. Ziller EC, Lenardson JD, Paluso NC, Talbot JA, Daley A. Rural-urban differences in the decline of adolescent cigarette smoking. *Am J Public Health*. 2019;109(5):771–773.
39. Coughlin LN, Bonar EE, Bohnert KM, et al. Changes in urban and rural cigarette smoking and Cannabis use from 2007 to 2017 in adults in the United States. *Drug Alcohol Depen*. 2019;205:107699.
40. Cepeda-Benito A, Doogan NJ, Redner R, et al. Trend differences in men and women in rural and urban U.S. settings. *Prev Med*. 2018;117:69–75.
41. Mantey DS, Barroso CS, Kelder BT, Kelder SH. Retail access to e-cigarettes and frequency of e-cigarette use in high school students. *Tob Reg Sci*. 2019;5(3):280–290.
42. Mantey DS, Cooper MR, Clendennen SL, Pasch KE, Perry CL. E-cigarette marketing exposure is associated with e-cigarette use among US youth. *J Adolesc Health*. 2016;58(6):686–690.
43. McMillen RC, Winickoff JP, Gottlieb MA, Tanski S, Wilson K, Klein JD. Public support for smoke-free section 8 public housing. *Western J Nurs Res*. 2019;1(8):1170–1183.
44. Hamilton WL, Biener L, Brennan RT. Do local tobacco regulations influence perceived smoking norms? Evidence from adult and youth surveys in Massachusetts. *Health Educ Res*. 2008;23(4):709–722.
45. Department of Health and Human Services. *Preventing tobacco use among youth and young adults: a report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease; 2012.
46. Albers AB, Siegel M, Cheng DM, Biener L, Rigotti NA. Effect of smoking regulations in local restaurants on smokers' anti-smoking attitudes and quitting behaviours. *Tob Control*. 2007;16(2):101–106.
47. Grassi MC, Enea D, Ferketich AK, Lu B, Nencini P. A smoking ban in public places increases the efficacy of bupropion and counseling on cessation outcomes at 1 year. *Nicotine Tob Res*. 2009;11(9):1114–1121.
48. Hahn EJ, Rayens MK, Langley RE, Darville A, Dignan M. Time since smoke-free law and smoking cessation behaviors. *Nicotine Tob Res*. 2009;11(8):1011–1015.
49. Parsons L. Reducing bias in a propensity score matched-pair sample using greedy matching techniques. Paper presented at Proceedings of the Twenty-Sixth Annual SAS Users Group International Conference 20012001.