Inequalities in tobacco outlet density by race, ethnicity, and socioeconomic status, 2012, USA: Results from the ASPiRE Study

Joseph G. L. Lee, PhD, MPH[1,2,*], **Dennis L. Sun, PhD, MS**[3], **Nina M. Schleicher, PhD**[4], **Kurt M. Ribisl, PhD**[2,5], **Douglas A. Luke, PhD**[6], and **Lisa Henriksen, PhD**[4]

[1]Department of Health Education and Promotion, College of Health and Human Performance, East Carolina University, Greenville, NC

[2]Department of Health Behavior, UNC Gillings School of Global Public Health, Chapel Hill, NC

[3]Department of Statistics, College of Science and Mathematics, Cal Poly, San Luis Obispo, CA

[4]Stanford Prevention Research Center, Stanford University School of Medicine, Palo Alto, CA

[5]Lineberger Comprehensive Cancer Center, UNC School of Medicine, Chapel Hill, NC

[6]George Warren Brown School of Social Work, Washington University in St. Louis, St. Louis, MO

Abstract

BACKGROUND—Evidence of racial/ethnic inequalities in tobacco outlet density is limited by: (1) reliance on studies from single counties or states, (2) limited attention to spatial dependence, and (3) an unclear theory-based relationship between neighborhood composition and tobacco outlet density.

METHODS—In 97 counties from the contiguous US, we calculated the 2012 density of likely tobacco outlets (N=90,407), defined as tobacco outlets per 1,000 population in census tracts (n=17,667). We used two spatial regression techniques, (1) a spatial errors approach in GeoDa software and (2) fitting a covariance function to the errors using a distance matrix of all tract centroids. We examined density as a function of race, ethnicity, income, and two indicators identified from city planning literature to indicate neighborhood stability (vacant housing, renter-occupied housing).

*Corresponding author: Joseph G. L. Lee, Department of Health Education and Promotion, East Carolina University, 1000 E. 5th Street, Mail Stop 529, Greenville, NC 27858; leejose14@ecu.edu.

RESULTS—The average density was 1.3 tobacco outlets per 1,000 persons. Both spatial regression approaches yielded similar results. In unadjusted models, tobacco outlet density was positively associated with the proportion of Black residents and negatively associated with the proportion of Asian residents, White residents and median household income. There was no association with the proportion of Hispanic residents. Indicators of neighborhood stability explained the disproportionate density associated with Black residential composition, but inequalities by income persisted in multivariable models.

CONCLUSIONS—Data from a large sample of US counties and results from two techniques to address spatial dependence strengthen evidence of inequalities in tobacco outlet density by race and income. Further research is needed to understand the underlying mechanisms in order to strengthen interventions.

INTRODUCTION

Cigarettes, the only consumer product that kills almost half of its users when used as directed, are sold in approximately 375,000 stores in the United States.[1] Tobacco outlets contribute to the toll of tobacco use through several mechanisms. Widespread availability reduces search costs to obtain tobacco products, and convenient access encourages use and undermines quit attempts.[2–4] U.S. stores contain an average of 30 tobacco advertisements, [1] and exposure to retail tobacco marketing is a risk factor for smoking initiation[5] and promotes impulse purchases.[6] In addition, the retail availability and marketing of tobacco products normalize their use.[7,8]

Smoking prevalence has a steep socio-economic gradient,[9] and morbidity and mortality from smoking are not equally distributed by race.[10] Inequalities in the retail availability of tobacco products may contribute to disparities in smoking and tobacco-related disease. The distribution of retailers varies widely depending on community characteristics with more retailers in neighborhoods with lower incomes and greater proportions of African-American residents.[11–15] The issue of outlet density is characterized as a problem of social justice. [16] Unfortunately, our understanding of racial/ethnic inequalities in tobacco outlet density has been limited by three factors: (1) the geographic area of prior studies, (2) lack of corrections for spatial autocorrelation, and (3) atheoretical explanations for evidence of disparities.

Geography

Most studies about racial/ethnic disparities examine tobacco outlet density in a single county or state, which limits generalizability. The one exception uses a national dataset from a single source of likely tobacco outlets and a limited set of outlet types (i.e., tobacco stores, grocery stores, gas stations and convenience stores).[13] Other studies use national samples but do not directly address inequalities in tobacco outlet density.[17] We used a national sample of tobacco outlets sourced from two business listings and included additional store types such as alcohol retailers, discount department stores such as Walmart, and pharmacies.

Spatial autocorrelation

Limited attention has been paid to spatial autocorrelation ("things closer together are more similar than things farther apart"), which can lead to violations of regression assumptions about independence and result in standard errors that are underestimated.[18] Thus, the Type 1 error rate for existing studies of tobacco outlet density may be inflated if spatial autocorrelation is not taken into account.[14] While studies have used spatial autocorrelation in analyses of tobacco outlet inequalities in other cities and states,[14,19–21] the one national study of tobacco outlet density inequalities identified significant inequalities by race, ethnicity, and income but did not address spatial autocorrelation.[13] This is of concern because when spatial regression approaches were used in a Boston, MA study, they found no significant neighborhood demographic correlates of tobacco outlet density.[21]

Theoretical explanations

Prior research has not developed theoretical explanations for associations between racial/ethnic neighborhood composition and tobacco outlet density. Associations between neighborhood composition and tobacco outlet density are usually partially but not fully (with rare exception[20]) accounted for by measures of socioeconomic status in the neighborhood, such as neighborhood income or poverty status[13,14,19]. Following theories of neighborhood inequalities,[22] resources *are* important in the production of health inequalities; however, resources contributing to these inequalities go well beyond measures of income to include other social and economic neighborhood characteristics. The stability of neighborhoods and economic, social, and political resources can influence capital for retailer investment, accessibility to potential customers based on neighborhood safety and transportation infrastructure, and owner decisions to expand.[22,23] Using a model from city planning on neighborhood stability and change,[24] we identified two proxies for neighborhood stability: the proportion of vacant housing units and the proportion of rental housing units. Similar measures have been used in studies of neighborhood deprivation and smoking[25] and in studies assessing perceptions of neighborhood wellbeing.[26] City planning research has noted the important role of home ownership both in perceptions of neighborhood and in promoting social connectedness in neighborhoods.[27,28] These measures of neighborhood resources have not been addressed in the tobacco outlet density literature.

Given the three limitations to the existing literature, the goals of this paper are to (1) assess inequalities in tobacco outlet density at the census tract level in a national study of 97 U.S. counties by race, ethnicity, and income; (2) conduct analyses addressing spatial autocorrelation; and, (3) assess the association of tobacco outlet density with indicators of two types of neighborhood resources that were derived from the city planning literature.

METHODS

This study is part of the NCI-funded Advancing Science and Policy in the Retail Environment (ASPiRE) Study conducted by the Stanford Prevention Research Center, UNC Gillings School of Global Public Health, and Washington University in St. Louis. The ASPiRE Study included 97 counties that were selected with probability proportional to

population size from all counties in the lower-48 U.S. states. In 2010, 79 million people (26% of the U.S. population) lived in these 97 counties.[29]

Tobacco Outlet List Creation

There is no national list of tobacco outlets. For the 97 counties, we obtained business lists of likely tobacco outlets in 2012 from North American Industry Classification System (NAICS) Association and ReferenceUSA. Detailed methods about the sample were published previously.[30] Briefly, we restricted likely tobacco outlets to stores with primary codes for supermarkets and grocery stores, convenience stores, tobacco shops, gasoline stations with convenience stores, warehouse clubs and supercenters, news dealers and newsstands, alcohol stores (except state-owned liquor stores), pharmacies (top 50 chains only), discount department stores (Walmart only), and other gasoline stations. We removed duplicate addresses and chains that had no-tobacco-sales policies. The approach has been validated in a field study in a state (North Carolina) without licensing[31] and was the recommended approach in a methods review.[32] There were few e-cigarette or vape shops in 2012, so our approach did not explicitly include or exclude these stores.

Measures

Dependent variable and areal unit—There were 90,407 likely tobacco outlets in the 97 counties in 2012. Following previous research[13,30] we calculated tobacco outlet density as the number of tobacco outlets per 1,000 population in a census tract. We defined neighborhoods as census tracts. In the 97 counties, there were 17,941 census tracts. Because small populations can render estimates unstable, we removed the 266 tracts with fewer than 250 households and excluded eight tracts that were missing economic data from all analyses. These 274 tracts contained 603 tobacco outlets.

Neighborhood demographics—Using 2010 Census data, we calculated the proportion of each census tract's population identifying as Black/African-American and Asian/Pacific Islander (alone or in combination with other races), identifying as Hispanic or Latino ethnicity, and identifying as White race alone. We scaled these in tens (e.g., 12%=1.2). We used American Community Survey 5-year estimates (2008–2012) for median household income in 2012 dollars.[33] Because income is relative (e.g., $34,000 a year may be above average in one county and well below average in another), we standardized income within each county using z-scores. We scaled these in tens (e.g., −0.12 = −1.2) so that a 1-unit change represents a change of 0.1 standard deviations.

Neighborhood characteristics—We used two variables to capture characteristics of neighborhood stability and neighborhood revitalization: the percentage of housing units that are renter occupied and the percentage of housing units that are vacant.[27,34] Both variables came from American Community Survey estimates[33] and were scaled in tens. The average correlation among all predictor variables was r_s=−0.08.

Analysis

Tobacco outlet density was our dependent variable and census tract characteristics were our predictor variables. Standard statistical approaches such as linear regression assume each

census tract in the analysis provides independent information that is not correlated with its neighbors. Yet, things closer together share more characteristics than things further apart, violating the assumption of independence in regression models.[18] We assessed our dependent variable for spatial dependence and found that there was a significant spatial clustering of tract tobacco outlet density, Moran's $I = 0.10$, $p_{psuedo} = 0.001$. There was also significant clustering in the ordinary least squares regression residuals, Moran's $I = 0.06$, $p_{psuedo} = 0.001$. To address this non-independence, we used spatial regression.

To address spatial autocorrelation we used two approaches. We first used a spatial error approach in GeoDa software (v.1.6.7). We created a second-order queen weights matrix and implemented the spatial regression approach with the error as a function of the error at nearby locations. In a second approach we fitted a covariance function to the errors in R software (v.3.2.2) using a weights matrix of all distances between tracts (17,667x17,667). Besides providing more information about the autocorrelation structure, this approach also is less sensitive to edge effects, which can be a problem with spatial error approaches.[18] Code to fit this approach was written by one of the authors (DLS) in the R programming language. We ran analyses using each spatial regression approach and compared the pattern of results between the two approaches.

Our modeling approach consisted of seven separate unadjusted models and one full model. We modeled the relationship of tobacco outlet density with (separately) (1) household income, (2) Asian/Pacific Islander race, (3) Black/African-American race, (4) Hispanic ethnicity, (5) White race, (6) vacant housing, (7) renter occupancy, and (8) an adjusted model including all variables except White race (to avoid multicollinearity as proportion of Black/African American race and proportion White race were negatively correlated). Neither GeoDa's multicollinearity diagnostics nor our examination of the correlation matrix of the independent variables suggested problems with multicollinearity.

We interpret inequalities from the unadjusted models; unadjusted models allow us to directly assess "on the ground" neighborhood inequalities (i.e., are there more tobacco outlets in neighborhoods with a greater proportion of residents who identify as a given racial or ethnic group?) as opposed to hypothetical neighborhoods (i.e., are there more tobacco outlets in neighborhoods with a greater proportion of residents who identify as a given racial or ethnic group when other neighborhood characteristics are statistically held constant?). Because no human subjects were involved in this study, IRB approval was not sought.

RESULTS

The average density was 1.3 retailers per 1,000 persons. Table 1 shows descriptive statistics about the 17,667 census tracts included in this study.

Spatial autocorrelation was present in these data. In addition, the two approaches to spatial regression produced the same pattern of results to one decimal place. We report the results of the first approach using GeoDa software. Ordinary least squares regression is reported in Supplemental Table 1.

We first report unadjusted relationships between tract racial/ethnic composition and income in relation to tobacco outlet density. In these models, we identified a significant negative association between tract median household income and tobacco outlet density (Table 2). We found a significant, albeit small, positive association between tobacco outlet density and the proportion of residents identifying as Black/African American. The opposite association was found for the proportions of Asian/Pacific Islander and White residents. Our results, however, suggest no evidence of a tobacco outlet density inequality by neighborhood proportion of Latino or Hispanic residents. These relationships are plotted by deciles in Figure 1.

We next report an adjusted model that controlled for tract income, racial/ethnic composition, and the two variables serving as proxies for neighborhood resources. In this model, income continued to show a significant negative association with outlet density as did the proportion of Asian residents. However, the proportion of Black/African-American and Hispanic residents had a negative association with tobacco outlet density. The proxies for neighborhood resources limitations (vacant housing and renter-occupied units) both were positively correlated with greater outlet density after controlling for neighborhood racial/ethnic composition and income.

DISCUSSION

We assessed inequalities in tobacco outlet density at the census tract level in a national study of 97 U.S. counties by race, ethnicity, and income. This study confirmed smaller county- and state-level studies as well as the one prior national study that found inequalities in tobacco outlet density by Black/African-American (positive association) and White (negative association) neighborhood racial composition as well as with neighborhood income (negative association).[11–14,19,20,35] This study is the first we are aware of to examine Asian/Pacific Islander neighborhood racial composition in relation to tobacco outlet density, and the association was negative. We did not identify an association between neighborhood Hispanic ethnicity composition and tobacco outlet density that has been found in previous research.[13]

One explanation of the higher tobacco outlet density in neighborhoods with a larger proportion of Black residents and higher income is suggested by studies showing that retailers in neighborhoods with lower income and higher proportions of Black residents tend to be smaller.[36] This could be due to historical differences in resource investment (e.g., redlining), racially-biased retailer decisions to [not] expand and invest resources in larger stores, and the impact of neighborhood segregation.[37] Previous research suggests that Asian enclaves may be healthier neighborhoods,[38] and further research is needed to determine whether the negative association observed here is replicable and to explore variation by racial/ethnic subgroup.

In a previous study of tobacco outlet density in the US, Rodriguez *et al.* found a large positive relationship between the logged proportion of Hispanic residents and logged tobacco outlet density in a multivariable model controlling for a variety of socioeconomic variables, urbanicity, and neighborhood composition measures.[13] The different results

regarding Hispanic ethnicity in the current study may stem from a number of reasons. First, our study area is more urban than the continental US, given the sampling strategy that selected counties with probability based on population size. Second, the current study reported unadjusted models and, in the adjusted model, used different control variables.

In our second aim, we sought to implement analysis addressing spatial autocorrelation and we used two spatial regression model approaches. These results were robust to the choice of analysis method, suggesting that the basic spatial regression lag and error models available in GeoDa, Stata, and R may be sufficient and that custom models may not be necessary. Spatial regression approaches, while indicated here given the positive spatial autocorrelation, may be even more critical when there are higher levels of autocorrelation than were present in our data.

In our third aim, we sought to assess the association of two indicators of neighborhood stability from the city planning literature with tobacco outlet density, proportions of vacant housing and rental housing. Control for these variables in multivariable models resulted in a negative association between Black/African-American racial composition and tobacco outlet density. Similar results were found for Hispanic ethnicity. While our models show inequalities in tobacco outlet density exist on the ground, they suggest that in a counterfactual world where these neighborhood stability measures were held constant across neighborhood racial/ethnic composition tobacco outlet density inequalities would be reversed. That is, Black and Hispanic racial/ethnic composition would be protective against tobacco outlet density similar to what is seen in the food retailer inequalities literature (i.e., fewer sources of healthy foods in neighborhoods with a greater proportion of Black residents).[36]

Of course, neighborhood characteristics are *not* constant across racial composition in the U.S.,[37] but this finding suggests that neighborhood stability measures may be an important piece of understanding tobacco outlet density. Indeed, the field of organizational ecology, which conceptualizes populations of organizations (i.e., tobacco outlets) as influenced by how they adapt to local competition and resources,[23] would suggest that changes to the wellbeing of neighborhoods might ameliorate inequalities in tobacco outlet density. Theoretical frameworks of neighborhood health inequalities[22] used in combination with organizational ecology[23] may suggest future ways of understanding inequalities in tobacco outlet density.

This research expanded on a previous national study[13] by using a broader definition of tobacco outlets (including Walmart, a major distributor of tobacco products, retailers from the top 50 pharmacy chains, and non-state owned alcohol retailers) sourced from two business listing services. In addition, the current study addressed spatial dependence and incorporated theory-informed measures of neighborhood stability.

Limitations

First, we did not address the role of store type, and store type may be patterned by neighborhood characteristics; thus, we cannot examine the role of store type in explaining the identified inequalities. Second, there are a number of challenges with using spatial data.

While we have addressed spatial autocorrelation and used a theoretically appropriate areal unit, previous research using these data identified possible edge effects (i.e., where areal units outside of the study area might have influenced results if included).[30] However, the fact that the GeoDa model yielded the same results as the explicit covariance model, which is less sensitive to edge effects, suggests that edge effects in this data are negligible. Third, the sampling design was intended yield a representative sample of US tobacco outlets, not US counties. Therefore, the results may not generalize to tobacco outlets in in other counties. Fourth, our indicators of neighborhood resources may themselves be proxies for unmeasured historical and ongoing forms of institutional discrimination by race that influence the availability of resources in a given neighborhood and are ultimately associated with tobacco outlet density. Fifth, our racial/ethnic groups are aggregated and do not distinguish intragroup differences (e.g., Japanese vs. Hmong ancestry). Sixth, this cross-sectional study cannot assess causality. Finally, although source data for likely tobacco outlets was derived using a validated[13,31] and recommended strategy,[32] in the absence of a national licensing list, the computation of density may be subject to measurement error.

Policy Implications

Given evidence of racial/ethnic and income disparities in tobacco outlet density, policy interventions[39] should be assessed for their contribution to reducing these inequalities. Retailer reduction can be achieved using strategies that limit the number of retailers (e.g., licensing cap), the types of retailers that can sell tobacco (e.g., tobacco-free pharmacies), and the locations of tobacco outlets (e.g., banning sales near schools).[15,40] Evidence suggests that the latter could eliminate tobacco outlet inequalities by race and income in Missouri and New York State.[15]

Strengthening the wellbeing of neighborhoods[24] may have the potential to change the retailer mix in ways that reduce tobacco outlet density overall as well as reduce inequalities.

Conclusions

There are inequalities in the density of tobacco outlets by neighborhood income, racial/ethnic composition, and neighborhood stability. Such inequalities likely compound other existing inequalities in neighborhood resources, tobacco retailer marketing, and the effects of residential segregation. Policy efforts to reduce outlet density and to revitalize neighborhoods should be examined for their potential to reduce inequitable exposure to tobacco outlets.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

References

1. Center for Public Health Systems Science. [Accessed October 3, 2014] Point-of-Sale Report to the Nation: The Tobacco Retail and Policy Landscape. 2014. http://cphss.wustl.edu/Products/Documents/ASPiRE_2014_ReportToTheNation.pdf

2. Halonen JI, Kivimaki M, Kouvonen A, et al. Proximity to a tobacco store and smoking cessation: a cohort study. Tob Control. 2014; 23(2):146–151. [PubMed: 23436138]

3. Reitzel LR, Cromley EK, Li Y, et al. The effect of tobacco outlet density and proximity on smoking cessation. Am J Public Health. 2011; 101(2):315–320. [PubMed: 21164089]

4. Cantrell J, Pearson JL, Anesetti-Rothermel A, Xiao H, Kirchner TR, Vallone D. Tobacco Retail Outlet Density and Young Adult Tobacco Initiation. Nicotine Tob Res. 2016; 18(2):130–137. [PubMed: 25666816]

5. Robertson L, McGee R, Marsh L, Hoek J. A Systematic Review on the Impact of Point-of-Sale Tobacco Promotion on Smoking. Nicotine Tob Res. 2015; 17(1):2–17. [PubMed: 25173775]

6. Siahpush M, Shaikh RA, Cummings KM, et al. The association of point-of-sale cigarette marketing with cravings to smoke: results from a cross-sectional population-based study. Tob Control. 2016; 25(4):402–405. [PubMed: 26024797]

7. 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. 2016; 91:287–293. [PubMed: 27569829]

8. McDaniel PA, Malone RE. Understanding community norms surrounding tobacco sales. PLoS One. 2014; 9(9):e106461. [PubMed: 25180772]

9. Jamal A, Homa DM, O'Connor E, et al. Current Cigarette Smoking Among Adults - United States, 2005–2014. MMWR Morb Mortal Wkly Rep. 2015; 64(44):1233–1240. [PubMed: 26562061]

10. Henley SJ, Thomas CC, Sharapova SR, et al. Vital Signs: Disparities in Tobacco-Related Cancer Incidence and Mortality - United States, 2004–2013. MMWR Morb Mortal Wkly Rep. 2016; 65(44):1212–1218. [PubMed: 27832048]

11. Hyland A, Travers MJ, Cummings KM, Bauer J, Alford T, Wieczorek WF. Tobacco outlet density and demographics in Erie County, New York. Am J Public Health. 2003; 93(7):1075–1076. [PubMed: 12835184]

12. Fakunle D, Morton CM, Peterson NA. The importance of income in the link between tobacco outlet density and demographics at the tract level of analysis in New Jersey. J Ethn Subst Abuse. 2010; 9(4):249–259. [PubMed: 21161808]

13. Rodriguez D, Carlos HA, Adachi-Mejia AM, Berke EM, Sargent JD. Predictors of tobacco outlet density nationwide: a geographic analysis. Tob Control. 2013; 22(5):349–355. [PubMed: 22491038]

14. Yu D, Peterson NA, Sheffer MA, Reid RJ, Schnieder JE. Tobacco outlet density and demographics: analysing the relationships with a spatial regression approach. Public Health. 2010; 124(7):412–416. [PubMed: 20541232]

15. Ribisl KM, Luke D, Snider D, Sorg A, Moreland-Russell S. Reducing disparities in tobacco retailer density by banning tobacco product sales near schools. 2016 Article under review.

16. Yerger VB, Przewoznik J, Malone RE. Racialized geography, corporate activity, and health disparities: tobacco industry targeting of inner cities. J Health Care Poor Underserved. 2007; 18(4 Suppl):10–38. [PubMed: 18065850]

17. Cantrell J, Anesetti-Rothermel A, Pearson JL, Xiao H, Vallone D, Kirchner TR. The impact of the tobacco retail outlet environment on adult cessation and differences by neighborhood poverty. Addiction. 2015; 110(1):152–161. [PubMed: 25171184]

18. Fotheringham AS, Rogerson PA. GIS and spatial analytical problems. International Journal of Geographical Information Systems. 1993; 7(1):3–19.

19. Loomis BR, Kim AE, Goetz JL, Juster HR. Density of tobacco retailers and its association with sociodemographic characteristics of communities across New York. Public Health. 2013; 127(4): 333–338. [PubMed: 23515009]

20. Fakunle DO, Milam AJ, Furr-Holden CD, Butler J 3rd, Thorpe RJ Jr, LaVeist TA. The inequitable distribution of tobacco outlet density: the role of income in two Black Mid-Atlantic geopolitical areas. Public Health. 2016

21. Duncan DT, Kawachi I, Melly SJ, Blossom J, Sorensen G, Williams DR. Demographic disparities in the tobacco retail environment in Boston: a citywide spatial analysis. Public Health Rep. 2014; 129(2):209–215. [PubMed: 24587559]

22. Bernard P, Charafeddine R, Frohlich KL, Daniel M, Kestens Y, Potvin L. Health inequalities and place: a theoretical conception of neighbourhood. Soc Sci Med. 2007; 65(9):1839–1852. [PubMed: 17614174]

23. Aldrich, H. Organizations and environments. Stanford, CA: Stanford Business Books; 2008.

24. Temkin K, Rohe W. Neighborhood Change and Urban Policy. Journal of Planning Education and Research. 1996; 15(3):159–170.

25. Shareck M, Dassa C, Frohlich KL. Improving the measurement of neighbourhood characteristics through systematic observation: inequalities in smoking as a case study. Health Place. 2012; 18(3): 671–682. [PubMed: 22297153]

26. Perkins DD, Meeks JW, Taylor RB. The physical environment of street blocks and resident perceptions of crime and disorder: Implications for theory and measurement. Journal of Environmental Psychology. 1992; 12(1):12–34.

27. Rohe WM, Stewart LS. Homeownership and neighborhood stability. Hous Policy Debate. 1996; 7(1):37–81.

28. Pendall R, Theodos B, Hildner K. Why High-Poverty Neighborhoods Persist The Role of Precarious Housing. Urban Affairs Review. 2016; 52(1):33–65.

29. Social Explorer. [Accessed Sept. 9, 2014] Census 2010, Total Population (Social Explorer Table T001_001). 2014. http://www.socialexplorer.com/pub/reportdata/HtmlResults.aspx?reportid=R10789430

30. Lee JG, Pan WK, Henriksen L, Goldstein AO, Ribisl KM. Is There a Relationship Between the Concentration of Same-Sex Couples and Tobacco Retailer Density? Nicotine Tob Res. 2016; 18(2):147–155. [PubMed: 25744959]

31. D'Angelo H, Fleischhacker S, Rose SW, Ribisl KM. Field validation of secondary data sources for enumerating retail tobacco outlets in a state without tobacco outlet licensing. Health Place. 2014; 28:38–44. [PubMed: 24742811]

32. Fleischhacker SE, Evenson KR, Sharkey J, Pitts SB, Rodriguez DA. Validity of secondary retail food outlet data: a systematic review. Am J Prev Med. 2013; 45(4):462–473. [PubMed: 24050423]

33. Social Explorer. [Accessed June 9, 2015] Social Explorer Tables: ACS 2012 (5-Year Estimates). 2015. http://www.socialexplorer.com/pub/reportdata/HtmlResults.aspx?reportid=R10967257

34. Accordino J, Johnson GT. Addressing the vacant and abandoned property problem. Journal of Urban Affairs. 2000; 22(3):301–315.

35. Peterson NA, Yu D, Morton CM, Reid RJ, Sheffer MA, Schneider JE. Tobacco outlet density and demographics at the tract level of analysis in New Jersey: A statewide analysis. Drugs: Education, Prevention, and Policy. 2011; 18(1):47–52.

36. Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med. 2002; 22(1):23–29. [PubMed: 11777675]

37. Landrine H, Corral I. Separate and unequal: residential segregation and black health disparities. Ethn Dis. 2009; 19(2):179–184. [PubMed: 19537230]

38. Walton E. Making Sense of Asian American Ethnic Neighborhoods A Typology and Application to Health. Sociological Perspectives. 2015; 58(3):490–515.

39. Coxe N, Webber W, Burkhart J, et al. Use of tobacco retail permitting to reduce youth access and exposure to tobacco in Santa Clara County, California. Prev Med. 2014; 67(Suppl 1):S46–50. [PubMed: 24513170]

40. Ackerman A, Etow A, Bartel S, Ribisl KM. Reducing the Density and Number of Tobacco Retailers: Policy Solutions and Legal Issues. Nicotine Tob Res. 2016

What is already known on this subject?

- Tobacco outlet density is associated with racial/ethnic neighborhood composition and neighborhood income in state and county-level studies and in one national study. Few studies address issues of spatial autocorrelation or use theory-informed approaches to investigate the possible reasons for these inequalities.

What this study adds?

- This is the first national study to address tobacco outlet density inequalities while also addressing spatial autocorrelation and examining theory-informed neighborhood characteristics in explaining identified inequalities.
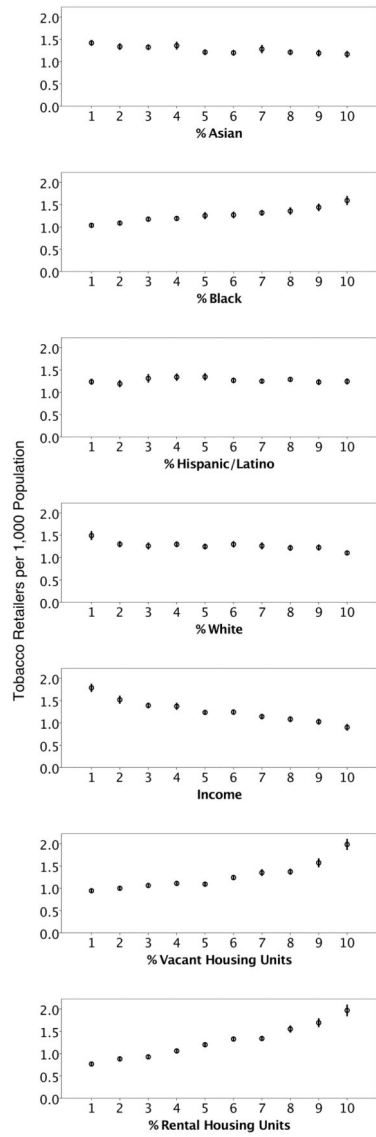
Figure 1.
Tobacco retailer density by tract characteristics in deciles, n=17,667, 2012

Table 1

Census tract characteristics, n=17,667

Variable	M	SD	Min	Max
Tobacco outlet density, per 1,000 population	1.3	1.6	0.0	51.0
Percentage Black or African American alone or in combination with other races	14.6	22.2	0.0	99.8
Percentage Asian or Pacific Islander alone or in combination with other races	9.0	11.8	0.0	89.8
Percentage White alone	64.3	25.0	0.0	99.6
Percentage Hispanic or Latino	26.7	26.4	0.0	99.0
Median household income in 2012 dollars	$65,214	$34,060	$5,760	$250,000
Percentage of housing units that are renter-occupied	45.4	24.0	2.3	100.0
Percentage of housing units that are vacant	9.9	8.8	0.0	88.6

Table 2

Census tract tobacco outlet density models, n=17,667

Model (DV = Tobacco outlets per 1,000 Population)	Unadjusted Models 1–7	Adjusted Model 8
Neighborhood Characteristic (scaled to 10s)	Coefficient (95% CI)	Coefficient (95% CI)
Income (*z*-scored by county)	**−0.24 (−0.27, −0.22)**	**−0.08 (−0.11, −0.04)**
% Asian/Pacific Islander	**−0.04 (−0.06, −0.01)**	**−0.03 (−0.05, 0.00)**
% Black/African American	**0.05 (0.04, 0.07)**	**−0.04 (−0.05, −0.02)**
% Hispanic/Latino	0.01 (−0.01, 0.02)	**−0.05 (−0.06, −0.03)**
% White Alone	**−0.04 (−0.05, −0.03)**	-
% Housing Units Vacant	**0.35 (0.32, 0.38)**	**0.22 (0.19, 0.26)**
% Housing Units Not Owner Occupied	**0.15 (0.14, 0.16)**	**0.12 (0.10, 0.13)**

Note: Bold signifies significance at $p < 0.05$ level. DV = dependent variable, CI = confidence interval. Median household income (adjusted to 2012 dollars) was standardized to each county with z-scores, multiplied by 100, and scaled to 10s (i.e., z=0.23 is coded as 2.3). Demographic variables were scaled to 10s (i.e., 12% is coded as 1.2). Using a row-standardized second order queen weights matrix.