HHS Public Access

Author manuscript

J Racial Ethn Health Disparities. Author manuscript; available in PMC 2020 April 01.

Published in final edited form as:

J Racial Ethn Health Disparities. 2019 April ; 6(2): 409–418. doi:10.1007/s40615-018-00538-9.

Does Tobacco Outlet Inequality Extend to High-White Mid-Atlantic Jurisdictions? A Study of Socioeconomic Status and Density

David O. Fakunle, PhD[*],
School of Community Health & Policy – Morgan State University, *Baltimore, Maryland,*
Department of Mental Health – Johns Hopkins Bloomberg School of Public Health, *Baltimore, Maryland*

Roland J. Thorpe Jr., PhD,
Department of Health, Behavior & Society – Johns Hopkins Bloomberg School of Public Health, *Baltimore, Maryland*

C. Debra M. Furr-Holden, PhD,
Division of Public Health – Michigan State University College of Human Medicine, *Flint, Michigan*

Frank C. Curriero, PhD, and
Department of Epidemiology – Johns Hopkins Bloomberg School of Public Health, *Baltimore, Maryland*

Philip J. Leaf, PhD
Department of Mental Health – Johns Hopkins Bloomberg School of Public Health, *Baltimore, Maryland*

Abstract

Tobacco outlet density research has evolved to require a more refined examination of socioeconomic status' influence beyond median household income. This study investigates the effects of SES on Census-Tract level tobacco outlet density in five predominantly-White Maryland jurisdictions. Tobacco license addresses and demographic data were analyzed via t-tests and spatial lag modeling. Results showed that higher-SES jurisdictions had lower tobacco outlet density than lower-SES jurisdictions despite similar White populations, and that median household income had consistent associations with tobacco outlet density. This study corroborates findings that differences in SES correlate with differences in tobacco outlet density between racially similar areas.

[*]Corresponding author: David O. Fakunle, PhD, School of Community Health & Policy – Morgan State University, 4530 Portage Avenue Campus, Room 204, 1700 E. Cold Spring Lane, Baltimore, MD 21251, 410-440-8142, David.Fakunle@morgan.edu.

Conflict of Interest: Dr. Fakunle declares that he has no conflict of interest. Dr. Thorpe declares that he has no conflict of interest. Dr. Furr-Holden declares that she has no conflict of interest. Dr. Curriero declares that he has no conflict of interest. Dr. Leaf declares that he has no conflict of interest.

Compliance with Ethical Standards

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Keywords

Tobacco outlets; Census Tracts; Race; Socioeconomic Status; Income; Education

Introduction

Early studies of socioeconomic status' influence on tobacco outlet density were initially limited by analyzing the relationship with median household income. Those studies reported patterns of lower tobacco outlet density in neighborhoods with higher median household income, and later reported an inverse linear relationship with tobacco outlet density. These findings coincided with the reporting of patterns of higher tobacco outlet density in neighborhoods with higher concentrations of Black and Latino residents, and later the reporting of direct (or positive) linear relationships with tobacco outlet density [1–4]. Recent studies have included additional proxies of socioeconomic status such as educational attainment, employment status and vacant housing, reporting that they were also inversely (or negatively) related to tobacco outlet density [4–5]. This has compelled tobacco outlet density researchers to investigate how socioeconomic status proxies relate to each other, and if further parsing out socioeconomic status proxies help to further disentangle its relationship with both race and tobacco outlet density.

Tobacco Outlet Density and Spatial Statistics

Spatial statistics involve analytical techniques that acknowledge and adjust for similar characteristics across proximal and distal physical locations [9–11]. These similarities, if left unaddressed, could confound the relationships between covariates and tobacco outlet density by not determining whether the closeness of locales could potentially explain comparability in neighborhood dynamics. Specific to tobacco outlet density, it could not be unquestionably reported that there are patterns of higher density in neighborhoods with higher concentrations of Black and/or Latino residents, as well as in neighborhoods with lower median household income, without determining that the patterns are not due to some study areas being primarily occupied by Black, Latino and/or low-income residents [2, 7–8, 12]. Spatial dependence, also called spatial autocorrelation, is a factor that has become a salient methodological development in tobacco outlet density research [3–4, 7–8, 13]. Spatial dependence is an occurrence in which areas closer together tend to be more similar than areas further apart. This correlation violates the assumption of independence, a major underpinning in research, which may render the assessment of associations with tobacco outlet density, which is based on physical and geographic availability and access, difficult to interpret because a major confounder – space – was not controlled.

Recent research has utilized several techniques within spatial statistics to address spatial autocorrelation and remove the space confounder, such as spatial lag modeling, spatial errors approach, fitting a covariance function to the errors using a distance matrix of unit centroids, and geographically weighted regression analyses; while the specific aims varied, they all determined that spatial autocorrelation was present in the study areas [3–4, 7, 13–14]. Spatial lag modeling, the methodology used for this study, can control for spatial autocorrelation by specifying what model components are to be lagged, be it the covariates

included in the model, on the outcome in the model (auto-regressive), or both. Additionally, a spatial lag model can show the relationship between covariates and outcomes such as tobacco outlet density among the focal effects (i.e., effects operating at the area unit of analysis) and the spatial lag effects (i.e., effects defined through spatial lags to assess influence of the surrounding area units of analysis). This can provide a more complete perspective of how relationships are similar or different in immediate and distal areas. Regardless of the technique used, it is imperative that any research involving tobacco outlet density include spatial methodologies that account for the potential violation of independence via spatial dependence.

Fakunle and colleagues utilized the ecological-contextual heterogeneity of Maryland to investigate the relationship between socioeconomic status and tobacco outlet density within two similar predominantly-Black, yet economically divergent jurisdictions: Baltimore City and Prince George's County. The study utilized matching of sociodemographic variables as the primary modality for controlling the confounder of race, to determine if differences in median household income were related to differences in tobacco outlet density despite similar racial concentrations [3]. This study built on that previous work by utilizing the same technique with predominantly White jurisdictions in Maryland, with the aim of determining how varying magnitudes of socioeconomic status metrics – median household income, educational attainment, labor force participation, etc. – correlated with neighborhood-level tobacco outlet availability within jurisdictions with similar majority White populations, and if the findings would be similar those reported by Fakunle and colleagues. The hypotheses were that jurisdictions with a higher socioeconomic status would have greater tobacco outlet density despite having a similar White population percentage, and that jurisdictions with similar socioeconomic status and similar White population percentages would have similar tobacco outlet density.

Methods

Study Areas

Five jurisdictions were chosen for inclusion in this study based on preliminary examination of White population percentage and median household income (see Figure 1). Baltimore County is in northeast Maryland, had 211 Census Tracts, was predominantly White (~66%), and had an average median household income totaling $73,114. Howard County is in central Maryland, has 55 Census Tracts, was predominantly White (~60%), and had an average median household income totaling $117,889. Lower Eastern Shore (Dorchester County, Somerset County, Wicomico County and Worcester County) is in southern Maryland, had 50 Census Tracts, was predominantly White (~72%), and had an average median household income totaling $49,470. Montgomery County is in central Maryland, had 215 Census Tracts, was predominantly White (~58%), and had an average median household income totaling $109,126. Western Maryland (Allegany County, Garrett County and Washington County) is in western Maryland, had 62 Census Tracts, was predominantly White (~87%), and had an average median household income totaling $48,164. For reference, the White population percentage for the state of Maryland was 57.6% and the median household income totaled $74,551.

Data

Census Tract demographic data were obtained from the 2011–2015 American Community Survey (ACS), made available via the United States Census website. The American Community Survey, inaugurated in 2005, is a perennial survey administered by the U.S. Census Bureau that acquires data on the sociodemographic dynamics of people living in the United States [6]. The five-year pooled estimate of sociodemographic data was selected over the one-year and three-year pooled estimates because of the larger dataset that included data for all areas, thus allowing for examination of small Residential Census Tracts and assuring greater reliability.

Maryland tobacco outlet data – including retailer names, contact information and retail/mailing locations – were obtained from the Maryland State Licensing Bureau, which provided the addresses for retailers with an active Cigarette, Special Cigarette, Other Tobacco Product (OTP) or Tobacconist licenses as of April 30, 2017. Tobacco outlet retailer addresses were geocoded via MD iMap – the State of Maryland's Mapping and GIS Data Portal – the most current publicly available geocoding service for the state. Of the addresses provided (n = 2,851), only five needed to be modified: one determined to be a duplicate (deleted), one determined to be out-of-state (Florida) with no alternative address given (deleted), one determined to have two adjacent addresses (second address added), one determined to be closed (deleted), and one geocoded with the mailing address due to the outlet being a food truck. Most of the licensed tobacco outlets were successfully geocoded after the first iteration. Of the revised total addresses (n = 2,849), all but 144 were successfully geocoded via the Batch Address Look-Up service. The 144 entries that did not return a geocode were cross-referenced with Google Maps and other internet-based resources (e.g., retailer websites) to verify the correct address. After verification, the addresses were re-run via the Single Address Look-Up service of which all but 19 were successfully geocoded. In total, 2,830 of the 2,849 addresses (99.3%) were successfully geocoded. The addresses were then merged with Maryland sociodemographic data via the Spatial Join tool in ArcGIS. It was then determined that a total of 3 tobacco outlets were located among the 18 Census Tracts excluded from analyses.

For this study, tobacco outlet density was measured as the mean number of tobacco outlets per 1,000 persons per Census Tract. This measure, consistent with the previous study by Fakunle and colleagues, provided a standardized quantity the availability of tobacco outlets to residents [3]. This is as opposed to a count of tobacco outlets, which does not account for the varying population sizes of Census Tracts.

Eight variables measuring racial composition, socioeconomic status and built environment were selected from the ACS dataset. The expansion of socioeconomic covariates beyond the study of two predominantly-Black locales in Maryland by Fakunle and colleagues was to provide a more thorough understanding of the relationship between socioeconomic status, race and tobacco outlet density beyond one measure – median household income [3–5, 13]. Additionally, the expansion of socioeconomic covariates aimed to address the lack of consideration in research for income inequality's influence in health disparities [2, 15–16]. The measures included in the study were the total population, the total number of individuals who identify as Black or African American (converted to a percentage), the total number of

individuals who identify as White (converted to a percentage), the percentage of individuals 25 years and over who have obtained at least a Bachelor's degree, the Gini index of income inequality (presented as a coefficient), the total number of vacant housing units (utilized in spatial analysis models as per 100 units), the total number of individuals 16 years and older who are actively in the labor force (converted to a percentage), and median household income, expressed in 2015 inflation-adjusted dollars.

Residential Census Tracts have been the prevailing spatial unit of measurement in tobacco outlet density research, yet other spatial units have been utilized in tobacco outlet density studies such as census block groups, which are smaller and more refined than Residential Census Tracts [17–18]. Similar research in alcohol outlet density have also used census block groups as the spatial unit of measurement [19–21]. While there is no consensus unit of measurement, Residential Census Tracts are the most frequently used. Census block groups, while more refined than Residential Census Tracts, have more variation which can lead to analytical instability. Likewise, analyses of broad jurisdictions like cities, counties or states may lead to results that do not allow for inference [8]. Therefore, Residential Census Tracts are currently the best spatial units that both exude distinct neighborhood characteristics yet provide manageable data and potentially generalizable analysis results.

Analyses

Two-sample t-tests were conducted to compare the mean values per Census Tract of the study areas and provide a baseline measure of differences in tobacco outlet density and sociodemographic characteristics across pairs of areas. Consistent with Fakunle and colleagues the decision was made to focus on the ecological profile of each area via the mean sociodemographic characteristics, acknowledging that each area had variation among the individual Census Tract sociodemographics yet acknowledging that many tobacco policies are made on the local level and higher [3]. Rather than utilizing an analysis that compared all the study areas with each other, such as the Kruskal-Wallis Test or ANOVA (used in earlier tobacco outlet density studies), the area pairs for each t-test were specifically selected based on similarities and differences in median household income, the prevailing proxy of socioeconomic status in tobacco outlet density research. This is a replication of the methodology by Fakunle and colleagues, which aimed to analyze similarities and differences in sociodemographics and tobacco outlet density from an ecological perspective reflective of the natural composition of the areas. The two-sample t-tests were conducted via the SPSS statistical package [22].

Spatial lag Poisson regression models were built to examine the direct individual and collective effects of sociodemographics on tobacco outlet density both within and across jurisdictions. Consistent with Fakunle and colleagues, the outcome was the mean number of tobacco outlets per 1,000 persons per Census Tract [3]. As an advancement of the methodology by Fakunle et. al, the models were conducted to determine if there were differences in the magnitude of relationship between sociodemographics and tobacco outlet density based on the location. The covariables were spatially lagged, meaning the models included not only a tract-level specific covariable effect (focal effect) but also an effect for the averaged covariable in the adjacent proximal Census Tracts (spatial lag effect). To

conduct spatial analyses of social factors and tobacco outlet density, geospatial structures containing the sociodemographic and tobacco outlet density data of each residential Census Tract were created and spatial smoothing was conducted to assure more consistent outcomes tobacco outlet density measures across the established Census Tracts, particularly in rural and suburban areas [23]. The spatial smoothing was based on population, so areas with a higher population were weighted more heavily than area with a lower population. Additionally, an offset variable was included in the models. After spatial smoothing, Moran's I was tested to determine whether jurisdictions exhibited spatial dependence.

Four models were conducted for each study area: a univariable model for each covariable, a multivariable model for focal effect covariables, a multivariable model for focal effect and spatially lagged covariables (which shows the relationship between covariables and tobacco outlet density in both the immediate and adjacent neighborhoods), and a multivariable model for focal effect and spatially lagged covariables, and interaction terms between the focal effect and spatially lagged covariables (which shows the relationship between covariables and tobacco outlet density in both the immediate and adjacent neighborhoods, as well as how the proximity affects the individual relationships). The final multivariable model was built via the stepwise process with each of the focal and spatial lag covariables, and exponentiated beta coefficients were reported and magnified for easier interpretation. Due to the high number of significant coefficients in the models, the results presented focal effect and/or spatially lagged covariables that exhibited a consistent relationship (direct or inverse) across all four models. Chi-square statistics were conducted to determine the extent of Poisson model overdispersion in the final model compared to the null model.

After each individual jurisdiction was analyzed via the aformentioned four models, jurisdictions that were compared to each other in the two-sample t-tests were then compared to each other via place-based interaction Poisson models. The model was based on the multivariable model for focal effect and spatially lagged covariables and the interaction terms between the focal effect and spatially lagged covariables. Again, a replication of the methodology by Fakunle et. al, place-based interaction Poisson models were conducted to determine if there were differences in the magnitude of the relationship between sociodemographic covariates and tobacco outlet density based on location. Consistent with the hypothesis of socioeconomic status relating to tobacco outlet despite similar racial concentration, it was proposed that the strength of relationship between covariables and tobacco outlet density would be greater in the jurisdiction with lower socioeconomic status (signified by an exponentiated beta different than 1). While the direction of the relationship was noteworthy, the salience was in showing that the degree to which covariables related to tobacco outlet density varied between two jurisdictions. To assure consistency the jurisdiction with the lower tobacco outlet density was set as the reference variable, and due to the high number of significant coefficients in the model, this section highlighted covariates that exhibited a consistent relationship (direct or inverse) among both focal effects and spatial lag effects. All spatial analyses were conducted via the R software package [24].

Results

Descriptives

Analyses of the descriptives yielded some results consistent with the hypotheses. For example, Howard County was more affluent than Baltimore County across all SES measures and had lower tobacco outlet density with no difference in White population percentage (see Table 1). Similarly, Montgomery County was more affluent than Baltimore County across all SES measures and had lower tobacco outlet density despite a significantly lower White population percentage than Baltimore County. When compared to each other, Howard County and Montgomery County had comparable SES measures, White population percentages and similar tobacco outlet density (see Table 2). However, the comparison of Western Maryland and Lower Eastern Shore showed that Western Maryland has significantly lower tobacco outlet density than Lower Eastern Shore despite no significant differences in population, median household income and labor force participation rate [25]. Additional tables of the analyses results are provided in the Appendix.

Moran's I

Moran's I was tested on the smoothed data to determine the extent of spatial dependence in the State of Maryland and the individual jurisdictions that were examined. The coefficient was conducted with both the number of tobacco outlets and the number of tobacco outlets per 1,000 persons per Census Tract as outcomes. For Lower Eastern Shore and Western Maryland, Moran's I was tested on the counties that constitute both regions. The results showed that with the exception of Wicomico County based on tobacco outlet density ($I = 0.22$, $p = 0.01$), none of the study areas exhibited spatial dependence. However, because the state of Maryland, inclusive of the study areas, exhibited spatial dependence based on count ($I = 0.40$, $p = 0.001$) and tobacco outlet density ($I = 0.51$, $p = 0.001$), spatial lag modeling was conducted.

Univariable and Multivariable Spatial Lag Models

There were several consistent relationships – either focal effects, spatial lag effects or both – with tobacco outlet density across the study areas. For example, there was an inverse relationship between median household income and tobacco outlet density in Baltimore County, Howard County, Montgomery County and Western Maryland. Conversely, there was a direct relationship between White population percentage and tobacco outlet density in Baltimore County, Howard County, Lower Eastern Shore and Western Maryland, as well as a direct relationship between vacant houses and tobacco outlet density in Baltimore County, Howard County and Montgomery County. In the final model for each of the five study areas, the strongest relationship with tobacco outlet density was a direct relationship between labor force participation rate and tobacco outlet density. Additionally, Chi-square statistics showed a reduction in overdispersion between the null model and the final model for each of the five study areas. Additional tables of the analyses results are provided in the Appendix.

Place-Based Interaction Models

The results of the place-based interaction models showed that there were significant differences in the magnitude of relationships between covariables and tobacco outlet density for all the comparisons in the study. The differences in the magnitude of relationships were exhibited by areas when regressed on tobacco outlet density, with another area as a reference variable. Differences were also exhibited within areas among the focal and spatial lag effects, meaning that the proximity of neighborhoods affected how the sociodemographic variables in their individual areas related to tobacco outlet density. For example, there were differences in the magnitude of relationships between covariables and tobacco outlet density in the placed-based interaction model involving Montgomery County, with Howard County as the reference variable (see Table 3) and the place-based interaction model involving Baltimore County with Howard County as the reference variable (see Table 4). Additionally, both models exhibited differences in the magnitude of relationships with tobacco outlet density for both labor force participation rate and income inequality between the focal and spatial lag effects. Montgomery County also exhibited a difference in the magnitude of the relationship with tobacco outlet density for the percentage of individuals aged 25 years and older with at least a Bachelor's degree, between the focal and spatial lag effects. All other interactions between focal and spatial lag effects, while statistically significant, exhibited no change in the magnitude of relationship (i.e, the exponentiated beta = 1).

Another finding was that some relationships between covariables and tobacco outlet density were consistently exhibited across the models. For example, every model exhibited an inverse relationship between median household income and tobacco outlet density and an inverse relationship between income inequality and tobacco outlet density. Conversely, every model exhibited a direct relationship between labor force participation rate and tobacco outlet density. The strongest relationship exhibited was the direct relationship between labor force participation rate and tobacco outlet density within both focal and spatial lag effects, and this was consistent across all models. Additional tables of the analyses results are provided in the Appendix.

Discussion

The objective of this study was to examine the relationship between socioeconomic status and tobacco outlet density in predominantly-White Maryland jurisdictions, with the aim of testing the hypothesis that there would be an inverse relationship between socioeconomic status and tobacco outlet density despite a similar White population percentage. The first key finding was that the descriptives of sociodemographics and tobacco outlet density showed areas with higher measures of socioeconomic status, despite similar racial concentration, had lower tobacco outlet density. These patterns were consistent with the hypothesis and with findings from Fakunle et. al and contribute to the proposition that the relationship between sociodemographics and tobacco outlet density follows a socioeconomic gradient regardless of racial composition [3]. However, the descriptives showed that when compared to each other, areas with similar measures of socioeconomic status and similar racial concentrations did not have similar tobacco outlet density, which is not consistent with the hypothesis and past research. The suggestion is that the difference in tobacco outlet density was reflective of

the difference in urbanicity between Lower Eastern Shore and Western Maryland. While both locales are considered rural, Western Maryland exhibits more rurality (i.e., less urbanicity) than Lower Eastern Shore [26].

The second key finding resulted from the spatial regression models, which allowed for detailed analyses of sociodemographics and tobacco outlet density within and across the study areas. In 12 of the 14 total spatial analyses models, median household income within focal and/or spatial lag effects exhibited an inverse relationship with tobacco outlet density. This finding is consistent with past tobacco outlet density studies [2–3, 12–13, 27]. The implication is that median household income may be the best predictor of tobacco outlet density among measures of socioeconomic status, and coupled with the first key finding, suggests that municipalities should at least consider the household income of neighborhoods, regardless of the racial composition, when determining the number of tobacco outlets to allow.

Among all five study areas labor force participation rate had the largest exponentiated beta coefficient in the final spatial model, which included interaction terms for all the examined sociodemographic covariates. It is difficult to provide a rationale, but a suggestion is that the magnitude of the relationship with tobacco outlet density was reflective of the statistical interaction between sociodemographics in proximal Census Tracts and sociodemographics in distal Census Tract neighborhoods. In each study area, the exponentiated beta coefficient for labor force participation rate was higher in the multivariable model with interaction terms than the multivariable model without interaction terms. Conceptually, the magnitude of the relationship with tobacco outlet density may be reflective the high labor force participations rates in most of the jurisdictions. All five jurisdictions had a labor force participation rate of at least 60%. It is also possible that the high magnitudes of relationships could be driven by outliers within the Census Tracts, particularly those with a high number of outlets and low labor force participation rates, and while the measure of tobacco outlet density standardized Census Tract populations the spatial lag models did not include population as a variable. Finally, it is suggested that the direct relationship between labor force participation rate and tobacco outlet density was reflective of the higher populations in most of the study areas. All five jurisdictions had total population totaling at least 200,000. Nevertheless, the consistency of labor force participation rate's magnitude implies that tobacco control policies should be considerate of neighborhoods' employment levels, particularly in concurrence with median household income.

It is important to maintain an appropriate context when considering the findings of this study, because while statistical methodology allows researchers to parse through multifaceted relationships, the interaction of race and socioeconomic status is an inherently complex relationship. The most salient covariates, and their relationships with tobacco outlet density, were determined based on consistency shown across several spatial regression models as well as the two-sample t-tests. However, nearly all the covariates included in the models showed a significant association in one direction or the other. That exemplifies both the complexities of socioeconomic status and the contextual interaction of race, socioeconomic status and tobacco outlet density. However, the results demonstrate that perhaps median household income encompasses enough of socioeconomic status as a

construct to be a deciding metric by which tobacco use reduction interventions are administered. What makes this demonstration more salient is that it was shown among predominantly White jurisdictions. Whites are a racial group under-researched in tobacco outlet density. Fakunle and colleagues previously showed this association among predominantly Black areas in Maryland, and much of the explanation around the influence of socioeconomic status and tobacco outlet density focused on the effects of institutional racism and its many manifestations, including redlining and segregation [3]. The larger reality of understanding racial and socioeconomic disparities in the United States is that the pervasive history of institutional racism has rendered it all but impossible to fully disentangle race and socioeconomic status. That said, the presence of a similar association in White jurisdictions does not invalidate the mechanisms that may explain inequitable tobacco outlet distributions in predominantly Black jurisdictions, but it does suggest that similarly-premised mechanisms that detrimentally affect lower-income neighborhoods may explain inequitable distributions in predominantly White areas.

One strength of this study is that it investigated the influence of White populations on tobacco outlet density. While it must be noted that there is no standard system to determine the severity of tobacco outlet density inequality, this study serves as further confirmation that disparate distributions of tobacco outlets in geospatial areas are strongly related to its socioeconomic composition, regardless of its racial composition. Specifically, that the poorer an area, regardless of how high-White its population may be in this instance, the greater the availability of tobacco outlets in that same area. To the best of acquired knowledge, this was the first study that intentionally examined the relationships between socioeconomic proxies and tobacco outlet density in predominantly-White locales.

Conceptually, the goal of this study was to stress to tobacco and health disparities researchers alike that the despite the focus, manifestations of socioeconomic inequality are not limited to urban areas – which are predominantly occupied by non-White populations – but are present in suburban and rural areas, which are predominantly occupied by White populations. High-White areas categorized as lower-SES are also prone to tobacco outlet inequality and its public health ramifications. For example, according to the Maryland Department of Health's (then the Maryland Department of Health and Mental Hygiene) Office of Minority Health and Health Disparities, the 2007–2009 age adjusted heart disease mortality rates for Whites in the Western Maryland region (Allegany, Garrett and Washington counties) were not only higher than that of Whites across the entire state, but were comparable and in some cases higher than the mortality rates of Blacks across the entire state. Similar patterns were found with Emergency Department visits due to diabetes, a health outcome like heart disease that has been linked to chronic tobacco use. While in those cases the rates for Whites in Western Maryland were lower than Blacks across Maryland, the rates were consistently higher than Whites across Maryland. Between 2007 and 2009, the average median household income for Western Maryland, a predominantly-White region, was lower ($48,164) than Maryland's statewide median household income ($69,695) [28].

Historically tobacco outlet density research has restricted its focus on the association with race and tobacco outlet density to non-White racial groups such as Blacks and Hispanic/

Latinos, while Whites have been utilized as the reference or not studied at all. This is perhaps reflective of past research which showed direct relationships between non-White populations and tobacco advertising [2–3, 12, 29–31]. However, this study acknowledged that Whites are the majority racial group in most jurisdictions in Maryland and therefore garnered an in-depth exploration. Additionally, this study expanded beyond jurisdictions with similar racial concentrations yet disparate median household incomes to include jurisdictions with similar racial concentrations and similar socioeconomic metrics. This allowed for a more detailed examination of socioeconomic status as a construct, showing that not all metrics behave in the same manner, and exhibited the consistent relationship between socioeconomic status and tobacco outlet density at different magnitudes.

Future studies of sociodemographics and tobacco outlet density should combat intuition and aim to examine for the presence or absence of a socioeconomic gradient within areas majorly occupied by racial and ethnic groups beyond Blacks and Whites - particularly Latinos, Native American/Pacific Islanders, and Asians. Additionally, consideration should be given to methods that compare multiple areas simultaneously as opposed to one-on-one comparisons. Finally, studies should also analyze not only relationships with the availability of tobacco outlets, defined as outlets per number of residents, but also relationships with access to tobacco outlets, defined as outlets per miles or kilometers of roadway within a given area. Utilizing both measures provides a more thorough and standardized perspective on tobacco outlet density regardless of the geographic or population size, while acknowledging and controlling for their respective influence.

While it is important to understand the nuances between sociodemographics and tobacco outlet density, particularly has notable unequal relationships have been uncovered and verified, the field should begin shifting towards understanding the historical mechanisms of inequities that allowed disparities to manifest and to currently perpetuate. Such studies should involve the longitudinal chronicling of federal, state and local tobacco outlet licensing and zoning regulations and policies, concurrently paired with the mapping of tobacco outlets over the same historical period. For additional context and insight, particularly about the salience of tobacco outlets (such as serving purposes to consumers beyond selling tobacco products), studies should consider utilizing the narratives of residents who have experienced neighborhood changes over time to chronicle the presence, change and removal of tobacco outlets. Narratives could also be paired with analog and/or digital mapping techniques, the combination of which is known as qualitative GIS, and could provide a more complete perspective of how tobacco outlet density affects areas, and how those effects are greater or lesser in certain areas [32].

This study concludes that jurisdictions with relatively higher socioeconomic status, despite similar concentrations of Whites to jurisdictions with relatively lower socioeconomic status, exhibit lower tobacco outlet density. Additionally, this study concludes that median household income exhibits the most consistent association with tobacco outlet density among several metrics of socioeconomic status.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This study was supported by the National Institute on Drug Abuse (T32 DA007292).

References

1. Peterson NA, Lowe JB, Reid RJ. Tobacco outlet density, cigarette smoking prevalence, and demographics at the county level of analysis. Subst Use Misuse. 2005;40(11):1627–35. [PubMed: 16253931]
2. 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):249–59. doi: 10.1080/15332640.2010.522890. [PubMed: 21161808]
3. 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 7;136:35–40. doi: 10.1016/j.puhe.2016.02.032 [PubMed: 27076440]
4. Lee JG, Sun DL, Schleicher NM, Ribisl KM, Luke DA, Henriksen L.Inequalities in tobacco outlet density by race, ethnicity and socioeconomic status, 2012, USA: results from the ASPiRE Study. J Epidemiol Community Health. 2017 5;71(5):487–492. doi: 10.1136/jech-2016-208475. [PubMed: 28249990]
5. Mayers RS, Wiggins LL, Fulghum FH, Peterson NA. Tobacco outlet density and demographics: A geographically weighted regression analysis. Prev Sci. 2012 10;13(5):462–71. doi: 10.1007/s11121-011-0273-y. [PubMed: 22538505]
6. American FactFinder. U.S. Census Bureau website. http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml Accessed January 22, 2017.
7. Yu D, Peterson NA, Reid RJ. Exploring the impact of non-normality on spatial non-stationarity in geographically weighted regression analyses: Tobacco outlet density in New Jersey. GIScience & remote sensing. 2009;46(3):329–346.
8. 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 7;124(7):412–6. doi: 10.1016/j.puhe.2010.03.024. [PubMed: 20541232]
9. Ripley BD. Spatial Statistics (Vol. 575). Hoboken, NJ: John Wiley & Sons; 2005.
10. Gelfand AE, Diggle P, Guttorp P, Fuentes M. Handbook of Spatial Statistics. CRC Press; 2010.
11. Fischer MM, Gettis A. Recent Developments in Spatial Analysis: Spatial Statistics, Behavioural Modelling, and Computational Intelligence. Berlin: Springer-Verlag Berlin Heidelberg; 2013.
12. 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 7;93(7):1075–6. [PubMed: 12835184]
13. Rodriguez D, Carlos HA, Adachi-Mejia AM, Berke EM, Sargent JD. Predictors of tobacco outlet density nationwide: a geographic analysis. Tob Control. 2013 9;22(5):349–55. doi: 10.1136/tobaccocontrol-2011-050120. [PubMed: 22491038]
14. 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 4;127(4):333–8. doi: 10.1016/j.puhe.2013.01.013. [PubMed: 23515009]
15. Kawachi I, Kennedy BP. Income inequality and health: pathways and mechanisms. Health Serv Res. 1999 4;34(1 Pt 2):215–27. [PubMed: 10199670]
16. Subramanian SV, Kawachi I. Income inequality and health: what have we learned so far? Epidemiol Rev. 2004;26:78–91. [PubMed: 15234949]
17. Reid RJ, Peterson NA, Lowe JB, Hughey J. Tobacco outlet density and smoking prevalence: Does racial concentration matter? Drugs: education, prevention and policy. 2005;12(3): 233–238.

18. Ogneva-Himmelberger Y, Ross L, Burdick W, Simpson SA. Using geographic information systems to compare the density of stores selling tobacco and alcohol: youth making an argument for increased regulation of the tobacco permitting process in Worcester, Massachusetts, USA. Tob Control. 2010 12;19(6):475–80. doi: 10.1136/tc.2008.029173. [PubMed: 20817715]
19. Gorman DM, Speer PW, Gruenewald PJ, Labouvie EW. Spatial dynamics of alcohol availability, neighborhood structure and violent crime. J Stud Alcohol. 2001 9;62(5):628–36. [PubMed: 11702802]
20. Morrison C, Gruenewald PJ, Ponicki WR. Race, ethnicity, and exposure to alcohol outlets. J Stud Alcohol Drugs. 2016 1;77(1):68–76. [PubMed: 26751356]
21. Grubesic TH, Wei R, Murray AT, Pridemore WA. Comparative approaches for assessing access to alcohol outlets: exploring the utility of a gravity potential approach. Popul Health Metr. 2016 8 2;14:25. doi: 10.1186/s12963-016-0097-x. [PubMed: 27486385]
22. SPSS Statistics for Windows [computer program]. Version 24.0. IBM Corp; 2017.
23. Auchincloss AH, Gebreab SY, Mair C, Diez Roux AV. (2012). A A review of spatial methods in epidemiology, 2000–2010. Annu Rev Public Health. 2012 4;33:107–22. doi: 10.1146/annurev-publhealth-031811-124655. [PubMed: 22429160]
24. R [computer program]. Version 3.5.1. The R Project for Statistical Computing; 2018.
25. Fakunle DO**.** Black, White, or Green? The Effects of Racial Composition and Socioeconomic Status on Neighborhood-Level Tobacco Outlet Density in Maryland [dissertation]**.** Baltimore**:** Johns Hopkins Bloomberg School of Public Health**;** 2017.
26. Hambrick G Urban vs. rural: counties ranked in Maryland. Towson Patch. 12 8, 2016 https://patch.com/maryland/towson/urban-vs-rural-counties-ranked-maryland Accessed September 5, 2017.
27. Peterson NA, Lowe JB, Reid RJ. Tobacco outlet density, cigarette smoking prevalence, and demographics at the county level of analysis. Subst Use Misuse. 2005;40(11):1627–35. [PubMed: 16253931]
28. Maryland Office of Minority Health and Health Disparities Charts of selected Black vs. White chronic disease SHIP metrics: Western Maryland counties (Allegany, Garrett, and Washington). https://health.maryland.gov/mhhd/Documents/Jurisdictionprofiles_Western-Maryland.pdf Published April 16, 2012 Accessed September 12, 2018.
29. Laws MB, Whitman J, Bowser DM, Krech L. Tobacco availability and point of sale marketing in demographically contrasting districts of Massachusetts. Tob Control. 2002 6;11 Suppl 2:ii71–3. [PubMed: 12034986]
30. Luke D, Esmundo E, Bloom Y. Smoke signs: patterns of tobacco billboard advertising in a metropolitan region. Tob Control. 2000 3;9(1):16–23. [PubMed: 10691754]
31. Barbeau EM, Wolin KY, Naumova EN, Balbach E. Tobacco advertising in communities: associations with race and class. Prev Med. 2005 1;40(1):16–22. [PubMed: 15530576]
32. Cope M, Elwood S. Qualitative GIS: A Mixed Methods Approach. London, UK: SAGE Publications; 2009.

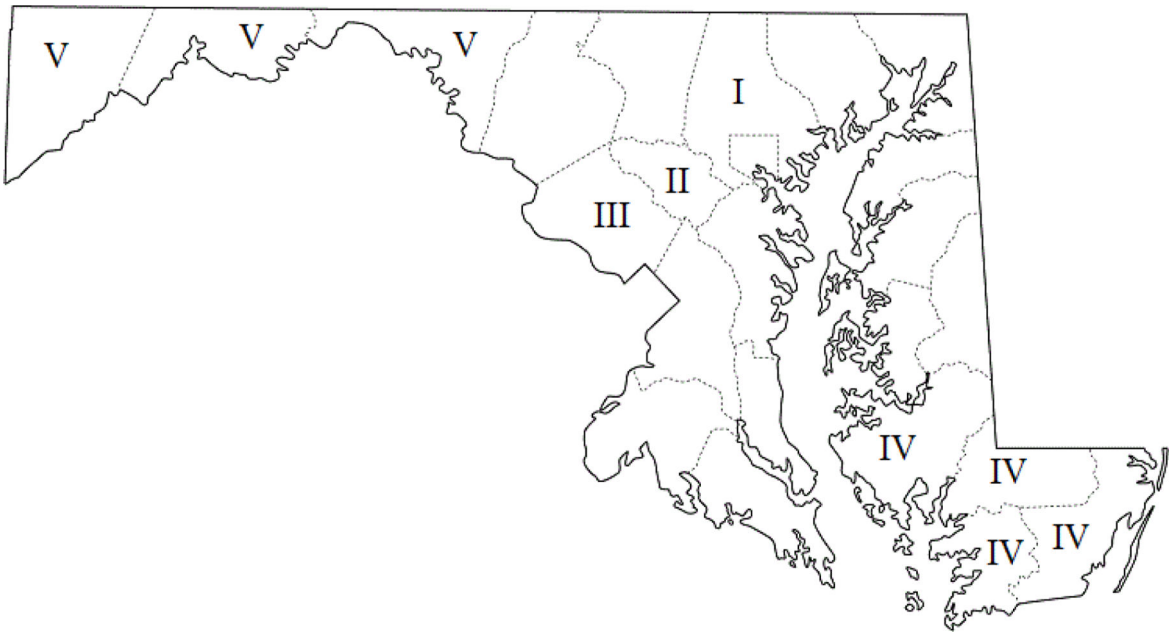

Figure 1: Geographical Map of Study Areas

I – Baltimore County, Maryland

II – Howard County, Maryland

III – Montgomery County, Maryland

IV – Lower Eastern Shore, Maryland (Dorchester County, Somerset County, Wicomico County and Worcester County)

V – Western Maryland (Allegany County, Garrett County and Washington County)

Table 1:

Descriptives of Sociodemographics and Tobacco Outlet Density of Baltimore County and Howard County, Maryland

Mean Characteristic Per Census Tract	Baltimore County (# Tracts = 211)	Howard County (# Tracts = 55)	*t-statistic*[1]	*df*
Population (SD)	3,900.28 (1,638.74)	5,529.36 (1,596.77)	***−6.60***	*264*
Black Population Percentage (SD)	24.92 (26.55)	17.94 (12.59)	*1.89*	*264*
White Population Percentage (SD)	66.21 (26.96)	60.17 (14.31)	*1.60*	*264*
Median Household Income (SD)	$73,114 ($26,299)	$117,889 ($35,909)	***−10.37***	*264*
Gini Coefficient (SD)	0.40 (0.05)	0.36 (0.05)	***5.28***	*264*
Percentage of Individuals Aged 25+ with at Least a Bachelor's Degree (SD)	35.52 (19.86)	61.10 (11.53)	***−9.15***	*264*
Labor Force Participation Rate (SD)[2]	66.34 (8.97)	72.76 (6.13)	***−5.01***	*264*
Number of Vacant Houses	112.71 (95.46)	89.73 (77.42)	*1.65*	*264*
Tobacco Outlets per 1000 (SD)	0.35 (0.49)	0.17 (0.22)	***2.65***	*264*

[1] boldface indicates statistical significance of $p<0.05$.

[2] for individuals aged 16 years and older.

Table 2:

Descriptives of Sociodemographics and Tobacco Outlet Density of Howard County and Montgomery County, Maryland

Mean Characteristic Per Census Tract	Howard County (# Tracts = 55)	Montgomery County (# Tracts = 215)	*t-statistic*	*df*
Population (SD)	5,529.36 (1,596.77)	4,734.23 (1,703.52)	***3.13***	*268*
Black Population Percentage (SD)	17.94 (12.59)	16.51 (13.86)	*0.70*	*268*
White Population Percentage (SD)	60.17 (14.31)	57.93 (20.65)	*0.76*	*268*
Median Household Income (SD)	$117,889 ($35,909)	$109,126 ($44,592)	*1.35*	*268*
Gini Coefficient (SD)	0.36 (0.05)	0.39 (0.05)	***−3.97***	*268*
Percentage of Individuals Aged 25+ with at Least a Bachelor's Degree (SD)	61.10 (11.53)	58.64 (18.52)	*0.94*	*268*
Labor Force Participation Rate (SD)	72.76 (6.13)	71.69 (9.16)	*0.82*	*268*
Number of Vacant Houses	89.73 (77.42)	82.22 (63.53)	*0.75*	*268*
Tobacco Outlets per 1000 (SD)	0.17 (0.22)	0.20 (0.42)	*−0.51*	*268*

Table 3:

Model # 4 – Sociodemographic Variable Interaction Coefficients of Spatial Lag Regression on Tobacco Outlet Density in Montgomery County, Maryland Relative to Howard County, Maryland – 2011–2015 (n = 215)

Variable	Multivariable Model			
	Focal & Spatial Lag		Focal & Spatial Lag Interaction	
	Exponentiated Beta	p-value	Exponentiated Beta	p-value
Focal Effects				
White Population Percentage (per 10%)	**0.87**	**<0.001**	**1.00**	**<0.001**
Median Household Income (per $10000)	**0.90**	**<0.001**	**1.00**	**<0.001**
Percentage of Individuals 25+ with at least a Bachelor's Degree (per 10%)	**2.93**	**<0.001**	**0.99**	**<0.001**
Labor Force Participation Rate (per 10%)	**9.25**	**<0.001**	**0.97**	**<0.001**
Gini Income Inequality Coefficient (per 1%)	**0.77**	**<0.001**	**2.15**	**<0.001**
Vacant Houses (x100)	**1.63**	**<0.001**	**1.00**	**<0.001**
Spatial Lag				
White Population Percentage (per 10%)	**1.48**	**<0.001**		
Median Household Income (per $10000)	**0.87**	**<0.001**		
Percentage of Individuals 25+ with at least a Bachelor's Degree (per 10%)	**1.47**	**<0.001**		
Labor Force Participation Rate (per 10%)	**17.18**	**<0.001**		
Gini Income Inequality Coefficient (per 1%)	**0.83**	**<0.001**		
Vacant Houses (x100)	**1.20**			
County	**0.81**	**<0.001**		

Table 4:

Model # 4 – Sociodemographic Variable Interaction Coefficients of Spatial Lag Regression on Tobacco Outlet Density in Baltimore County, Maryland Relative to Howard County, Maryland – 2011–2015 (n = 211)

Variable	Multivariable Model			
	Focal & Spatial Lag		Focal & Spatial Lag Interaction	
	Exponentiated Beta	p-value	Exponentiated Beta	p-value
Focal Effects				
White Population Percentage (per 10%)	**0.99**	**<0.01**	**1.00**	**<0.001**
Median Household Income (per $10000)	**0.88**	**<0.001**	**1.00**	**<0.001**
Percentage of Individuals 25+ with at least a Bachelor's Degree (per 10%)	**1.12**	**<0.001**	**1.00**	**<0.001**
Labor Force Participation Rate (per 10%)	**30.91**	**<0.001**	**0.95**	**<0.001**
Gini Income Inequality Coefficient (per 1%)	**0.84**	**<0.001**	**1.72**	**<0.001**
Vacant Houses (x100)	**0.92**	**<0.001**	**1.00**	**<0.001**
Spatial Lag				
White Population Percentage (per 10%)	**0.86**	**<0.001**		
Median Household Income (per $10000)	**0.80**	**<0.001**		
Percentage of Individuals 25+ with at least a Bachelor's Degree (per 10%)	**1.09**	**<0.001**		
Labor Force Participation Rate (per 10%)	**28.47**	**<0.001**		
Gini Income Inequality Coefficient (per 1%)	**0.79**	**<0.001**		
Vacant Houses (x100)	**1.30**	**<0.001**		
County	**0.38**	**<0.001**		