

The Legacy of Redlining and the Geography of Tobacco Retailers in Wisconsin

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ABSTRACT

Introduction: Housing discrimination as one of the main mechanisms for reinforcing racial segregation has persisted historically in the United States through a process known as “redlining.” In recent years, researchers across different disciplines have utilized the iconic “residential security maps” created by the Home Owners’ Loan Corporation (HOLC) in the 1930s to analyze the structural roots of racial disparities. HOLC maps designated grading of “best” to “still desirable” to “definitely declining” and “hazardous” to urban areas where percentage of African American and foreigners were among the reordered measures.

Objective: Given that sales and marketing of tobacco products also present a historical connection to structural racism in the US, this study examines how historical redlining relates to current geographies of tobacco retailers in Wisconsin.

Methods: Analyses were conducted for 4 cities in Wisconsin with available HOLC maps. We used negative binomial models to account for spatial heterogeneity and overdispersion of retailers, and we controlled for present-day sociodemographic characteristics.

Results: Findings indicated that the hierarchy of HOLC grades are reflected in the present-day retailer density, and areas historically graded as “less desirable” have a higher present-day density of tobacco retailers. The result of the statistical model shows that poverty and percentage minority are also significant factors in distribution of tobacco retailers.

Conclusions: These results highlight that to address the structural roots of health disparities, we need intervention strategies that employ a comprehensive look at the historical legacies of discrimination.

INTRODUCTION

It is estimated that 47.1 million adults in the United States currently use tobacco products.¹ Although there has been a substantial decrease in the prevalence of smoking in the US in the past decades, the disparities among specific subpopulations persist,² and

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Native American and non-Hispanic Black populations have the highest percentage of smokers.³ Among the US Census regions, the Midwest has the highest percentage of smokers.³ In 2020, 15.5% of Wisconsin adults smoked, which is the same as national average.⁴ Annual health care costs directly caused by smoking in Wisconsin were estimated around \$2.66 billion.⁵ In 2020, Wisconsin allocated \$5.3 million for tobacco use prevention.⁴ However, Wisconsin is 1 of 19 states spending less than 10% of the amount recommended by the Centers for Disease Control and Prevention (CDC) for tobacco prevention programs, making the ratio of industry marketing to state tobacco prevention spending 31.1 to 1.5. Furthermore, research has shown that lower income and minority neighborhoods are disproportionately targeted by tobacco marketing,⁶ and neighborhood characteristics (eg, poverty and segregation, density of tobacco retailers) play an important role in the prevalence of adolescent and teen smoking.⁷

The relationship between race, neighborhood characteristics, and health inequity in the US points to a historically persistent gap. There are many studies on the origins of the current disparities, with evidence of the role of residential segregation and geographies of concentrated disadvantage.⁸ The extent to which these concentrated disadvantaged neighborhoods and the consequent existing disparities can be explained by previous racial housing policies has received growing attention in the last decade. One driving factor for this emerging interest is place-based causality and health outcomes. That is why understanding the patterns of residential segregation, their characteristics, and the underlying

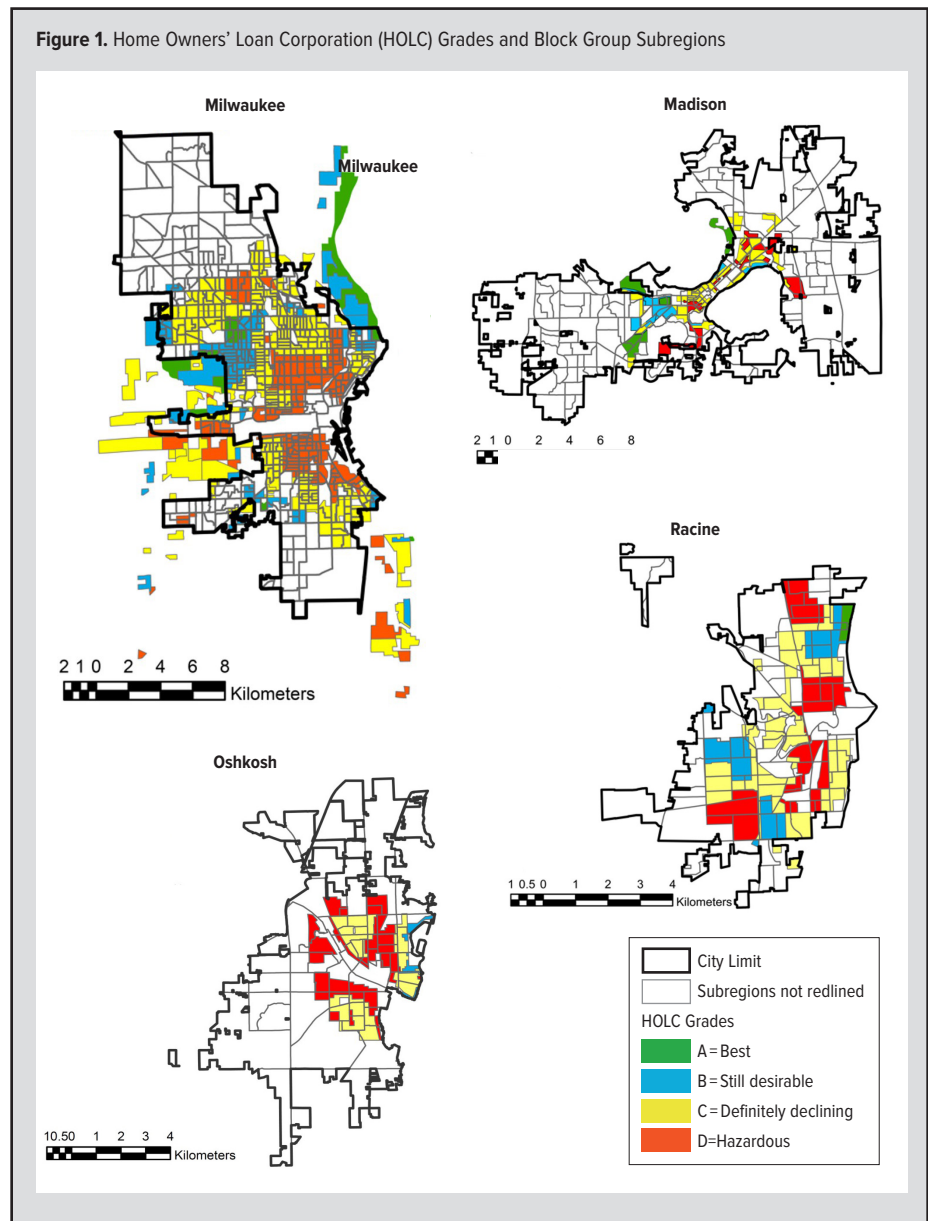
contexts are important for health disparity research.

In the US, the major forces in shaping the cities and their residential patterns were the Great Migration and the appraisal practices of the Home Owners' Loan Corporation (HOLC) in the 20th century. As a product of the housing policies in the first half of the 20th century, HOLC maps were designed to systematically limit housing choices for African-American and other minority groups, while encouraging "white flight" to the suburbs.⁹ The rating system employed by this program also affected future investments through assigned neighborhood grades (A=best, B=desirable, C=declining, and D=hazardous). Previous studies have shown the long-lasting legacy of redlining in American cities.^{10,11} For example, contemporary racial and ethnic settlement patterns have been affected by previous housing policies and discriminatory practices.¹¹ A recent meta-analysis provided evidence of association between living in historically redlined areas with increased risk of multiple serious adverse health outcomes.¹⁰ Recent studies also have speculated about the relationship between redlining designations and contemporary tobacco retailer disparities.¹² One pathway through which redlining might be associated with present day tobacco retailers' density is the long-lasting effects of redlining on current racial and ethnic settlement patterns across the country.¹¹

Today, initiatives such as Mapping Inequality¹³ have made historical HOLC data widely available for analysis. Building on previous research on residential segregation and geographies of tobacco retailers,^{12,14} this study examines the inequity in the distribution of tobacco retailers, which has been shown as one of the determining factors for smoking risk disparities.¹⁵ For example, a recent meta-analysis of 27 studies on the relationship between tobacco retailers' density and proximity and smoking behavior showed an estimated 2.48% reduction in risk of tobacco use from reductions in tobacco retailer density and proximity.¹⁵ The research questions in this study included:

1. Is there a systematic disparity in contemporary geographies of tobacco retailers that corresponds with HOLC categories across Wisconsin? We hypothesized that HOLC grades are reflected in present-day tobacco retailers' density.

Figure 1. Home Owners' Loan Corporation (HOLC) Grades and Block Group Subregions



2. Is there a relationship between tobacco retailers' density and the current neighborhood level socioeconomic characteristics, including percentage minorities, percentage below poverty, and percentage below age 18 in Wisconsin? We hypothesized that areas with higher tobacco retailer density exhibit higher rates of concentrated poverty and minority populations.

METHODS

Data Sources

We retrieved the HOLC boundary and grade data from Mapping Inequality.¹³ At the time of this writing, the HOLC maps are available for 5 Wisconsin cities. We retrieved block group-level information about race/ethnicity, age, poverty, and total population from the 2016 American Community Survey 5-year estimates.

We were able to obtain the list of locations with tobacco sale licenses in 2020 from the city clerk's office from 4 cities

(Milwaukee, Madison, Oshkosh, and Racine). These retailers were then geocoded based on their street address.

Analysis

Contemporary Sociodemographic Measures

We used the 2016 American Community Survey 5-year estimates to calculate the following measures for each block group: percentage of minority population, percentage in poverty, and percentage under age 18. Given that the percentage of African American (Black) population varies greatly across the cities studied and there are small percentages of Hispanic, Asian, and Native American population in most cities, the non-White population was categorized as minority population.

We used the Wisconsin state averages to define the cutoffs for “above average (high)” and “below average (low)” groups.¹² The average percentage of population living in poverty, the average percentage of minority population, and the average percentage of population under 18 in Wisconsin were 10.4, 19.1, and 21.8, respectively.¹⁶ For example, block groups with percentage below poverty over 10.4 were coded as having above average prevalence of poverty; all other block groups were coded as low prevalence of poverty. Block groups with minority populations over 19.1% were coded as above average minority prevalence and the rest as low. Similarly, block groups with over 21.8% population under 18 were coded as above average prevalence of young people.

Historical Redlining Maps and Contemporary Measures

We overlaid the Shapefiles of the historical redlining maps for 4 Wisconsin cities with block group boundaries. We then defined smaller subregions for each HOLC-graded area that overlapped with a 2016 block group tract. These subregions as the unit of analysis were then assigned their respective HOLC grade. We marked areas that were not assigned a HOLC grade in the 1930s as “E.” We excluded the redlined areas that were outside of the city’s boundaries. Figure 1 shows the subregions and HOLC grades for these cities. We reallocated the total population and tobacco retailer counts to the subregions by reinterpolating by area size. This resulted in 1654 subregions with population and retailer counts.

Table 1. Summary of Four Regression Models on Associations Between Tobacco Retailer Counts in Subregions and Different Variables

Variables	Model 1:	Model 2:	Model 3:	Model 4:
	HOLC	Socioeconomic Variables	HOLC Grade and Socioeconomic Variables	HOLC Grade, Socioeconomic Variables and City Effect
	Estimate 95% CI	Estimate 95% CI	Estimate 95% CI	Estimate 95% CI
% Below age 18		-0.32 ^a	-0.30 ^a	-0.28 ^b
Above avg vs below avg		-0.499 to -0.146	-0.472 to -0.119	-0.464 to -0.104
% Below poverty		0.73 ^a	0.66 ^a	0.65 ^a
Above avg vs below avg		0.524 to 0.938	0.447 to 0.866	0.439 to 0.861
% Minority		0.61 ^a	0.60 ^a	0.63 ^a
Above avg vs below avg		0.391, 0.837	0.377 to 0.820	0.379 to 0.881
HOLC Grade B vs A	0.91 ^c 0.030 to 1.933		0.77 -0.107 to 1.802	0.78 ^c -0.095 to 1.817
HOLC Grade C vs A	1.61 ^a 0.773 to 2.602		1.28 ^b 0.441 to 2.279	1.29 ^b 0.448 to 2.289
HOLC Grade D vs A	1.89 ^a 1.048 to 2.890		1.54 ^a 0.697 to 2.547	1.55 ^a 0.705 to 2.559
HOLC Grade E vs A	1.52 ^a 0.697 to 2.519		1.30 ^b 0.472 to 2.302	1.31 ^b 0.475 to 2.308
Milwaukee vs Madison				-0.06 -0.305 to 0.191
Racine vs Madison				-0.18 -0.520 to 0.149
Oshkosh vs Madison				-0.00 -0.422 to 0.414
Akaike information criterion	3669.8	3579.6	3559	3563.8

Abbreviations: HOLC, Home Owners’ Loan Corporation; avg, average.

^a $P < 0.001$, ^b $P < 0.01$, ^c $P < 0.1$

Table 2. Summary Statistics of the Tobacco Retailers by Socioeconomic Factors and HOLC Grade

City	No. of Subregions	Percentage With Above Average:			HOLC Grade (%)				
		Poverty	Minority	Under 18	A	B	C	D	E
Madison	308	49.35	47.08	27.60	4.22	6.82	19.81	9.74	59.42
Milwaukee	1032	71.80	83.14	62.5	2.42	12.69	31.40	17.93	35.56
Racine	194	58.76	84.02	65.46	2.06	12.37	27.83	15.46	42.27
Oshkosh	120	59.16	7.5	43.34	—	4.17	24.16	30.83	40.83
Total	1654	65.18	71.04	54.96	2.54	10.94	28.30	17.05	41.17

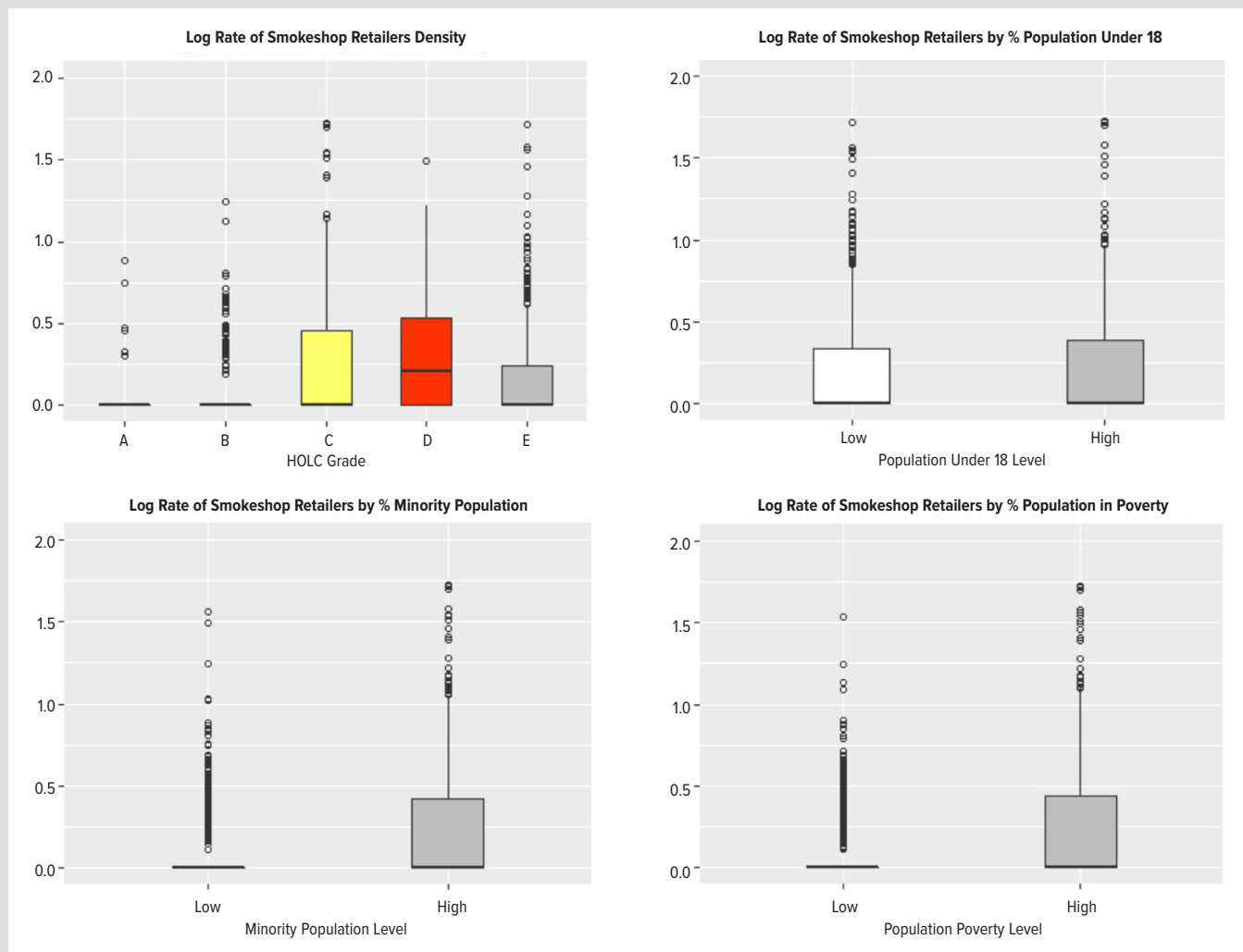
Abbreviations: HOLC, HOLC, Home Owners’ Loan Corporation.

Statistical Analysis

First, we explored relationships between tobacco retailer density and sociodemographic factors and HOLC grade using boxplots and descriptive statistics. In examining the differences for tobacco retailer density and socioeconomic variables by HOLC grade, we used Mann-Whitney U test, a nonparametric test of the null hypothesis. We then used negative binomial regression models to examine the relationship between retailer density and sociodemographic factors. This method is used to model count (usually overdispersed) outcome variables and to account for overdispersion across subregions.¹⁷

In this study, the negative binomial statistical analysis included 4 models (Table 1). In the first model, we looked at the relation-

Figure 2. Boxplots of the Log Rate of Tobacco Retailers' Density, per 1000 People, by HOLC Grade and Socioeconomic Variables



Abbreviation: HOLC, Home Owners' Loan Corporation.

ship between density of retailers and HOLC grades. In the second model, we looked only at socioeconomic factors. In the third model, we looked at both socioeconomic variables and HOLC grades. In the fourth model, we also accounted for the effect of city. To compare the models, we used the Akaike information criterion (AIC), which is an estimator for relative quality of a statistical model. We used MASS and magrittr packages in R (R Core Team, 2022)

RESULTS

The analysis resulted in 1117 retailers across 1654 subregions in 4 cities, with a total population of 1903254. Table 2 provides a summary of the distributions of socioeconomic factors and HOLC grades across the study cities. Most subregions (41.17%, 643235 people) were not historically graded (E). Of those subregions that were graded, the majority were grade C “definitely declining” (28.30% of subregions, 279037 people), followed by D: “hazardous” (17.05% of subregions, 164611 people), then B:

“still desirable” (10.94% of subregions, 88807 people), and A: “best” (2.54% of subregions, 17143 people). Table 2 also shows that the majority of the subregions have above average prevalences of poverty, minority populations, and population under 18.

Figure 2 displays summaries of the log retailer density and sociodemographic characteristics based on HOLC grades. The results show that retailer density mirrors the hierarchy of the HOLC grades. Also, the retailer density is higher in areas with above average percentage of minorities and prevalence of poverty. The retailer density seems slightly higher in areas with above average population under 18.

The results of the Kruskal-Wallis test for tobacco retailer density and the socioeconomic measures indicate that for all the measures, there were significant differences across HOLC grades. As illustrated in Table 3, Mann-Whitney U tests revealed that for retailer density, all of the differences were statistically significant, except for the difference between grades B and A and the difference between grades B and areas not redlined. For percent under

Table 3. Mann–Whitney U Test Results for Tobacco Retailer Density and Socioeconomic Characteristics Based on HOLC Grades

HOLC Grade	Tobacco Retailers Density		% Below Poverty		% Minority		% Under Age 18	
	Difference in Median	95% CI	Difference in Median	[95% CI]	Difference in Median	95% CI	Difference in Median	95% CI
B–A	-0.000	-0.000 to 0.000	-3.208	-7.318 to 0.063	-9.226 ^a	-17.905 to -1.780	-1.588	-4.762 to 1.463
C–A	-0.000 ^c	-0.000 to -0.000	-12.461 ^c	-17.920 to 7.514	-17.456 ^c	-28.330 to -8.521	-2.716	-6.320 to 0.888
D–A	-0.000 ^c	-0.283 to -0.000	-15.894 ^c	-22.142 to -10.478	-14.526 ^c	-25.385 to -6.028	-2.540	-6.418 to 1.459
C–B	-0.000 ^c	-0.000 to -0.000	-7.930 ^c	-10.818 to -5.242	-5.841 ^b	-11.584 to -1.725	-0.834	-2.837 to 1.152
D–B	-0.000 ^c	-0.047 to -0.000	-11.310 ^c	-14.508 to -8.173	-3.656	-9.261 to 0.782	-0.555	-2.944 to 1.736
D–C	-0.000 ^a	-0.000 to 0.000	-3.115 ^a	-5.802 to -0.455	2.114	-0.842 to 5.374	0.181	-1.703 to 2.185
A–E	-0.000 ^a	-0.000 to -0.000	-3.663 ^a	-7.350 to -0.540	-5.580	-12.837 to 1.285	0.426	-2.826 to 3.521
B–E	-0.000	-0.000 to 0.000	-0.245	-2.094 to 1.589	3.643	-0.017 to 7.722	2.082 ^a	0.389 to 3.751
C–E	0.000 ^c	0.000 to 0.000	7.857 ^c	5.985 to 9.819	12.153 ^c	8.460 to 16.376	2.805 ^c	1.374 to 4.212
D–E	0.000 ^c	0.000 to 0.000	11.270 ^c	8.934 to 13.625	9.363 ^c	5.316 to 14.159	2.503 ^b	0.737 to 4.293

Abbreviation: HOLC, Home Owners’ Loan Corporation.

^a $P < 0.05$, ^b $P < 0.01$, ^c $P < 0.001$

poverty, all were statistically significant, except for the difference between grades B and A and the difference between grades B and areas not redlined. For minority populations, all differences are significant except for D and B, D and C, A and E, and B and E.

Table 1 shows the results of different models for the negative binomial regression. Model 3, including both HOLC grades and socioeconomic variables, is a better fit compared to the others. For example, the expected log count for subregion with above average percent of minority population is 1.822 higher than areas with below average percentage of minority population. The expected log count for subregions with above average percentage of poverty is 1.934 higher than subregions with low prevalence of poverty. Additionally, with the exception of grade B, the geography of retailer locations mirrors that of HOLC grades hierarchy. For example, in grade D areas, the expected log count is 4.664 higher than the expected log count in grade A areas. The part of the cities that were not graded also has higher tobacco retailers than grade A. The results also show that areas with an above average percentage of the population under 18 have fewer tobacco retailers.

For sensitivity analysis, we also ran the models with different cutoffs for percentage below poverty, minority percentage, and percentage under 18. We ran the models for top quarter and 80th and 90th and 3rd percentiles. While HOLC levels remained significant in all of these variations, other variables were not consistently significant. For example, in models using 90th percentile, 80th percentile, and top quarter cutoff, percentage minority was statistically significant, while in models with 3rd percentile cut off, percentage below poverty was significant.

We also ran the models stratifying by city. And while the results remain significant for Milwaukee and Madison, for Oshkosh and Racine, which had smaller numbers of subregions, the models were not significant. In Racine, only percentage of poverty was statistically significant, and in Oshkosh, none of the variables were statistically significant. Also, looking at minority groups separately would result in statistically significant associa-

tion with tobacco retailer count for African American population only.

DISCUSSION

This study examined the association between historical redlining and disparities in the distribution of present-day tobacco retailers in 4 Wisconsin cities. The first research question was whether there is a systematic disparity in contemporary geographies of tobacco retailers that corresponds with HOLC categories across Wisconsin. Our findings showed that there is a statistically significant association between previous housing policies and the current geographies of tobacco retailers across the Wisconsin cities. The analysis showed that lower HOLC grades were associated with higher number of present-day tobacco retailers, such that areas historically graded as “best” had lower exposure to tobacco retailers than lower graded areas.

The second question was whether there is a relationship between tobacco retailers’ density and the current neighborhood-level socioeconomic characteristics, including percentage minorities, percentage below poverty, and percentage under age 18 population in Wisconsin. Our findings also showed that socioeconomic factors including percentage in poverty and percentage of minority population were associated with a higher number of tobacco retailers. Areas with a higher percentage of the population under 18 had a slightly lower number of tobacco retailers.

In recent years, many studies have pointed to the legacies of redlining across the United States and its association with disparate health outcomes.¹⁸ The results of this study add to previous findings regarding the relationship between redlining and health-related behavioral factors,²¹ as well as previous research indicating an association between redlining and the geographical distribution of tobacco retailers in Ohio.¹²

Reducing health inequalities requires an understanding of the systematic patterns of discrimination perpetuated through housing policies and neighborhood environments. It is important to

note that while the results do not prove causality, they highlight the long-lasting effects of structural racism and housing discrimination on exposure to tobacco products. And although historical redlining is not a proxy for current-day neighborhood characteristics,¹¹ the results indicate that understanding the historical context is important for tobacco use prevention and control policy, as well as education-based interventions in Wisconsin. Licensing and zoning are effective strategies to impact the density of tobacco retailers across neighborhoods.²⁰ In Wisconsin, a license is required to sell tobacco products other than e-cigarettes.⁴ A statewide Tobacco Retailer Licensing Program to regulate access to all tobacco products is the most effective policy approach for monitoring and restricting businesses that sell tobacco products. Regulating the density of tobacco retailers through zoning provisions has been adopted as a tobacco control policy by many local governments across the country; examples include restriction of new retailers in residential areas or in proximity of some land uses (eg, places where youth frequent) and limiting the number or density of tobacco retailers in certain zones through zoning ordinances.²¹

Educational initiatives are also particularly important in raising awareness of the adolescents and youth living in concentrated disadvantaged neighborhoods as they are exposed to higher rates of secondhand smoking and other inequities that can increase the chances of smoking both during adolescence and later adult life.²² Interventions to target disparate exposure to tobacco products—especially in cities with a long history of racial segregation—should draw on the historical context of structural racism to advance political will to alleviate the consequent health disparities.

Strengths and Limitations

We used a comprehensive list of tobacco retailers' locations in these cities. The study covers the most populated urban areas in the state. The analysis also uses block group units to provide more detailed results but inherits the limitations associated with small area estimations. However, this study only examined 4 cities due to data availability. Further research is needed to include the entire State of Wisconsin and other cities across the US. The population estimates for subregions were calculated based on area interpolations and are subject to the limitations of this method.

CONCLUSIONS

The results of this study suggest that to address the structural roots of health disparities, intervention strategies that take into account a comprehensive look at the historical legacies of discrimination are needed.

Funding/Support: This work was supported by grants from the National Institutes of Health (NCI R01CA214805, T32HP10030). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Financial Disclosures: None declared.

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