Between the Lines: How Historic Redlining Practices Affect Present-Day Life Expectancy

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Abstract

This study shows how historic redlining practices and racial and socioeconomic composition affect present-day life expectancy. Using United States Census tracts as a proxy for neighborhoods, this study also controls for the impact of present-day demographics on the relationship between redlining and life expectancy. Data used were obtained from Diversity Data Kids and The Centers for Disease Prevention and Control. My sample comprises five cities (one from each region) and 3,160 census tracts. The regression results show that historic HOLC neighborhood grades are associated with present-day disparities in life expectancy, with racial and class composition serving as primary mechanisms by which that relationship rests.Findings also suggest regional differences in the extent of redlining's effect on life expectancy.

Introduction

Health is frequently attributed to individual behaviors. Despite this, social factors significantly account for population health disparities across groups and neighborhoods. Many fail to recognize the systemic factors significantly affecting health and life expectancy (Link and Phelan 1995). The variations in health and life expectancy have been attributed to factors extending beyond the individual (Mujahid et al. 2021; Fitzpatrick and LaGroy 2003). Both cultural racism (racist ideas perpetuated through mainstream society, e.g., the media) and structural racism (historical and current systemic factors and institutions perpetuating a racist status quo, e.g., segregation) play a significant role in determining numerous life outcomes, including health and life expectancy (Bailey et al. 2017; Williams and Sternthal 2010). Disparities in these life outcomes reach far beyond a given individual. A neighborhood's racial and socioeconomic composition plays a significant role in its overall health and life expectancy (Mujahid et al. 2021; Fitzpatrick and LaGory 2003). Health disparities in race and socioeconomic status (SES) are interrelated (Williams and Collins 1999).

Segregation and redlining are major forms of structural racism and have historically and today significantly impacted health and life expectancy. Segregation acts as a means of structural racism by separating "in-groups" from "outgroups"; this separation perpetuates the myth of Black inferiority and results in an inequitable distribution of municipal resources. This distribution has devastating effects on the health of Black Americans (Collins and Williams 1999). Another form of structural racism is redlining. After the great depression, the Homeowners Loan Corporation (HOLC) and Federal Housing Administration (FHA) devised a new strategy to distribute home loans. HOLC and FHA mapped out major American cities and assigned one of four grades, ranging from "A" to "D," to each neighborhood. Neighborhoods were color-coded based on their grades (A=green, B=blue, C=yellow, and D=red). Residents of neighborhoods with higher grades had an increased chance of receiving home loans. Redlining rendered it nearly impossible for those living in red, "D" graded neighborhoods to obtain home loans. Neighborhoods given a "D" grade had the highest percentage of Black, Jewish and immigrant residents. These ratings did not correlate with a resident's likelihood of loan repayment. The effects of redlining are still enduring, affecting homeownership and life

expectancy. Redlining also has a significant impact on the effects of the racial and socioeconomic compositions of neighborhoods, perpetuating segregation patterns. Black people residing in formerly redlined neighborhoods (neighborhoods with a "D" grade) have poorer health outcomes in comparison to people living in neighborhoods with an "A" grade. (Swope et al. 2022; Graetz and Esposito 2021; Nardone et al. 2022; Wing et al. 2020; Linde et al. 2022; Huang et al. 2022).

In this paper, I assess whether, and to what extent, historic redlining practices affect present-day neighborhoods' life expectancy. Simultaneously, I analyze whether and to what extent a neighborhood's racial or socioeconomic composition impacts average neighborhood life expectancy, helping to account for any association between historic neighborhood HOLC grades and present-day disparities in life expectancy. For my analysis, I draw on geospatial data from the Centers for Disease Control and Prevention and Kids Count; to answer the following questions; To what extent does redlining affect the average life expectancy of those neighborhoods? Does a neighborhood's racial/class composition mediate redlining's effect on life expectancy?

Literature Review

Population health disparities extend far beyond individual choices. The social identities of a population play a tremendous role in health and life expectancy outcomes. Race and socioeconomic composition are two of the more consequential social determinants of population health and life expectancy. Health and life expectancy disparities are also geographically patterned. Geographical disparities are derived from historical and contemporary segregation practices, including redlining. (Link and Phelan 1995; Mujahid et al. 2021; Fitzpatrick and LaGory 2003; Mujahid et al. 2021; Fitzpatrick and LaGory 2003).

Socioeconomic Status and Health

Disparities in health and life expectancy between low and high SES (Socioeconomic Status) individuals are highly pervasive and have existed since at least the 19th century; these disparities have persisted for centuries because health disparities between people of low and high SES reproduce themselves (Phelan et. al. 1995; Glymour et. al. 2014). Knowledge, money, power, prestige, and social connections protect against disease; more often than not, low SES people need these protectors. Socioeconomic disparities in mortality are more pronounced among preventable diseases; this exemplifies the disparity in the ability to prevent diseases between low and high-SES individuals. Knowledge allows one a better understanding of diseases and how to prevent them. Money allows people to afford life-saving medications, medical procedures, and healthcare—power, and prestige grant priority to those seeking specific medical treatments. Social connections make medical professionals more accessible to high SES people. Certain privileges reserved for high SES people serve as protectors from undesirable health outcomes and even premature mortality (Link and Phelan 1995; Glymour et al. 2014; Woolf and Braveman 2011).

Glymour et al. (2014), in a 10-year longitudinal study, found that SES alone produced meaningful health disparities. When accounting for other demographic factors (e.g., age and sex), a person in the least advantaged 25% was nearly three times more likely to have died during those ten years than a person in the most advantaged 25%. After accounting for behavior with adverse health effects, being in the bottom 25% of SES made a person 1.5x more likely to die than their counterparts in the top 25%.(Glymour et al. 2014).

Race and SES

Previous literature has found disparities in socioeconomic status based on race. Black and Hispanic people are more likely to be low-income, while White people are more likely to be affluent (Fitzpatrick and LaGory 2003). Many of these disparities can be attributed to structural and cultural racism. In addition to cultural and structural discrimination, Black and Brown people are also subject to discrimination in individual and interpersonal interactions. These discriminatory interactions can result in racial trauma that in turn harms mental and physical health. Racial health disparities are perpetuated through cultural, structural, and individual discrimination. In addition to discrimination, socioeconomic disparities also perpetuate health inequalities (Thoits 2010; Williams and Sternthal 2010; Bailey et al. 2017; Wing et al. 2022; Link and Phelan 1995; Swanson et al. 2009; Linde et al. 2022; Collins et al. 1999; Glymour et al. 2014).

On average, White people live longer than Black people. Health disparities between the two racial groups are highly prevalent; nonetheless, they are nuanced. This difference in life expectancy is attributed to Black and White people being more likely to die from differing undesirable health outcomes; For example, Black people are more likely to suffer from high blood pressure resulting in higher mortality rates; while White people are more likely to die as a result of committing suicide (Kochanek et al. 2013). Asian people are expected to live the longest (85.7 yrs), followed by Hispanic people (82.2 yrs), then White people (78.9 yrs). Black people have the second to lowest life expectancy (75.3 yrs), and Indigenous people have the lowest average life expectancy (73.1 yrs) (National Institutes of Health).

Structural racism and economic inequality are manifested through disparities in urban infrastructure. Inadequate or even hazardous infrastructure, including having lead-based paint and pipes in old homes, or contaminated water systems, perpetuates health inequality (Woolfe and Braveman 2011; Fitzpatrick and LaGory 2003). Having access to healthcare, and living in an environment conducive to overall health, mitigates the effects of structural and cultural racism (Williams and Sternthal 2010). While accounting for structural racism could benefit people of color, it is virtually impossible to erase the effects of cultural racism. Despite the association between SES and race, not all people of color are low SES; however, cultural racism is experienced by people of color regardless of SES. In addition, the psychological stressors of racism plague people of color from all income brackets. Structural racism can be mitigated with education and upward mobility, but until society no longer holds and perpetuates discriminatory attitudes, cultural racism will remain inevitable.

Segregation and Health

Historical redlining practices have been found to affect present-day segregation patterns. Cities redlined by HOLC remain more segregated than non-HOLC cities (Faber 2020; Massey 2020). The United States is becoming more segregated despite increasing diversity (Massey 2020). More diversity does not directly translate to lesser inequality; in this instance, the distribution of resources and perpetuation of cultural and structural racism still has a greater bearing on health disparities (Williams and Sternthal 2010; Massey 2020).

The health impacts of segregation are multifaceted. Like many forms of structural racism, the impact of segregation starts young. Black children are more likely to attend economically disadvantaged, segregated schools. These schools lack funding, resulting in less experienced teachers and fewer and lower-quality supplies. Unequal distribution of funds can result in hazardous school infrastructure. If a school lacks the funds to repair the damage, this can result in devastating health consequences. Black people who attend segregated schools are less likely to graduate from high school. Individuals who do not graduate high school earn less on average than those with a high school diploma (Massey et al. 2020; Collins and Williams 1999). On average, those without a high school diploma have a lower life expectancy (Collins et al. 1999; Hahn 2022). Segregation is the leading cause of lower socioeconomic status for Black families . Segregated schools perpetuate a vicious cycle for the children attending them (Williams and Collins 2001).

Redlining and Health

Redlining was originally done under the guise of the likelihood that people residing in each neighborhood could repay home loans. In actuality, redlining was based on neighborhood racial composition (Berkovec et al. 2018). The percentage of Back, Jewish and immigrant residents was the most significant determinant of a neighborhood's HOLC rating. Nationally, Black neighborhoods were over twice as likely as White neighborhoods to receive a "D" rating; 13% of predominantly White neighborhoods were redlined compared to 30% of predominantly Black neighborhoods (Graetz and Esposito 2021). Living in a historically redlined neighborhood increases the likelihood of experiencing numerous undesirable health outcomes, from asthma to reduced life expectancy (Graetz and Esposito 2021; Nardone et al. 2022; Wing et al. 2020). People in redlined neighborhoods are less likely to have health insurance than those in green neighborhoods. Those living in redlined neighborhoods without health insurance are more likely to experience diabetes, asthma, poor mental health, and preterm birth (Nardone 2020; Lee et al. 2022). Krieger et al. (2020) found that among babies born in New York City between 2013 and 2017, babies born to parents living in "red" neighborhoods were 1.5 times more likely to be born preterm than babies born to those in green neighborhoods. Babies born into red neighborhoods are more likely to be born preterm and have shorter life expectancies compared to their peers in "green neighborhoods." Not only are people living in red neighborhoods more likely to suffer from asthma and poor mental health, but they are also significantly more likely to suffer from strokes and live shorter lives (Wing et al., 2022). Graetz and Esposito (2021) found that people

residing in "red" neighborhoods die an average of six years earlier in comparison to those living in "green" neighborhoods.

Many factors account for health disparities, including race, income, socioeconomic status, and segregation. Despite the numerous mechanisms at play, redlining in and of itself dramatically impacts health outcomes. Anywhere between 45% and 65% of the variation in diabetes rates can be accounted for by HOLC scores alone (Linde et al., 2022). HOLC scores are impactful, but other intertwined factors, e.g., race and socioeconomic status, cannot be entirely separated from the effects of redlining. Huang et al. (2022) found that neighborhoods with a "C" rating and a high percentage of Black residents had the lowest life expectancy compared to neighborhoods with all racial compositions and neighborhood scores. When controlled for, race results shifted, and neighborhoods with a "D" rating had the lowest life expectancy.

Other findings show the nuances in the relationship between redlining and life expectancy and demonstrate the nuance between redlining and health. For example, people living in historically redlined neighborhoods report lower mental and physical health levels but no significant difference between IMR (Infant Mortality Rate) in A and D-graded areas. This finding challenges other literature and its findings of higher preterm birth in historically redlined neighborhoods. (Lynch et al. 2021; Krieger et. al. 2020; Glymour et. al 2014).

Redlining affects health inequality. Both redlining and segregation impact socioeconomic and racial inequality. Racial and socioeconomic inequality perpetuates disparities in health and life expectancy.(Faber 2020; Massey 2020; Williams and Collins 1999; Graetz and Esposito 2021; Nardone 2020; Lee et. al. 2022: Wing et al. 2022).

This study expands on previous literature to understand whether and to what extent historic redlining practices affect life expectancy outcomes. My sample will include geospatial health data from one city in each of the five United States regions. Previous literature has demonstrated the immense impact of both race and socioeconomic status on health and life expectancy outcomes (Faber 2020; Massey 2020; Williams and Collins 1999; Graetz and Esposito 2021; Nardone 2020; Lee at. al. 2022; Wing et al., 2022). This study will expand on these findings by analyzing the proportion of neighborhood health and life expectancy outcomes affected by racial composition, and the proportion affected by socioeconomic composition.

Methods and Data

Census tract HOLC (Home Owners Loan Corporation) grades in this study were taken from Diversity Data Kids (Diversitydatakids.org). This data set consists of cities redlined by HOLC.HOLC neighborhood grades of the 1930s were mapped to 2010 and 2020 census tracts.. There is considerable overlap between 1930s HOLC grades and present-day census tracts. Sixty percent of 2010 census tracts had neighborhoods with multiple HOLC grades (Diveristy Kids Data.org)

Data on life expectancy was extracted from the Center for Disease Prevention and Control Small Area Life Expectancy Estimates Project (CDC). USALEEP data consists of the life expectancy at birth for people living in a given United States Census tract. USALEEP measured life expectancy for most census tracts from 2010-2015. Census-tract level data from the American Community Survey (2011-2015 5-yr) were drawn from Social Explorer. The demographics pulled from Social Explorer are also at the tract level. The American Community

Survey is a nationwide annual survey by the U.S. Census Bureau. This study used the following variables: Race, Median Household Income, and Ratio of Income to Poverty Level of Families. Race measures the percentage of each racial category in a census tract. Median household Income is the median annual income per household adjusted for inflation in 2015 dollars. The income-to-poverty ratio variable calculates the number and percent of households that fall below the official poverty line.

All data used for analysis were collected during the early-mid 2010s to keep variables consistent. Race and socioeconomic variables were also analyzed because both factors play a significant role in life expectancy and redlining scores (Link and Phelan 1995; Williams and Collins 1999; Bailey et al. 2017)

Data were compiled in ArcGIS Pro (a geospatial analysis software), and subsequently analyzed in Stata (a statistical analysis software). The following variables were used for analysis in Stata, HOLC grade, life expectancy, percent non-Hispanic Black, percent Hispanic, Percent impoverished, and median household income (per $1,000).

After being compiled data were subsequently analyzed. First, the measures of central tendencies for numeric variables and measures of frequency for categorical variables were generated. Tables were created to provide visualization for descriptive statistics. Next, ANOVAs were conducted to obtain bivariate statistics and find the difference in means between categorical and numeric variables. In addition to ANOVAs, a scatterplot matrix was created to visually demonstrate the correlation between critical variables. To visually demonstrate my ANOVAS, strip plots displayed the variation in means of numeric variables by HOLC scores. Finally, three OLS (ordinary least Squares) regressions were run, one with only life expectancy by HOLC scores, and I included the addition of race and poverty variables in the subsequent two models. Tables represent these regressions. Cook's d (distance) test was run to ensure that there were no outliers skewing results.

Results

Table 1 Descriptive Statistics for Dependent Numeric Variables

Dependent Numeric Variable	Mean	SD	Min.	Max.
Life Expectancy (in years)	78.4	4.5	59.9	93.3
Percent Non-Hispanic Black	23.2	31.8	0	100
Percent Hispanic	33.9	31.4	0	100
Percent of People Living in Poverty	22.2	14.4	0	91.8
Median Household Income (per $1,000)	$54	$32.5	$0	$250

Table 1 presents the descriptive statistics (mean, standard deviation, minimum and maximum) for the numeric variables used in the OLS regression. The average life expectancy for

all the census tracts within the five cities is 78.36 years, ranging from less than 60 years to over 90 years (min = 59.9, max = 93.3). The standard deviation for life expectancy is 4.5 years. The average percentage of non-Hispanic Black individuals in analyzed census tracts is 23.3%. The proportion of non-Hispanic Black people in census tracts ranges from all to none (min = 0%, max = 100%). The standard deviation is higher than the mean; there is great variation in the proportion of non-Hispanic Black people across census tracts (SD = 31.8). The mean proportion of Hispanic people across census tracts is just over one-third (mean = 33.9%). Like non-Hispanic Black people, the proportion of Hispanic people across census tracts also ranges from 0% to 100% (min=0%, Max=100%). This wide range is also evident in the standard deviation, which is just two percentage points away from the mean (SD = 31.4). The mean percentage of people living in poverty is 22.2%. The percentage of people living in poverty across census tracts ranges from zero to over 90% (min = 0%, max = 91.84%). The standard deviation in the percentage of people living in poverty is 14.4. The average median household income is $54,000 annually; median household incomes range from less than $1,000 to over $200,000. The standard deviation in median household income is $32.5k (min = $0k, max = $250k).

Table 2 Descriptive Statistics HOLC grade

HOLC Grade	**Frequency (# of tracts)**	**Percent**
A	169	5.4
B	522	16.5
C	1,538	48.6
D	932	29.5

Table 3 Descriptive Statistics City

City	Frequency (# of tracts)	Percent
Atlanta	121	3.9
Chicago	1,079	34.1
Dallas	116	3.8
Los Angeles	1,394	44.1

Tables 2 and 3 display descriptive statistics for categorical variables used in the analysis, HOLC grade, and city; the mode HOLC grade is C, assigned to over 1,500 census tracts, nearly half of all census tracts studied (frequency = 1,530, percentage = 48.6%). The least frequently assigned HOLC grade is A, with less than 200 tracts comprising 5% of all census tracts (frequency = 169, percentage = 5.3%). HOLC grade B is just ahead of A in terms of frequency. B has been assigned to just over 500 tracts comprising 16% of assignments (frequency = 522, percentage = 16.5%). D is the second-most frequent HOLC assignment, with a frequency of 932, comprising 29.5% of assignments. The city with the most census tracts is Los Angeles, with over

1,000 census tracts comprising over 40% of census tracts studied (frequency= 1,394, percentage = 44.1%). Following closely behind LA is Chicago, with a frequency of 1,079 tracts comprising 34.2% of tracts studied. In third place, yet trailing far behind, is Philadelphia, with 450 tracts, comprising 14.2% of tracts. Atlanta has the second to least number of tracts (frequency = 121, percent = 3.8%). Dallas has the fewest tracts, five fewer than Atlanta (frequency = 116, percent = 3.8%). The total number of tracts across all five cities is 3,160.

Figure 1: Strip Plot Life Expectancy Over HOLC Grade

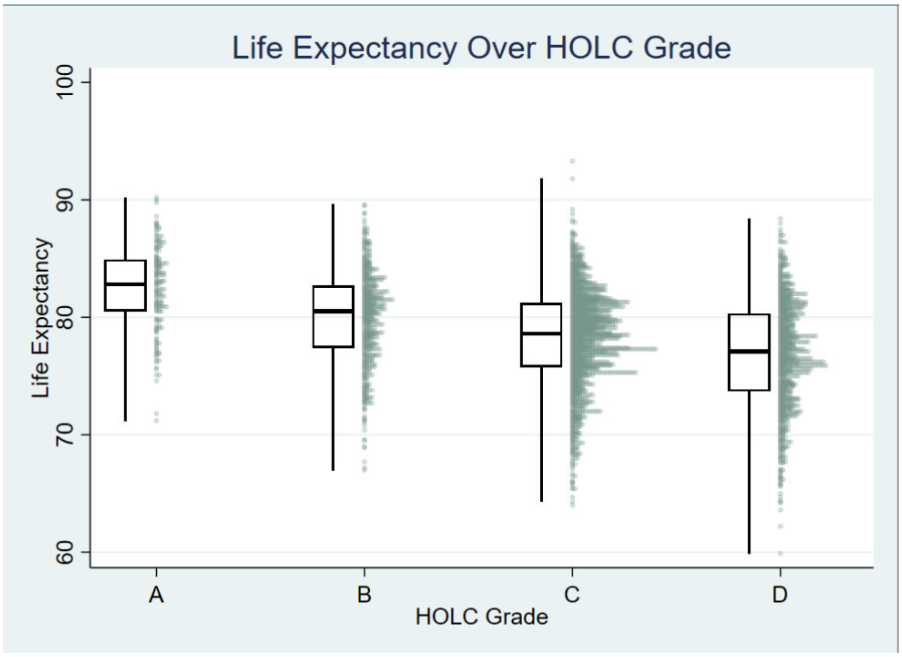

Figure 1 is a strip plot displaying the distributions (medians and interquartile range) in life expectancy over HOLC grade. The green dots represent actual tracts and their location on the life expectancy scale. At first glance, one can observe an apparent decrease in life expectancy as the HOLC grade moves from A to D. For census tracts with A-HOLC grades, the mean life expectancy, not shown in the graph, is 82.4 years; for those with a B grade, the mean drops to 79.9 years. Census tracts with a C grade have an average life expectancy of 78.2 years. Finally, those residing in D-graded census tracts can expect to live an average of 76.8 years. People living in A-graded census tracts can expect to live over five years longer than those in D-graded census tracts.

Figure 2: Scatter Plot Matrix, All Continuous Variables

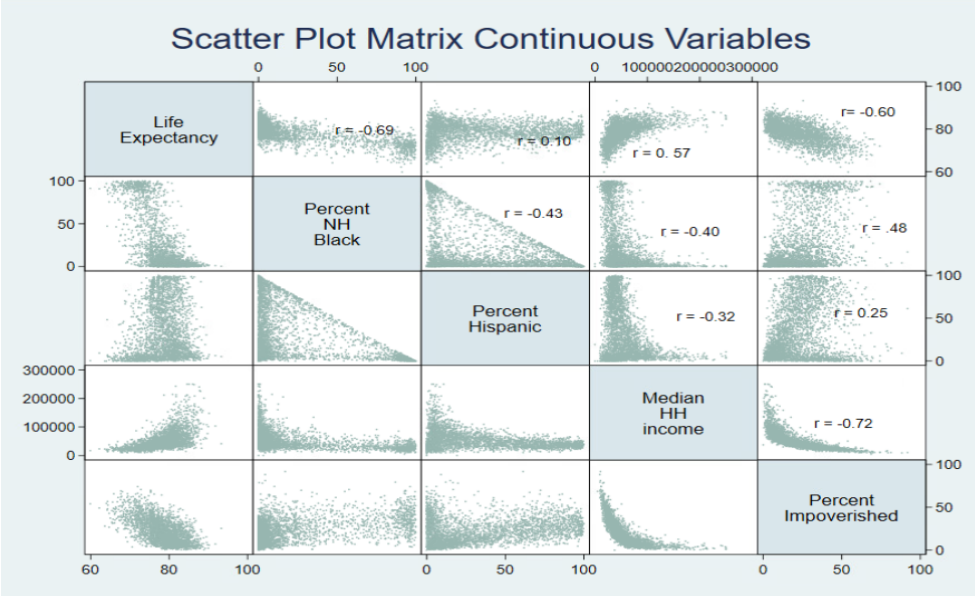

Figure 2 is a scatter plot matrix displaying scatter plots between all continuous variables. The leftmost scatterplot in the top row is between life expectancy and the percentage non-Hispanic Black. There is a strong negative correlation between tract's average life expectancy and its percentage of non-Hispanic Black residents (r = -0.69). In other words, as census tracts, the percentage of non-Hispanic Black residents increases, and average life expectancy decreases. The scatterplot in the top right displays the correlation between life expectancy and percent impoverished. There is a large negative correlation between tract's life expectancy and the percentage of its residents who live below the poverty line (r = -0.60). An increase in the percentage of impoverished residents is associated with a moderate decrease in life expectancy. The right-most scatter plot in the second row shows the correlation between the percentage of non-Hispanic Blacks and the poverty rate. There is a strong-moderate positive correlation between the percentage of non-Hispanic Black people and the percentage of impoverished people (r = 0.49). The center scatter plot in the second row displays the correlation between the percentage of non-Hispanic Black residents and Hispanic residents. There is a moderate negative correlation between the percentage of Black residents and the percentage of Hispanic residents (r = -0.43). The second to rightmost scatterplot in the third row shows the correlation between the percent Hispanic and median household income. There is a moderate negative correlation between a census tract's percentage of Hispanic residents and its median household income (r = -0.32).

The right-most scatter plot on the third row displays the correlation between the percentage of Hispanic residents and the poverty rate. There is a weak positive correlation between a tract's percentage of Hispanic residents and its poverty rate. The right-most scatter plot on the fourth row displays the correlation between median household income and the percent impoverished. There is a strong positive correlation between median household income

and the percent impoverished (r = -0.72). The center scatter plot in the top row shows the correlation between life expectancy and percent impoverished. There is a weak positive correlation between life expectancy and the percent Hispanic (r = 0.10). The second to right-most scatter plot in the top row displays the correlation between life expectancy and median household income. There is a strong positive correlation between life expectancy and median household income (r = 0.57). The second to right-most scatter plot in the second row shows the correlation between the percent Black and median household income. There is a moderate negative correlation between a census tract's median household income and its percentage of Black residents.

Figure 3 Percent Impoverished, Percent Non-Hispanic Black, Percent Hispanic, and Median Household income by HOLC Grade

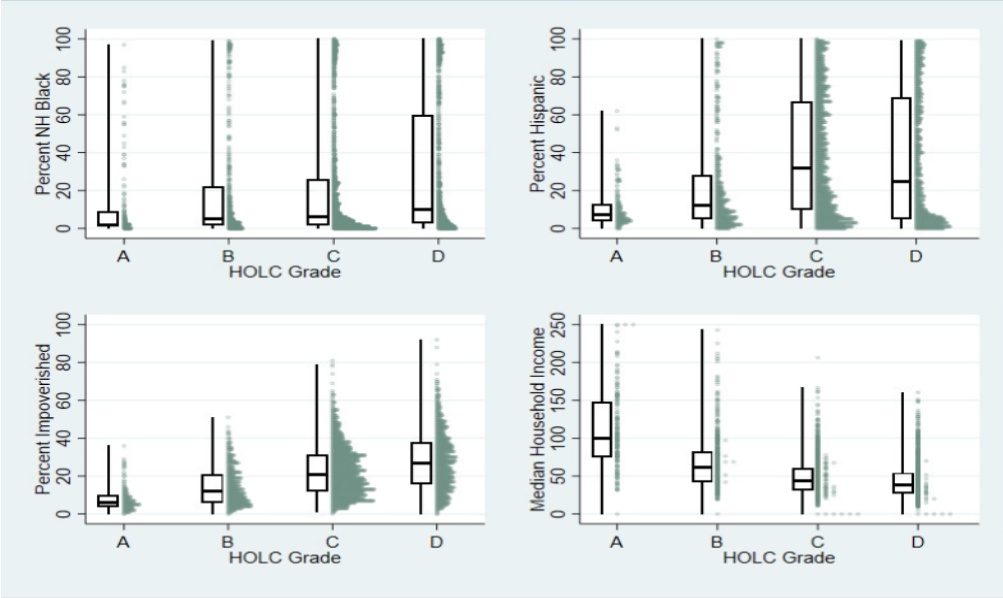

Figure 3 contains a strip plot of the percent non-Hispanic Black, percent Hispanic, percent impoverished, and median household income over HOLC Grade. The strip plot on the top left shows the median percentage of Non-Hispanic Black people living in census tracts with each HOLC grade. As the HOLC grade decreases from A to D, the median percentage of Non-Hispanic Black People increases. The mean (not shown) percentage of Non- Hispanic Black people in A-graded census tracts is 11.8%, and the mean percentage of Black People in B-graded tracts is 20%. On average, census tracts with a C grade are 21.4%, non-Hispanic Black People. D-graded census tracts have an average of 30% Non-Hispanic Black residents. The strip plot on the top right displays the median percentage of Hispanic people residing in census tracts with each HOLC grade. C-graded tracts, on average, have the highest percentage of Hispanic people (mean = 38.5%). D-graded tracts have the second-highest mean percentage of Hispanic people (mean = 37%). Tracts with B grades, on average, have fewer Hispanic residents than tracts with

C grades (mean = 22.3%). A-graded tracts have the lowest average percentage of Hispanic residents (mean = %10.4). On the bottom left is the strip plot showing the percent impoverished over HOLC grade. The mean poverty percentage increases as the HOLC grade decreases from A to D. Census tracts with a D grade have the highest average percentage of people living in poverty (mean= 28.2%), while tracts with an A grade have the lowest (mean = 8%). Census tracts with a C grade have the second to highest poverty rate (mean = 22.8%), and those with B grades have the third to highest (mean = 14.4%). On the bottom right is a strip plot of the median household income (per $1,000) over HOLC grade. As HOLC grades decrease from A to D, average household income also decreases. The average median household income for A-graded census tracts is $110.4k. The median household income for B-graded census tracts amounts to $67.9k. For C and D grades, census tracts' mean median household incomes are $48.7k and $44.7k, respectively.

Table 4: OLS Regression Results

	Model 1	Model 2	Model 3
B	-2.48***	-1.29***	-0.21
	[-3.24, -1.72]	[-1.84, -0.75]	[-0.75,0.33]
C	-4.16***	-2.39***	-0.80**
	[-4.86, -3.46]	[-2.90, -1.87]	[-1.33, -0.27]
D	-5.61***	-3.02***	-1.22***
	[-6.33, -4.88]	[-3.55, -2.48]	[-1.77, -0.68]
% NH Black		-0.10***	-0.07***
		[-0.11, -0.10]	[-0.07, -0.06]
% Hispanic		-0.03***	0.00
		[-0.03, -0.02]	[-0.00,0.01]
% Impoverished			-0.06***
			[-0.07, -0.05]
Median HH Income			0.00***
			[0.00,0.00]
Constant	82.42***	83.94***	80.44***
	[81.76,83.08]	[83.47,84.42]	[79.61,81.27]
Observations	2919	2919	2919
R^2	0.1003	0.5484	0.5989

95% confidence intervals in brackets
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 represents the regression results of all OLS regressions. Model 1 is a regression of life expectancy by HOLC grade. Model 2 is a regression of life expectancy by HOLC grade, percent non-Hispanic Black, and percent Hispanic. Model 3 contains all the variables mentioned above with the addition of the percent impoverished and median household income (per $1,000). HOLC grade A is the reference group, and the average life expectancy for the A-graded census tracts is 82.42. All other variables constant census tracts with B grades have an average 2.48-year decrease in life expectancy (coeff. = -2.48). Those living in B-graded neighborhoods can expect to live 79.94 years. C-graded neighborhoods are associated with an average of a 4.16-year decrease in life expectancy compared to those living in A-graded census tracts (coeff. = -4.16); people living in C-graded census tracts can expect to live an average of 78.26 years. Census tracts with a D grade have an average life expectancy of 5.61 years less than those in A-graded census tracts (coeff = -5.61). Those living in D-graded census tracts can expect to live an average

of 76.81 years. 10% Of the variation in life expectancy can be accounted for by HOLC scores (r squared = 0.10).

Race/Ethnic composition variables are included in Model 2. For every 10% increase in the percentage of non-Hispanic Black residents, the mean life expectancy of a tract decreases by one year (coeff=.10). For every 10% increase in the proportion of Hispanic residents, a tract's mean life expectancy decreases by one-third of a year (coeff = 0.03). All of the coefficients for HOLC grade in Model 2 are smaller in magnitude than those in Model 1; this suggests that racial/ethnic composition serves as a mediating mechanism. Coefficients may appear smaller as they approach zero; contrarily, they are larger because a "smaller" coefficient indicates greater value. The "smaller" coefficients indicate how many years within the effect of HOLC grades can be accounted for by the percentage of Black and Hispanic Residents. For example, residents living in neighborhoods with a B grade have an average life expectancy of 2.48 years less than those living in census tracts with an A grade; however, of those 2.48 years, 1.29 of them can be attributed to the percentage of Black and Hispanic people in a census tract. Fifty-five percent of life expectancy variation across census tracts can be attributed to a combination of HOLC grades, percentage of Black Residents, and percentage of Hispanic residents.

Socioeconomic variables are included in Model 3. The coefficients decrease in magnitude from model to model. For every 10 percent increase in the percent of impoverished people, a census tract's life expectancy decreases by 0.6 years (coeff.= 0.06). Of the 2.48-year difference in life expectancy of those living in A versus B grade tracts, 1.29 of those years can be attributed to the percentage of Black and Hispanic people residing in a census tract; further, 1.41 can be attributed to household income, and .21 can be attributed to the poverty rate and median household income (see figure 4). After adding socioeconomic variables into Model 3 the effect of the percentage of Hispanic residents on a census tract's life expectancy is fully accounted for (coeff.= 0). As more variables are added, the r-squared increases. Fifty-Five percent of the variation in life expectancy across census tracts can be accounted for by a combination of HOLC grades and percentage of Black and Hispanic residents (r squared = 0.548); the addition of percent impoverished and median household income accounts for 60% of the variation in life expectancy (r squared = 0.598). From model to model, the coefficients are decreasing in magnitude because the additional demographic variables are helping to account for original HOLC grade effects, acting as mediating mechanisms. I performed a Cooks D (distance) test following my multiple OLS regression. All values were less than 0.5. There are no outliers in the data set skewing the results of my regression. *

Figure 4: Coefficient Plot- All Models

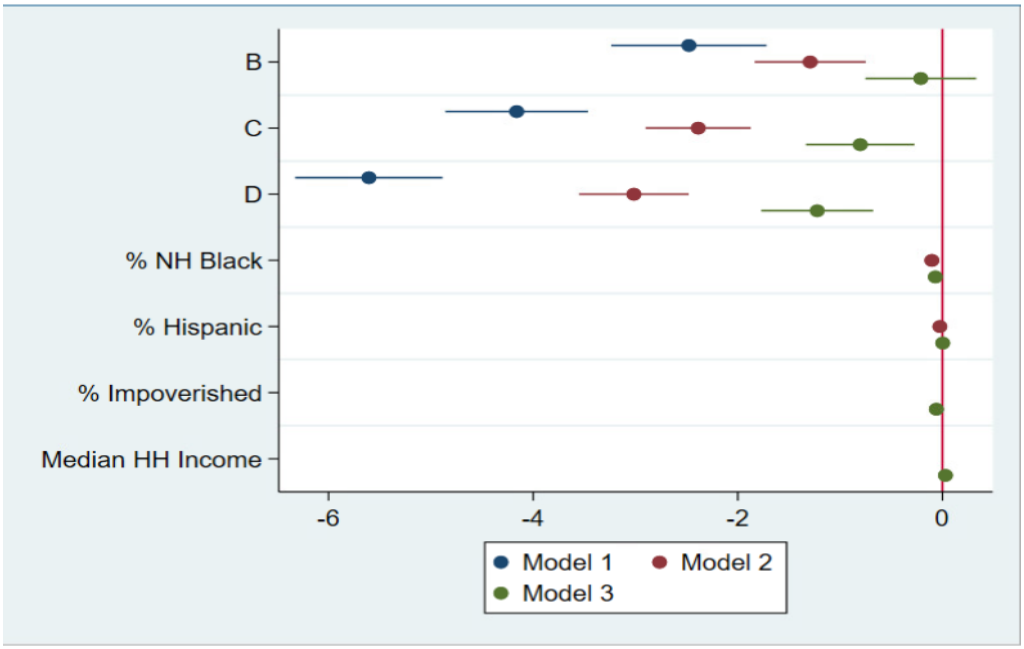

Figure 4 is a coefficient plot of Models 1, 2, and 3 in the OLS regression. The dots represent the coefficients, and the lines represent the 95% confidence interval. The red line on the right represents zero (null). From model to model the coefficients move closer to zero, and confidence intervals decrease. Demographic variables help to illustrate the mediating effect that present-day racial and class composition play in accounting for the original HOLC grade-life expectancy relationship. For example, the coefficients for census tracts with a B grade tend to be the closest to zero, while those with D grades tend to be the furthest. The proximity of coefficients indicates that the mean life expectancy for B-graded tracts is closest to the constant (A-graded census tracts), while the mean life expectancy for D-graded census tracts is the furthest.

*I ran OLS regressions of all dependent variables by HOLC score and r squared by each city. The model performed well in all instances; but differed in how much of the variance of life expectancy across tracts it accounted for. R squared for Dallas was 0.79, and for Atlanta, 0.78. The r squared for Philadelphia was .61. The r squared for Los Angeles, and Chicago were 0.65 and 0.42, respectively. The vast differences in R squared across cities can likely be attributed to regional differences.

Conclusion/Discussion

This analysis has produced several salient conclusions. First, the results align with previous literature; the association between 1930s HOLC scores and current life expectancy remains intact (Wing et al., 2022; Graetz and Esposito, 2021; Huang et al., 2022; Krieger et al. 2020). Second, 10% percent of the disparities in life expectancy across census tracts can be accounted for by redlining. At first glance, 10% may not appear to be a lot, however, for a variable as seemingly straightforward as HOLC grade to have any bearing on a variable as nuanced and paramount as life expectancy, 10% is certainly meaningful. Third, the racial and socioeconomic composition variables could explain most disparities in life expectancy (60%) (see table 4). Finally, some variables were not accounted for in the analysis that could likely further explain the disparities in life expectancies across census tracts. For example, race was a major factor in HOLC's decision on neighborhood grades; I only accounted for the composition of two racial/ethnic groups; accounting for the proportion of different racial groups would likely further explain the disparities in life expectancy across census tracts, because both the percentage of people of color and White people, were instrumental in HOLC's neighborhood designations (Graetz and Esposito 2021).

Another factor I did not account for is environmental racism. Environmental racism is the practice of disposal of refuse and hazardous waste being disproportionality placed in communities of color (Oxford Languages). The disproportionate placement of toxic material negatively affects health, increasing the risk of developing certain cancers (Peña-Parr 2020). These adverse health effects likely shorten life expectancy.

Racial and socioeconomic disparities span numerous areas of life; no dependent variable exists in a vacuum. For example, race and socioeconomic status are interrelated, and their effects on redlining cannot be fully separated.

This thesis has focused on the many constants in American history since the 1930s and prior. In many ways, the socioeconomic and racial distribution of HOLC neighborhoods and census tracts remain similar to the designations of the 1930s. However, gentrification has resulted in major demographic shifts in numerous neighborhoods. Gentrification is the changing of a neighborhood's character, resulting from an influx of affluent residents attracting new businesses and improving housing (Oxford Languages). Some neighborhoods given a "D" rating by HOLC decades ago have undergone a major demographic shift. This shift changes a neighborhood but not the plight of its original inhabitants, who are often forced out of their homes due to rising costs. The data was unable to account for these changes.

This study has some limitations. The designations used by HOLC in the 1930s are currently not in use. Obtaining data aligned with HOLC designation was impossible. Census tracts are the closest present-day designation, but there is considerable overlap between the two. In the data used in my analysis, each census tract was assigned one HOLC grade; in reality, present-day census tracts contain neighborhoods with multiple HOLC grades. Future research would benefit from studying the relationship between the proportion of a census tract with a given HOLC grade, and how the distributions in HOLC grades across census tracts affect results. It would also be beneficial to use HOLC neighborhood designations in the analysis. Over 200 cities were redlined; my sample consisted of five out of over 200 cities.

It would also be beneficial to control for regions, in future analyses. Especially given the vast difference in r squared between cities, this difference suggests regional differences in the effects of redlining; it would be worth further analysis to determine if these differences result from the cities in my sample or if regional patterns arise.

In addition, it would be beneficial to conduct a longitudinal study measuring the effects of redlining over time. My analysis of census tracts' racial composition only focuses on two racial/ethnic groups. The increase in the percentage of Black and Hispanic people in a census tract affects life expectancy in opposing ways. An increase in the percentage of Hispanic people in a neighborhood increases the expected average life expectancy, while an increase in the percentage of Black people decreases it (see figure 2). This pattern is likely because Hispanic people live longer on average than White people, so their presence in a census tract increases its life expectancy (National Institute of Health). Throughout this paper, I have talked about the cultural and structural disadvantages people of color face and their current effects. However, cultural and structural racism affects each group of color differently. These differing levels and forms of racial discrimination are evident in the life expectancies of each racial/ethnic group. Compared to White people, however, Hispanic and Asian people have longer life expectancies. Future research should more deeply examine the differences between all racial groups.

In the meantime, policymakers, public health officials, and scholars can use these findings to direct efforts to improve the infrastructure of marginalized census tracts; and to shift the responsibility of health disparities away from individuals and towards policy.

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