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Redlining, racism and food access in US urban cores

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Abstract

In the 1930s, the Home Owners' Loan Corporation (HOLC) graded the mortgage security of urban US neighborhoods. In doing so, the HOLC engaged in the practice, imbued with racism and xenophobia, of "redlining" neighborhoods deemed "hazardous" for lenders. Redlining has caused persistent social, political and economic problems for communities of color. Linkages between redlining and contemporary food access remain unexamined, even though food access is essential to well-being. To investigate this, we used a census tract-level measure of low-income and low grocery store food access from the US Department of Agriculture Food Access Research Atlas, redlining data from Mapping Inequality Project, and demographic data from the American Community Survey. We employed generalized estimating equations with robust covariance estimates to analyze data pertaining to 10,459 census tracts in 202 US cities. Tracts that the HOLC graded as "C" ("decline in desirability") and "D" ("hazardous") had reduced contemporary food access compared to those graded "A" ("best"). Increases in contemporary census tract proportions of Black, Hispanic, or other racial/ethnic minority residents, as well as disabled residents, were associated with reduced food access. Increases in contemporary proportions of residents age 75 years and older or those without a car were associated with better food access. Tracts that underwent housing redevelopment since being graded had better food access, while those undergoing gentrification had reduced food access. Results suggest that issues of redlining, housing discrimination, racism, ableism, displacement, and food inaccessibility are deeply intertwined.

Keywords Food access · Food justice · Redlining · HOLC zones · Racially/ethnically minoritized groups

Abbreviations

HOLC	Home Owners Loan Corporation
LILA	Low income and low grocery store food access
COVID-19	Coronavirus disease 2019
USDA	United States Department of Agriculture

Introduction

Access to food is a critical measure of well-being. Unfortunately, 1 in 5 US households experienced food insecurity in 2020, whereby they had limited or uncertain access to adequate food (USDA 2021). Food insecurity has also heightened during COVID-19 as increasing numbers of households struggle financially (O'Hara and Toussaint 2021). Food insecurity is expected to continue expanding as the pandemic unfolds if the underlying structural inequalities in food systems are not addressed (Alkon et al. 2020a; Raja 2020). Food insecurity is disproportionately present in low-income, Black, and Hispanic households (USDA 2021).

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There are significant disparities in food insecurity in US cities that need to be addressed.

Food inaccess is not an isolated form of harm, and it is related to other forms of harm in US urban neighborhoods—limited economic opportunities, neighborhood divestment, substandard housing, environmental pollution—which extend from over a century of structural racism. As McKittrick (2013, p. 7) states, this "normal way of life is rooted in racial condemnation; it is spatially evident in the sites of toxicity, environmental decay, pollution, and militarized action that are inhabited by impoverished communities… What stands out are the ways we can trace the past to the present and the present to the past through geography." Geographic disparities in food access, especially in the context of these additional harms, are concerning because they influence the physical health of people living there and everyone has the fundamental right to access to healthy food. Poor food access has remained a particularly pernicious problem for the "urban poor" (Eisenhauer 2001). A lack of access to grocery stores in low-income urban communities is reflective of spatial supermarket redlining, in which chain supermarkets locate stores in the wealthy suburbs instead of the inner city or remove existing stores from lower-income urban neighborhoods (Zhang and Ghosh 2016).

Areas where people experience reduced access to healthy foods such as fruits and vegetables due to a lack of proximate supermarket are commonly known as "food deserts" (USDA 2015; Thibodeaux 2016). Activists and scholars have criticized the "food desert" terminology as it inaccurately suggests that a lack of local food access is "natural," thus obfuscating the embedded structural forces that have produced a dearth of food in some areas (De Master and Daniels 2019). For this reason, we do not use the term "food desert" in this paper. Many researchers operationalize food access based on the distance from a particular neighborhood to the nearest supermarket (Thomas 2010). While proximate supermarkets logically improve ease of access to healthy food, purely distance-based methods of defining food access have been critiqued as they neglect other important factors, like concentrations of low-income households (Wright et al. 2016). This study examines a measure of low income and low grocery access, and quantitatively investigates associations for that measure with sociodemographic and urban structure characteristics at the census tract-level in the US.

Food insecurity, which includes difficulties in physically accessing and being able to afford food at conveniently located grocery stores, represents a food justice issue shaped by broader political, economic, and cultural dynamics as well as micro-level factors (Alkon and Agyeman 2011). Food injustice researchers have identified sociodemographic characteristics associated with reduced access to food at the neighborhood-level; most such studies emphasize disparate food access based on minority race/ethnicity. Individual-level studies of food insecurity have also highlighted car access, disability status, and age as relevant. We review these factors in turn.

Racial/ethnic disparities in access to grocery stores in the US have been well documented (Walker et al. 2012, 2010; Raja et al. 2008). Neighborhoods with greater composition of Black people had fewer supermarkets and reduced access to fresh fruits and vegetables (Bodor et al. 2010) and better access to dollar stores (Shannon 2021). Nationwide, chain supermarkets were 52 percent and 32 percent less available in Black and Hispanic vs. White ZIP codes, respectively, when controlling for income (Powell et al. 2007).

These racial patterns in food access have historical roots. For example, in Los Angeles, rates of car ownership were high as of the 1930s, which facilitated early patterns of suburbanization. Since land was cheaper there, grocery stories increasingly located in the suburbs (Barker et al. 2012). Restrictive covenants, redlining and housing discrimination made those suburban supermarkets less accessible to Black residents. Purchasing homes in those White areas continued to be difficult for Black Angelinos for decades to come. In the 1950s, 93 percent of non-White homeowners lived in substandard dwellings. The following decades saw the civil unrest of the 1960s, the racial protests of the 1990s, and continued White flight out of Los Angeles. In 1989, research again documented a persistent lack of access to retail stores in South Los Angeles. Contemporarily, South Los Angeles has reduced access to food as compared with whiter parts of the city (e.g., West Los Angeles). Their supermarkets serve twice as many people and are less likely to carry fresh fruits and vegetables than those in West Los Angeles (Barker et al. 2012). This historical example from Los Angeles illustrates the historical roots of contemporary food access inequities.

Even though there have been policy efforts to address food insecurity, there are still food access disparities between racially/ethnically minoritized groups and their White counterparts (Odoms-Young 2018). The COVID-19 pandemic has exacerbated food injustices in the US with racial/ethnic minorities experiencing significantly more food insecurity than Whites (Morales et al. 2021). Due to urban marginalization and infrastructural exclusion, minoritized communities have faced deliberate disinvestment in many regards, including access to housing and food market development (Deener 2017). In sum, because of systemic racism, people's racial/ethnic identities influence both the neighborhoods they live in and their access to food.

In addition to race/ethnicity, car access affects food accessibility (Wright et al. 2016), although car access is not usually considered in neighborhood-level studies of food access. Those who do not have cars are much more limited by their most proximate food retail options than are those with cars (Bodor et al. 2013). As such, Bodor et al. (2013) suggested that research should account for car ownership. People with disabilities are at high risk for food insecurity (Coleman-Jensen 2020; Schwartz et al. 2019). Heflin et al. (2019) found that disabilities increased the likelihood of food insecurity across all individuals, while movement-related disabilities only significantly impacted the food access of individuals ages 19–59. However, disability status is rarely included in neighborhood-level studies of food access. Children and the elderly are vulnerable populations that need to be accounted for when studying food insecurity. According to the USDA (2021), food insecurity affected 14.8 percent of households with children, 6.9 percent of households with elderly people, and 8.3 percent of households with elderly folks living alone in 2020. We address limitations of prior neighborhood-level studies of food access by including measures of car access, disability status, and age composition.

Apart from the social characteristics of nearby residents, other neighborhood characteristics are hypothetically linked to food access. Gentrification, or the process by which more affluent residents displace less affluent residents, may eventually result in neighborhood affluence and better food access, but gentrifying neighborhoods may also be sites of displacement, and economic inequality. The food access that accompanies gentrification is often overpriced and targets higher income residents moving in (Sullivan 2014; Alkon et al. 2020b). This can create "food mirages" or situations in which food retailers are present, but too expensive or culturally exclusionary for longer-term residents (Sullivan 2014; Cohen 2018).

While important, food justice studies focused solely on contemporary social determinants of food access neglect the historical underpinnings of such patterns, including the role that "redlining" may have played in the current landscape. Redlining took place in the 1930s when the Home Owners' Loan Corporation (HOLC) graded residential neighborhoods in major US cities to assess the "mortgage security" for potential investors. Neighborhoods that received the grade "A" (green) meant that they were the "best" neighborhoods and that residents there were prime candidates for receiving bank loans. The grade "B" (blue) applied to neighborhoods that were "still desirable." "C" (yellow) meant that the neighborhood's desirability was declining. A grade of "D" (red) was given to neighborhoods that were deemed "hazardous" (Nelson et al. 2020). These color-coded "security" maps were instrumental for later popularizing the term "redlining", which was coined by activists to highlight "the geographic dimensions of housing discrimination" (Nelson et al. 2020, n.p.). Redlining greatly constrained African Americans, other people of color, and immigrants from accessing capital and achieving social mobility gains (Nelson et al. 2020). Redlining was finally prohibited in 1968, yet its legacies continue today (Joyner et al. 2022).

The practice of grading neighborhoods was imbued with racism and xenophobia and led to financial disinvestment and resource deficiencies in communities where Black, indigenous, people of color (BIPOC) resided and currently reside (Nardone et al. 2020; Nelson et al. 2020). The legacies of historic redlining include hotter temperatures (Hoffman et al. 2020; Wilson 2020), reduced tree canopy (Locke et al. 2021) and green space (Nardone et al. 2021), more gun violence (Benns et al. 2020) and more alcohol sales outlets (Lee et al. 2020). Areas of Pittsburgh that were graded unfavorably (red or yellow) by the HOLC were shown in recent decades to have a larger proportion of African American residents, a higher concentration of poverty, higher rates of population loss, and a lower rate of homeownership (Rutan and Glass 2018). This pattern exists beyond Pittsburg. The majority of US neighborhoods that were given the D HOLC grade decades ago are still low income (i.e., 74 percent) and are majority racial/ethnic minority (i.e., 64 percent) (Mitchell and Franco 2018). Redlining has led to continued housing discrimination, segregation, poverty, and racial disadvantage (Mitchell and Franco 2018).

Studying the potentially enduring effects of past systematic injustices such as redlining on contemporary food access is important for understanding 'legacy' effects (Sadler et al. 2021). Understanding food (in)access today requires understanding how spaces came to be sites of (un)healthy lives. Some have conducted case studies as to how historical forces shape urban food access (Harper et al. 2009; McClintock 2011). For example, McClintock (2011) examined how historical development in Oakland shaped the contemporary food landscape. While important, these case studies do not offer systematic analyses of how redlining is related to grocery store access across the US, as we do here, although prior studies support some hypotheses.

In Salt Lake City, a mapping project suggests that low income/low grocery access census tracts are overrepresented in C and D zones (Joyner et al. 2022). A study in the city of Baltimore examined the impact of redlining and gentrification on food access (Sadler et al. 2021). The authors used food access data from the Healthy Food Availability Index-Brief (HFAI-B) tool. They operationalized redlining using the original HOLC grade maps that have been fully digitized, georeferenced, and made publicly available via the University of Richmond's Mapping Inequality Project (Nelson et al. 2020). Redlining and gentrification were associated with better food access in Baltimore (Sadler et al. 2021). Sadler and colleagues (2021) suggested that future researchers should look at this pattern across the US. This study answers that call and examines redlining, gentrification, and food access at a national scale.

While redlining may have contributed to current food injustices in the US, this has not been comprehensively investigated nationwide. To address this, we conduct a national-level study of census tracts (neighborhoods) in cities that were graded by HOLC, predicting the odds of neighborhoods having "low income and low grocery access" or LILA. We address the following research questions and pose associated hypotheses: Is neighborhood HOLC grade associated with LILA status? H_1: C and D grades increase odds of LILA status relative to A graded neighborhoods. Is neighborhood racial/ethnic composition associated with LILA status? H_2: Greater percentages of racial/ethnic minority residents increase odds of LILA status. Is neighborhood composition of disabled folks, households without cars, young people (under 5 years of age), and elderly people (plus 75 years of age) associated with LILA status? $H_{3\text{-i,ii,iii,iv}}$: Greater percentages of disabled residents (i), households without cars (ii), young people (iii) and elderly people (iv) increase odds of LILA status. Is neighborhood gentrification or housing redevelopment associated with LILA status? $H_{4\text{-i,ii}}$: Gentrification (i) and housing redevelopment (ii) reduce odds of LILA status.

Methods

Study area and unit of analysis

The study area included census tracts in the continental United States that are located within areas originally graded by HOLC. Specifically, there are 10,503 census tracts with centroids located within the boundaries of one of the four HOLC grade polygons nationwide. We excluded the 63,499 tracts with centroids not falling within a HOLC zone. We also excluded 44 tracts due to missing values, leaving the an analysis *n* of 10,459. All of these tracts are located within urban areas.

Variables

Dependent variable: LILA tracts

To measure low food access, we use a tract-level dichotomous variable from the 2019 (most recent) Food Access Research Atlas of the United States Department of Agriculture (USDA), which gauges low-income and low grocery store access (USDA 2021). This variable was called the "food desert" indicator in the 2015 version of the dataset (USDA 2015). Specifically, this low income and low access (LILA) variable codes these urban tracts as 1 if they have both low-income and low access to grocery stores, and 0 if they do not (USDA 2021). Specifically, "low-income" is defined as "a tract with either a poverty rate of 20 percent or more, or a median family income less than 80 percent of the State-wide median family income; or a tract in a metropolitan area with a median family income less than 80 percent of the surrounding metropolitan area median family income" (USDA 2021). "Low access" is defined as having "at least 500 people, or 33 percent of the population, living more than one-half mile from the nearest supermarket, supercenter, or large grocery store" (USDA 2021). Our variable does not include small-scale food vendors such as bodegas and instead includes bigger supermarkets that tend to sell more affordable food products. USDA also provides a similar variable with access measured at 1 mile instead of one-half mile, which we use in a sensitivity analysis. We decided to use the LILA ½ mile instead of LILA at 1 mile for our main analysis because one mile is beyond walkable and ½ mile is a better measure of a walkable distance in cities. Table 1 provides descriptive statistics for these two dependent variables. Approximately 34 percent of tracts are low-income/low food access tracts assessed at one-half mile. The percentages drop to only 8 percent at one-mile. Figure 1 provides a map of the tracts with HOLC grades included in the study, shaded based on LILA status at one-half mile.

Explanatory variables: HOLC zones and demographic data

The focal independent variable is a census tract-level categorical variable pertaining to the four HOLC zone grades (A, B, C, D). To create it, we used the digitized and georeferenced HOLC zone maps provided by the Mapping Inequality Project hosted by the University of Richmond's Digital Scholarship Lab (Nelson et al. 2020). This is the most comprehensive digitized dataset available for HOLC zone maps, containing information for 202 cities in the United States (Nelson et al. 2020).

To create the categorical variable, we overlaid the HOLC zone polygons over census tract boundaries using ArcGIS Pro 2.5.1. We assigned each census tract a HOLC zone grade (i.e., A, B, C, or D) based on which HOLC zone polygon the centroid of the tract fell within. This method has been used by others (Wilson 2020; Nardone et al. 2020, 2021). Table 1 provides descriptive statistics for the HOLC zone data. Approximately 28 percent of tract centroids are in D zones, while 7 percent, 21 percent and 45 percent are in A, B and C zones, respectively.

To adjust for sociodemographic composition, gentrifying status, and housing redevelopment at the census tract level, we use data from the 2015–2019 American Community Survey, which we downloaded from the National Historical Geographic Information System (NHGIS) (Manson et al. 2017). In terms of racial/ethnic composition, we include variables for the proportions of individuals within the tracts who identify as Latina/x/o or Hispanic (any race), Black non-Hispanic, Asian non-Hispanic, and multi-racial/other non-Hispanic. We omit the proportion non-Hispanic White racial category from multivariable analysis because it serves as the reference category. We include the proportion of disabled persons in the tract as per ACS definitions. ACS defines disabled persons as anyone with any of the six

Table 1 Descriptive statistics for independent variables ($n = 10{,}459$ census tracts)

Variables	Minimum	Maximum	Mean	Std. deviation	Yes *n* (%)	No *n* (%)
Dependent variables						
Low-income/Low access (1/2 mile)					3593(0.344)	6866(0.656)
Low-income/Low access (1 mile)[a]					833(0.08)	9626(0.92)
Independent variables						
HOLC Zones						
"A" Best					677(0.065)	9782(0.935)
"B" Still Desirable					2152(0.206)	8307(0.794)
"C" Declining					4704(0.45)	5755(0.55)
"D" Hazardous					2926(0.28)	7533(0.72)
Prop. Black, non-Hispanic	0	1	0.264	0.308		
Prop. Asian, non-Hispanic	0	0.871	0.072	0.118		
Prop. Hispanic	0	1	0.229	0.255		
Prop. Other race, non-Hispanic	0	0.368	0.034	0.032		
Prop. no automobile	0	0.936	0.232	0.196		
Prop. disability	0	0.472	0.130	0.062		
Prop. under 5 years	0	0.366	0.063	0.030		
Prop. over 75 years	0	0.464	0.056	0.035		
Urban redevelopment						
Pre-1979					9998(0.956)	461(0.044)
Post-1980					461(0.044)	9998(0.956)
Gini index	0.165	0.903	0.455	0.066		
Population density (per sq. km.)	24.79	84,508.95	7267.04	9257.50		

Data in the Yes/No columns are given in the form Frequency (Proportion)

[a]Variable used in sensitivity analysis

disability types: hearing difficulty, vision difficulty, cognitive difficulty, ambulatory difficulty, self-care difficulty, and independent living difficulty. The disability variable includes all males and females of all ages that have any of the disability types. We examine children and the elderly in terms of the proportion of the population less than 5 years old and the proportion population 75 years old or over. The proportion ages 5 and 74 serve as the reference group. We include the proportion zero-vehicle households (no automobile). We do not include an independent variable for socioeconomic status (SES) (e.g., median household income) since low income is included in the dependent variable and thus adjusted for.

To account for if a tract is gentrifying, we use the Gini index, which represents tract-level inequality in the income distribution, untransformed. Others have shown the Gini index to correlate positively with gentrification and use it as a proxy for gentrification within North American cities (Walks and Maaranen 2008; Collins et al. 2017). For urban residential redevelopment, we re-coded data on the median year of housing construction into two categories, $1 = \geq 1980$ and $0 = \leq 1979$. Given that HOLC zones were attributed to areas in the 1930s, tracts with HOLC zones that have contemporary median age of housing stock values post-1980 have been substantially redeveloped. We also include population density as a control variable. Table 1 presents descriptive statistics for these variables.

Statistical approach

We use generalized estimating equations (GEE) with a robust covariance estimate to analyze the data, which are appropriate for clustered and non-normally distributed data (Liang and Zeger 1986). Other studies addressing similar research questions have used GEEs (e.g., Mullen et al. 2020; Collins et al. 2015; Grineski et al. 2017). Our models use a binomial distribution and a logit link function because the dependent variable was dichotomous. We apply an exchangeable correlation matrix, which assumes constant intra-cluster dependency, meaning that the off-diagonal elements of the correlation matrix are defined as equal (Garson 2012; Liang and Zeger 1986). GEEs assume that observations from within a cluster are correlated, but observations from different clusters are independent. We define clusters based on city (within which specific HOLC zones were originally delineated and graded together; $n = 202$) and by 8 equal categories of median housing value

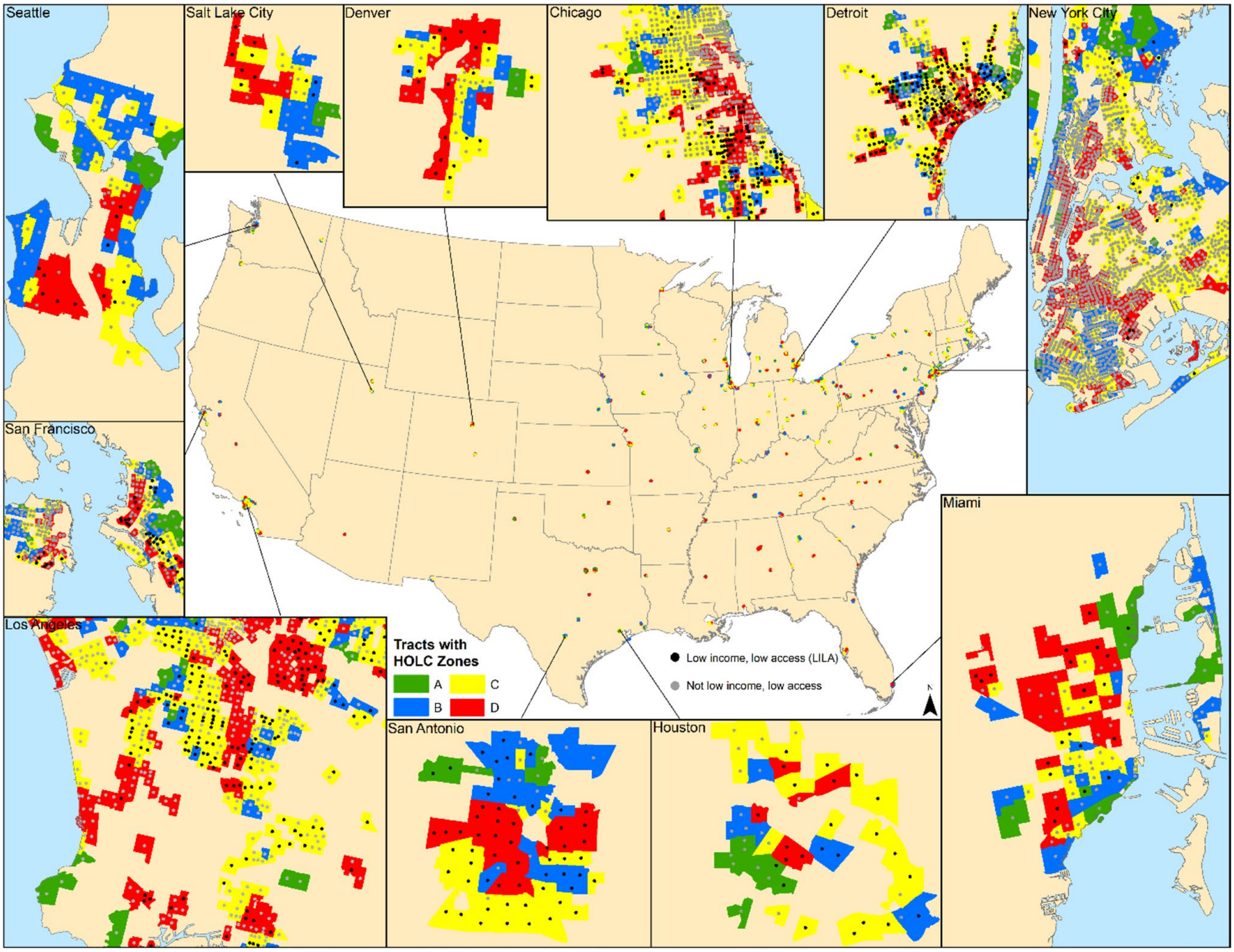

Fig. 1 Low income and low food access census tract centroids with HOLC zone ratings ($n = 10{,}459$)

(in 2019 USD): "less than $60,700", "$60,701-$98,500", "$98,500-$158,950", "$158,950-$249,500", "$249,501-$379,650", "$379,651- $501,000", "$501,001-$722,400", and "$722,401 or higher." This resulted in 820 clusters with a minimum of 1 and a maximum of 341 tracts per cluster. Other environmental justice papers have used median housing values to define clusters (e.g., Collins et al. 2015; Grineski et al. 2017).

We ran three models. The first model includes only the HOLC grade variables, with category A as the reference (Model 1). The second model is the full model, with the HOLC grade (ref: A), sociodemographic and housing variables (Model 2). The third model is a sensitivity analysis to the full model, which measures whether the results are robust to changes in how LILA was defined (i.e., accessibility at a half mile vs. one mile). All continuous independent variables in the models were standardized before being entered into the model. We used IBM SPSS Statistics v. 25 to conduct the analyses.

Results

Model 1 investigates associations between HOLC grades and the odds of a tract being LILA without any other variables (see Table 2). Compared to tracts with HOLC grade A, those with a grade of B were associated with an 80 percent increase ($p < 0.001$) in the odds of being LILA, while those with grades C and D were associated with 107 and 149 percent increases ($p < 0.001$) in the odds of a tract being LILA, respectively.

Model 2 includes the additional independent variables (see Table 2). Relative to tracts having an A grade, grades of B, C, and D were associated with 75, 134, and 128 percent increases ($p < 0.001$) in the respective odds of a tract being LILA. In terms of race/ethnicity, a standard deviation increase in the proportion of Black residents (0.308) was related to a 54 percent increase ($p < 0.001$) in the odds of a tract being LILA. An increase of one standard deviation in the proportion of Hispanic residents (0.255)

Table 2 Results from the binary logistic GEE predicting odds of a tract having low income and low grocery access a ½ mile (LILA)

Parameter	Model 1				Model 2			
	Odds ratio	Hypothesis Test	95% Wald Confidence Interval		Odds Ratio	Hypothesis Test	95% Wald Confidence Interval	
		Sig	Lower	Upper		‘Sig6	Lower	Upper
(Intercept)	.074	<.001	.058	.095	.151	<.001	.116	.197
"B" Still Desirable (ref: A)	1.800	<.001	1.418	2.284	1.752	<.001	1.407	2.181
"C" Declining (ref: A)	2.066	<.001	1.627	2.622	2.344	<.001	1.848	2.974
"D" Hazardous (ref: A)	2.488	<.001	1.948	3.178	2.281	<.001	1.781	2.921
Prop. Black					1.542	<.001	1.451	1.638
Prop. Asian					1.072	.010	1.017	1.129
Prop. Hispanic					1.468	<.001	1.373	1.569
Prop. Other					1.205	<.001	1.086	1.337
Prop. no automobile					.819	<.001	.762	.881
Prop. disability					1.551	<.001	1.420	1.693
Prop. under 5 years					1.025	.264	.981	1.072
Prop. over 75 years					.714	<.001	.656	.777
Median Age of Housing ≥ 1980 (ref: ≤ 1979)					.742	.017	.581	.948
Gini					1.174	<.001	1.106	1.247
Pop. Density					.255	<.001	.206	.315

HOLC "A" grade is the reference category. The models used a binomial distribution, a logit link function, an exchangeable correlation matrix and adjust for clustering based on county and eight categories of median age of housing value. All continuous variables were standardized

corresponded with a 47 percent increase ($p < 0.001$) in the odds of a tract being LILA. When the proportion of Asian residents increased by one standard deviation (0.118), we saw a 7 percent increase ($p < 0.01$) in the odds of a tract being LILA. For the proportion of residents of other races, a standard deviation increase (0.032) corresponded with a 21 percent increase ($p < 0.001$) in the odds of a tract being LILA.

When the proportion of residents without a car increased by one standard deviation (0.196), there was an 18 percent decrease ($p < 0.001$) in the odds of a tract being LILA. A one standard deviation increase in the proportion of disabled residents was associated with a 55 percent increase ($p < 0.001$) in the odds of a tract being LILA. For age, the proportion of residents under 5 years of age was not significantly associated with odds of LILA status ($p < 0.264$), but a one standard deviation increase in the proportion of residents over 75 was associated with a 29 percent decrease ($p < 0.001$) in the odds of a tract being LILA.

When the median age of housing was 1980 or newer, there was a 26 percent decrease ($p = 0.017$) in odds of a tract being LILA compared to when the housing was older. In terms of the Gini coefficient, a standard deviation increase in income inequality was associated with a 17 percent increase ($p < 0.001$) in the odds of a tract being LILA.

Sensitivity analysis

Table 3 compares results for Model 2 using LILA at a half mile (see Table 2) vs. LILA at one mile. We find that key results were generally not sensitive to the definition of distance band in the dependent variable in terms of direction and significance. The exceptions were for the Gini coefficient, Asian coefficient, proportion of under 5 years and housing redevelopment variables. The Gini coefficient, which was positive and significant at a half mile, became positive and not significant at one mile. The Asian coefficient, which was positive and significant at half mile, became negative and significant at one mile. The young children variable was positive and not significant at half mile, and became significant at one mile. Lastly, housing redevelopment, which was negative and significant at half a mile, retained its negative coefficient but became non-significant at one mile.

Table 3 Sensitivity analysis: comparison of direction and significance of odds ratios between the two dependent variables

	Low-income and low grocery access assessed at ½ mile[a] <u>Odds Ratio</u>	Low-income and low grocery access assessed at 1 mile <u>Odds ratio</u>
Intercept	[−]	[−]
"B" Still Desirable (ref: A)	[+]	[+]
"C" Declining (ref: A)	[+]	[+]
"D" Hazardous (ref: A)	[+]	[+]
Gini	[+]	+
Prop. Black	[+]	[+]
Prop. Asian	[+]	[−]
Prop. Other	[+]	[+]
Prop. Hispanic	[+]	[+]
Prop. no automobile	[−]	[−]
Prop. disability	[+]	[+]
Prop. under 5 years	+	[+]
Prop. over 75 years	[−]	[−]
Pop Density	[−]	[−]
House built post-1980 (ref: pre-1980)	[−]	−

In this table "+" under the odds ratio column means a positive association whereas a "−" means a negative association. […] indicates that the p-value is less than 0.05

[a]Full results are presented in Table 2 (Model 2)

Discussion

Knowledge about how historic redlining shapes contemporary food access remains underdeveloped. This study is a first step towards furthering that understanding nationwide. We find, in line with H_1, the neighborhoods that were graded as C and D (and to a lesser extent B) had reduced food access than those graded A. Real estate agents, banks, government and people made redlining happen by "actively and passively structur[ing] the process of neighborhood decline, e.g. by producing maps that not only *describe* but also *prescribe* neighborhood decline" (Aalbers, 2014 p. 527). As we show here, one manifestation of this decline is redlining's legacy effect on tract-level food insecurity at a national level. A similar pattern emerged through bivariate analysis in Salt Lake City (Joyner et al. 2022).

However, the study examining a similar question in Baltimore using multivariable methods found the opposite (Sadler et al. 2021). Sadler et al.'s (2021) findings likely diverge from the national pattern in part due to differences in research methodology and variables. It is possible though that findings would diverge even if they had used our approach or we had applied their methods. Baltimore is a majority Black city, which is rare in the US context. As of the 2020 Census, there are only 22 US cities with populations over 100,000 that are > 50 percent Black. When the majority of a city's population is Black (as is the case in Baltimore but not the US as whole), it is possible that the linkages between redlining, concentrations of BIPOC, and low grocery access would vary from the national pattern. As Sadler et al. (2021) reported, contemporary settlement patterns in Baltimore suggest the people who initially suffered from redlining may no longer be in those redlined areas. Indeed, they found that older parts of Baltimore scored higher on their Healthy Food Availability Index when they were in gentrifying neighborhoods. The divergent pattern that Sadler et al. (2021) documented in Baltimore vs. what we find in the US indicates that relationships between redlining and food access varies to some degree between geographic contexts. However, the national trend signals a lingering effect of redlining on contemporary neighborhood food insecurity.

In terms of findings for race/ethnicity, we find that greater racial/ethnic minority composition was associated with reduced food access (which supports H_2). This aligns with results from prior studies (Bodor et al. 2010; Odoms-Young 2018; Morales et al. 2021; Deener 2017), and is likely explained by historic and contemporary patterns of systemic racism and the "interlocking workings of human worth, race and space" (McKittrick 2013, p. 6). The addition of the racial/ethnic variables in Model 2 had little effect on the strength of associations between HOLC D and C zonation and reduced food access. If the addition of the racial/ethnic composition variables in Model 2 had made the associations for grades D and C statistically non-significant, then we would have concluded that contemporary racial dynamics accounted for, or explain away, the effect of redlining on food access. But we found independent effects of historic redlining and contemporary racial/ethnic composition, indicating that racism operates in multifaceted ways across space and time (perhaps in interlocking fashion) to structure food injustices. This contemporary trifecta of redlined neighborhoods, BIPOC, and low income/low grocery access appears to reflect the after-life of slavery, in Saidiya Hartman's terms (Hartman 2007; Davis 2019). The afterlife of slavery reflects how "Black lives are still imperiled and devalued by a racial calculus and a political arithmetic that were entrenched centuries ago" and encompasses "skewed life chances, limited access to health and education, premature death, incarceration, and impoverishment" (Hartman 2007, p. 6).

In terms of our findings for the effects of car access, age, and disability status on food access, an increase in the proportion of residents without a car corresponds with better food access. This ran counter to our hypotheses ($H_{3\text{-ii}}$) and suggests that low income/low food access tracts were not characterized by disproportionately high concentrations of transportation-disadvantaged residents (adjusting for the effects of other variables). Increases in the neighborhood composition of disabled residents corresponds to reduced food access (which supports $H_{3\text{-i}}$). This finding is practically concerning and may reflect ableism and a lack of support and services in contexts low income neighborhoods with poor food access. In contrast to $H_{3\text{-iv}}$, higher neighborhood composition of older age residents is associated with better food access, which is important to note since this group is vulnerable to food insecurity (Pooler et al. 2019).

Our findings for the gentrification and housing redevelopment indicators are alarming. We find that gentrifying neighborhoods—defined based on their high levels of income inequality and presence in historic central city areas mapped by the HOLC—have reduced food access (which is counter to $H_{4\text{-i}}$). It is important to note that our examination of income inequality in relation to LILA specifically captures "gentrifying" rather than fully gentrified neighborhoods, with a mix of both wealthier and poorer residents as well as lower average incomes and low food access. In Baltimore, in contrast, they examined gentrification (e.g., increases in median income over time) and found it to be associated with better food access (Sadler et al. 2021). Our result for the gentrifying variable is concerning because they highlight a lack of food access for poorer residents in gentrifying low-income/low access tracts and reveal a broader pattern whereby ongoing gentrification of (still low-income) historic, central city neighborhoods in the US is associated with inadequate food access, which may increase food insecurity for the substantial numbers of lower income people in those contexts.

We find that neighborhoods that have undergone housing redevelopment also have improved food access (which supports $H_{4\text{-ii}}$). This indicates that housing redevelopment is connected with improvements in food access, such that financial investments in gentrifying areas (where housing infrastructure has been entirely replaced) tend to improve food access, while the enduring neighborhood disinvestment instantiated by redlining has constrained the development of healthful food options (Nelson et al. 2020). When paired with findings showing that contemporary racially/ethnically minoritized neighborhood composition has independent effects on worse food access, this suggests that geographically uneven investments in gentrification and redevelopment are intertwined with the displacement of BIPOC communities and the production of urban food injustices in US cities (Alkon et al. 2020b). While it is clear that the marginalization of BIPOC via longstanding and persistent patterns of urban (dis)investment has shaped neighborhood disparities in food access, our cross-sectional approach provides limited basis for explanation. Future research should use historical methods to clarify how gentrification and housing redevelopment have intersected with racism and displacement to structure the landscape of food injustice in particular urban contexts.

Limitations

Our study had some limitations. We did not analyze individual-level data so our results pertain to tract-level characteristics and inferences cannot be extended to individuals. Future research should use individual-level data sets to examine similar questions. Some people visit grocery stores beyond the one-half and one-mile distances captured in our food access measure (Drewnowski et al. 2010; Aggarwal et al. 2014), but it is important to note that those more distant options are most viable for those with cars (especially in suburban contexts not examined here) and/or proximity to public transit, which does not extend to everyone. Additionally, our food access measure only captures the distance to the nearest large grocery store, supermarket and supercenter, which does not account for other ways people obtain food (e.g., farmers markets, community gardens, convenience store, small ethnic food stores, bodegas), making our measure an imprecise one for capturing all food access options. Our measure is the best available for a national study, but research focused on specific cities could incorporate these small food providers into a grocery access metric. While we examine how some axes of inequality impact food access, we did not consider gender or use an intersectionality framework (McKinney and Thomson 2022; Bauer et al. 2021). Future research should investigate how different axes of inequality, including gender, intersect to shape food access.

Conclusion

This study is one of the first to quantitatively examine the connection between redlining and contemporary food access in the US. Our findings illuminate how nearly a century of disinvestment in historically redlined neighborhoods (Nardone et al. 2020; Nelson et al. 2020) has constrained contemporary food access. Moreover, they suggest that systemic inequalities based on racism, ableism, housing discrimination, and displacement may lead to lack of food options in US central city neighborhoods. Our results provide additional evidence that the phrase "food desert" is problematic as these social spaces of nutritional deprivation were created by intentionally racist and discriminatory policies, rather than passive and natural processes. Thus, the phrase "food apartheid" more accurately reflects the phenomenon (Sevilla 2021; Penniman 2018).

The disparities in food access that we documented here should be addressed, as they reflect food injustices and indicate that racist policies like redlining, have enduring impacts on neighborhood food environments. Reparations should be considered as activists try to bring food justice to communities. Policies and programs that encourage supermarkets and food retailers to locate in low-income BIPOC communities are another potential avenue for action (Barker et al. 2012). As an example, the public–private partnership Fresh Food Financing Initiative (FFFI) in Pennsylvania has attracted food retailers to areas in need using grants and loans (Doshna 2015). These sorts of market-based neoliberal initiatives are one potential way to begin to undo decades of disinvestment in redlined communities, but they are not enough to address the multiple aspects of structural racism that led to supermarket redlining in the first place.

In the absence of accessible supermarkets, policies and programs are needed to address the challenges small food retailers (e.g., bodegas) face in trying to stock and sell fresh and healthy foods (Barker et al. 2012). In the absence of grocery stores, many residents shop at small food retailers, yet these retailers have limited access to vendors who sell fresh foods. Small store owners often have to purchase those fresh foods at retail prices from supermarkets, leading to a shorter-shelf lives and higher prices for local consumers (Barker et al. 2012). To address this, programs such as the non-profit group DC Central Kitchen link small retailers with wholesale fresh food suppliers (DC Central Kitchen 2022). Additionally, programs can bypass the physical infrastructure of a store and bring fresh foods directly to consumers, as the Peaches and Greens truck does in Detroit (Peaches and Greens 2022). In Baltimore, the Virtual Supermarket Project allowed residents to order groceries online and have them delivered the next day to a public library, if the grocery delivery service was not offered to their address (Owens 2010). Research on the program demonstrated that it addressed barriers to transportation and food availability (Lagisetty et al. 2017).

While community gardens and urban agricultural opportunities are another potential course of action to address food access issues, these efforts can lead to green gentrification, which is when environmental amenities lead outside investors to reinvest in previously neglected communities because of those new environmental amenities. This can lead to the displacement of long-term residents (Anguelovski et al.2018). Alkon et al. (2020b) recommends that those seeking to create and support alternative food systems (e.g., community gardens) engage in a "reflexive local politics of food" whereby they interrogate their own notions of "right living" and "right eating," which are "wrapped up in these possessive investments in race, class and gender" (DuPuis and Goodman 2005, p. 363). Food activists must reflect on the potential unintended consequences of upscaling food and the neighborhoods in which it is grown (Alkon et al. 2020b). Alkon and colleagues (2020b, p. 330) "suspect that greater reflexivity will push food activists and movements toward deeper engagement with low-income communities and communities of color. This is…important and necessary, particularly when more privileged groups can do the hard work of reflecting on their own advantages and listen to the life experiences of less privileged ones." While our study highlights the need for investments in healthful and reasonably priced food options in low-income, minoritized neighborhoods that were historically redlined, we argue that this must be done in a manner that is community-centered and does not create food mirages or induce green gentrification, such that residents are protected from displacement.

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References

Aalbers, M.B. 2014. Do maps make geography? Part 1: Redlining, planned shrinkage, and the places of decline. *ACME: an International Journal for Critical Geographies* 13 (4): 525–556.

Aggarwal, A., A.J. Cook, J. Jiao, R.A. Seguin, A.V. Moudon, P.M. Hurvitz, and A. Drewnowski. 2014. Access to supermarkets and fruit and vegetable consumption. *American Journal of Public Health* 104: 917–923.

Alkon, A.H., and J. Agyeman (Eds.). 2011. *Cultivating food justice: Race, class, and sustainability*. Cambridge, MA. MIT Press.

Alkon, A.H., S. Bowen, Y. Kato, and K.A. Young. 2020b. Unequally vulnerable: A food justice approach to racial disparities in COVID-19 cases. *Agriculture and Human Values* 37 (3): 535–536.

Alkon, A.H., Y. Kato, and J. Sbicca. (Eds.). 2020b. *A recipe for gentrification: Food, power, and resistance in the city*. NYU Press.

Anguelovski, I., J. Connolly, and A.L. Brand. 2018. From landscapes of utopia to the margins of the green urban life: For whom is the new green city? *City* 22 (3): 417–436.

Barker, C., A. Francois, R. Goodman, and E. Hussain. (with American Civil Liberties Union). 2012. Unshared Bounty: How Structural Racism Contributes to the Creation and Persistence of Food Deserts New York Law School Racial Justice Project. https://digitalcommons.nyls.edu/cgi/viewcontent.cgi?article=1002&context=racial_justice_project. Accessed 25 May 2022.

Bauer, G.R., S.M. Churchill, M. Mahendran, C. Walwyn, D. Lizotte, and A.A. Villa-Rueda. 2021. Intersectionality in quantitative research: A systematic review of its emergence and applications of theory and methods. *SSM-Population Health* 14: 100798.

Benns, M., M. Ruther, N. Nash, M. Bozeman, B. Harbrecht, and K. Miller. 2020. The impact of historical racism on modern gun violence: Redlining in the city of Louisville, KY. *Injury* 51 (10): 2192–2198.

Bodor, J.N., J.C. Rice, T.A. Farley, C.M. Swalm, and D. Rose. 2010. Disparities in food access: Does aggregate availability of key foods from other stores offset the relative lack of supermarkets in African-American neighborhoods? *Preventive Medicine* 51 (1): 63–67.

Bodor, J.N., P.L. Hutchinson, and D. Rose. 2013. Car ownership and the association between fruit and vegetable availability and diet. *Preventive Medicine* 57 (6): 903–905.

Cohen, N. 2018. *Feeding or starving gentrification: The role of food policy*. New York, NY: CUNY Urban Food Policy Institute.

Coleman-Jensen, A. 2020. US food insecurity and population trends with a focus on adults with disabilities. *Physiology and Behavior* 220: 112865.

Collins, T.W., S.E. Grineski, J. Chakraborty, M.C. Montgomery, and M. Hernandez. 2015. Downscaling environmental justice analysis: Determinants of household-level hazardous air pollutant exposure in Greater Houston. *Annals of the Association of American Geographers* 105 (4): 684–703.

Collins, T.W., S.E. Grineski, and D.X. Morales. 2017. Environmental injustice and sexual minority health disparities: A national study of inequitable health risks from air pollution among same-sex partners. *Social Science and Medicine* 191: 38–47.

Davis, D.A. 2019. Trump, race, and reproduction in the afterlife of slavery. *Cultural Anthropology* 34 (1): 26–33.

DC Central Kitchen 2022. Our mission. https://dccentralkitchen.org/mission/. Accessed 25 May 2022.

De Master, K.T., and J. Daniels. 2019. Desert wonderings: Reimagining food access mapping. *Agriculture and Human Values* 36 (2): 241–256.

Deener, A. 2017. The origins of the food desert: Urban inequality as infrastructural exclusion. *Social Forces* 95 (3): 1285–1309.

Doshna, J.P. 2015. *Community development in the age of neoliberalism: The case of the Pennsylvania Fresh Food Financing Initiative*. Rutgers The State University of New Jersey - New Brunswick. ProQuest Dissertations Publishing, #3734209.

Drewnowski, A., A. Aggarwal, A.V. Moudon. 2010. The supermarket gap: How to ensure equitable access to affordable, healthy foods. A research brief. University of Washington Center of Public Health Nutrition. https://nutr.uw.edu/wp-content/uploads/2019/10/cphnbrf051910.pdf. Accessed 25 Feb 2022.

DuPuis, E.M., and D. Goodman. 2005. Should we go "home" to eat?: Toward a reflexive politics of localism. *Journal of Rural Studies* 21 (3): 359–371.

Eisenhauer, E. 2001. In poor health: Supermarket redlining and urban nutrition. *GeoJournal* 53 (2): 125–133.

Garson, G.D. 2012. *Generalized linear models and generalized estimating equations*, 350. Asheboro, NC: Statistical Associates Publishing.

Grineski, S.E., T.W. Collins, J. Chakraborty, and M. Montgomery. 2017. Hazard characteristics and patterns of environmental injustice: Household-level determinants of environmental risk in Miami, Florida. *Risk Analysis* 37 (7): 1419–1434.

Harper, A., A. Shattuck, E. Holt-Giménez, A. Alkon, and F. Lambrick. 2009. *Food policy councils: Lessons learned*. Oakland, CA: Food First/Institute for Food and Development Policy.

Hartman, Saidiya. 2007. *Lose your mother: A journey along the Atlantic slave route*. NewYork: Farrar, Straus, and Giroux.

Heflin, C.M., C.E. Altman, and L.L. Rodriguez. 2019. Food insecurity and disability in the United States. *Disability and Health Journal* 12 (2): 220–226.

Hoffman, J.S., V. Shandas, and N. Pendleton. 2020. The effects of historical housing policies on resident exposure to intra-urban heat: A study of 108 US urban areas. *Climate* 8 (1): 12.

Joyner, L., B. Yagüe, A. Cachelin, and J. Rose. 2022. Farms and gardens everywhere but not a bite to eat? A critical geographic approach to food apartheid in Salt Lake City. *Journal of Agriculture, Food Systems, and Community Development* 11 (2): 67–88.

Lagisetty, P., L. Flamm, S. Rak, J. Landgraf, M. Heisler, and J. Forman. 2017. A multi-stakeholder evaluation of the Baltimore City virtual supermarket program. *BMC Public Health* 17 (1): 1–9.

Lee, J.P., W. Ponicki, C. Mair, P. Gruenewald, and L. Ghanem. 2020. What explains the concentration of off-premise alcohol outlets in Black neighborhoods? *SSM-Population Health* 12: 100669.

Liang, K.Y., and S.L. Zeger. 1986. Longitudinal data analysis using generalized linear models. *Biometrika* 73 (1): 13–22.

Locke, D.H., B. Hall, J.M. Grove, S.T. Pickett, L.A. Ogden, C. Aoki, C.G. Boone, and J.P. O'Neil-Dunne. 2021. Residential housing segregation and urban tree canopy in 37 US Cities. *NPJ Urban Sustainability* 1 (1), 1–9.

Manson, S., J. Schroeder, D. Van Riper, and S. Ruggles. 2017. IPUMS National Historical Geographic Information System: Version 12.0 [database]. Minneapolis: University of Minnesota, 39.

McKinney, L., and R. Thomson. 2022. Landfills and disasters: A geospatial analysis of environmental injustice across the Southern United States. *Environmental Sociology* 8 (2): 173–186.

McKittrick, K. 2013. Plantation futures. *Small Axe: A Caribbean Journal of Criticism* 42: 1–15.

McClintock, N. 2011. From industrial garden to food desert. In *Cultivating food justice: Race, class, and sustainability*, ed. A.H. Alkon and J. Ageyman, 89–120. Cambridge: MIT Press.

Mitchell, B., and Franco, J. 2018. HOLC "redlining" maps: The persistent structure of segregation and economic inequality. National Community Reinvestment Coalition. Washington, DC, USA, 1–29. https://ncrc.org/wp-content/uploads/dlm_uploads/2018/02/NCRC-Research-HOLC-10.pdf. Accessed 25 Feb 2022.

Morales, D.X., S.A. Morales, and T.F. Beltran. 2021. Racial/ethnic disparities in household food insecurity during the COVID-19 pandemic: A nationally representative study. *Journal of Racial and Ethnic Health Disparities* 8 (5): 1300–1314.

Mullen, C., S. Grineski, T. Collins, W. Xing, R. Whitaker, T. Sayahi, et al. 2020. Patterns of distributive environmental inequity under different PM2.5 air pollution scenarios for Salt Lake County public schools. *Environmental Research* 186: 109543.

Nardone, A., J. Chiang, and J. Corburn. 2020. Historic redlining and urban health today in US cities. *Environmental Justice* 13 (4): 109–119.

Nardone, A., K.E. Rudolph, R. Morello-Frosch, and J.A. Casey. 2021. Redlines and greenspace: The relationship between historical redlining and 2010 greenspace across the United States. *Environmental Health Perspectives* 129 (1): 017006.

Nelson, R. K., Winling, L., Marciano, R., and Connolly, N. 2020. Mapping inequality: Redlining in the new deal America. *American Panorama: An Atlas of United States History. University of Richmond: Digital Scholarship Lab*. https://dsl.richmond.edu/panorama/redlining/#loc=5/39.1/-94.58. Accessed 25 Feb 2022.

Odoms-Young, A.M. 2018. Examining the impact of structural racism on food insecurity: Implications for addressing racial/ethnic disparities. *Family and Community Health* 41 (Suppl 2): S3–S6.

O'Hara, S., and E.C. Toussaint. 2021. Food access in crisis: Food security and COVID-19. *Ecological Economics* 180: 106859.

Owens, D.M. 2010. Check it out: Get Your Groceries at the Library. National Public Radio. https://www.npr.org/templates/story/story.php?storyId=126282239. Accessed 16 June 2022.

Peaches and Greens 2022. Peaches and greens mobile market. https://www.peachesandgreens.org/. Accessed 25 May 2022.

Penniman, L. 2018. *Farming while black: Soul fire farm's practical guide to liberation on the land*. Hartford: Chelsea Green Publishing.

Pooler, J.A., H. Hartline-Grafton, M. DeBor, R.L. Sudore, and H.K. Seligman. 2019. Food insecurity: A key social determinant of health for older adults. *Journal of the American Geriatrics Society* 67 (3): 421.

Powell, L.M., S. Slater, D. Mirtcheva, Y. Bao, and F.J. Chaloupka. 2007. Food store availability and neighborhood characteristics in the United States. *Preventive Medicine* 44 (3): 189–195.

Raja, S., C. Ma, and P. Yadav. 2008. Beyond food deserts: Measuring and mapping racial disparities in neighborhood food environments. *Journal of Planning Education and Research* 27 (4): 469–482.

Raja, S. 2020. Planning and pandemics COVID 19 illuminates why urban planners should have listened to food advocates all along. *Agriculture and Human Values* 37 (3): 553–554.

Rutan, D.Q., and M.R. Glass. 2018. The lingering effects of neighborhood appraisal: Evaluating redlining's legacy in Pittsburgh. *The Professional Geographer* 70 (3): 339–349.

Sadler, R.C., U. Bilal, and C.D. Furr-Holden. 2021. Linking historical discriminatory housing patterns to the contemporary food environment in Baltimore. *Spatial and Spatio-Temporal Epidemiology* 36: 100387.

Schwartz, N., R. Buliung, and K. Wilson. 2019. Disability and food access and insecurity: A scoping review of the literature. *Health and Place* 57: 107–121.

Sevilla, N. 2021. Food Apartheid: Racialized Access to Healthy Affordable Food. *NRDC*

Shannon, J. 2021. Dollar stores, retailer redlining, and the metropolitan geographies of precarious consumption. *Annals of the American Association of Geographers* 111 (4): 1200–1218.

Sullivan, D.M. 2014. From food desert to food mirage: Race, social class, and food shopping in a gentrifying neighborhood. *Advances in Applied Sociology* 4 (1): 30–35.

Thibodeaux, J. 2016. A historical era of food deserts: Changes in the correlates of urban supermarket location, 1970–1990. *Social Currents* 3 (2): 186–203.

Thomas, B.J. 2010. Food deserts and the sociology of space: Distance to food retailers and food insecurity in an urban American neighborhood. *International Journal of Humanities and Social Sciences* 4 (7): 1545–1554.

USDA 2015. Food Access Research Atlas (2015). United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/.

USDA 2021. Food Access Research Atlas (2019). United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov/data-products/food-access-research-atlas/. Accessed 25 Feb 2022.

Walker, R.E., J. Block, and I. Kawachi. 2012. Do residents of food deserts express different food buying preferences compared to residents of food oases? A mixed-methods analysis. *International Journal of Behavioral Nutrition and Physical Activity* 9 (1): 1–13.

Walker, R.E., C.R. Keane, and J.G. Burke. 2010. Disparities and access to healthy food in the United States: A review of food deserts literature. *Health and Place* 16 (5): 876–884.

Walks, R.A., and R. Maaranen. 2008. Gentrification, social mix, and social polarization: Testing the linkages in large Canadian cities. *Urban Geography* 29 (4): 293–326.

Wilson, B. 2020. Urban Heat Management and the Legacy of Redlining. *Journal of the American Planning Association* 86 (4): 443–457.

Wright, J.D., A.M. Donley, M.C. Gualtieri, and S.M. Strickhouser. 2016. Food deserts: What is the problem? What is the solution? *Society* 53 (2): 171–181.

Zhang, M., and D. Ghosh. 2016. Spatial Supermarket Redlining and Neighborhood Vulnerability: A Case Study of Hartford, Connecticut. *Transactions in GIS* 20 (1): 79–100.

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