

Impact of Neighborhood Sociodemographic Characteristics on Food Store Accessibility in the United States Based on the 2020 US Census Data

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Abstract

Background: It has been previously reported that access to quality food is greatly impacted by neighborhood food store quality and availability, which in turn is determined by a complex interplay of sociodemographic factors. Low-income predominantly Black neighborhoods face the most limited access to quality food. The purpose of this study was to examine the newly available 2020 Census to see if any significant change has occurred to this pattern and if any new insights can be gained by analyzing these data. **Methods:** 2020 US Census and current ReferenceUSA™ food store data were merged and multivariate Negative Binomial Count Regression Models were used to establish the relationship between different types of food stores (high, medium, and low quality) and neighborhood characteristics including urbanicity, poverty level, and race/ethnicity. **Results:** 11.5% of the predominantly Non-Hispanic (NH) White census tracts (CT) (6,486 out of 56,192), 61.3% (4,002 out of 6,531) of the predominantly Non-Hispanic Black CTs, and 44.1% (3,644 out of 8,258) of the predominantly Hispanic CTs were in the high poverty category. Compared to the reference group of NH White/low-poverty group, the incident rate ratio (IRR) and 95% Confidence interval [CI] of having access to high quality food stores for NH Black was significantly lower starting at the low poverty level (0.57 [0.48, 0.67], $p < 0.001$) and decreasing further with increasing poverty: NH Black/medium poverty (0.48 [0.42, 0.55], $p < 0.001$); NH Black/high poverty (0.38, [0.34, 0.42], $p < 0.001$). A similar pattern was seen with the Hispanic groups as well, though to a lesser degree. We further examined access to computer/electronic devices including smartphones from 2017 to 2020. High poverty NH Black households experienced the fastest growth from 73.6% access rate in 2017 to 82.6% in 2020, compared with 87.0% to 92.0% in the total population. **Conclusion:** Analyses of the 2020 Census data reveal that access to high-quality food stores in high-poverty minority neighborhoods, NH Black neighborhoods in particular, remains severely limited. Innovative interventions and emerging technologies, online grocery shopping for example, warrant further evaluation as potential strategies to improve access and decrease disparities in social determinants of healthy eating.

Introduction

When certain geographic areas within the United States lack resources to supply their residents with healthy food due to limited access to affordable and high-quality food stores, the area can be defined as a food desert.¹ Research suggests that neighborhoods with better access to supermarkets and limited access to convenience stores tend to have healthier diets and lower levels of obesity and obesity-related chronic diseases.²⁻⁴ In neighborhoods without larger supermarkets, the smaller stores charge higher prices for fresh produce and sometimes completely lack other food items like nonfat milk or whole grain bread.⁵ This problem directly affects those 39.5 million Americans living in low-income and low-access areas, with

socioeconomic status playing a key role in determining the quality and quantity of food in close proximity.⁶ A White neighborhood has four times the supermarkets a predominantly Black neighborhood contains.⁷ Using the 2000 Census data, a research study reported that the number of supermarkets (a surrogate marker for access to high quality, healthful food) decreased, while grocery and convenience stores (representing lower quality food) increased with increasing level of neighborhood poverty, with the impoverished, predominantly Black communities doubly afflicted by supermarket inaccessibility.⁸ A number of projects and initiatives have since been implemented in an effort to improve access to healthier food options in disadvantaged neighborhoods with mixed results.^{2,9,10} In this study, we sought to evaluate interval change in food store accessibility based on neighborhood sociodemographic characteristics using the newly available 2020 US census data.

Methods

Data Sources

2020 US Census data were obtained through the US Census Bureau website.¹¹ Neighborhoods were represented as census tracts (CT). Food store information was obtained via ReferenceUSATM, a nationwide business and residential information database that contains real-time updated comprehensive business information including street address, phone number, hours of operation, number of employees, online presence, Standard Industrial Classification (SIC) codes, business contacts, etc.¹² Census data and various grocery store data from ReferenceUSATM were merged by business address, SIC code or both.

Dependent Variable

The dependent variables were the counts of high, medium, and low-quality food stores in each CT. High-quality food stores (collectively named “supermarkets”) included wholesale clubs (SIC code 531110) and big grocery stores (SIC codes 541101, 541104-541108 and ≥ 50 employees); medium-quality food stores included small grocery stores (SIC codes 541101, 541104-541108 and < 50 employees); low-quality food stores included convenience stores (SIC 541103), service/gas stations (SIC 554101, 554103), and variety stores (SIC 533101).

Independent Variables

1. Race and ethnicity: five race and ethnicity categories were constructed based on the standard guideline for reporting race and ethnicity in research.¹³ A CT was defined as predominantly Non-Hispanic (NH) White, NH Black, Hispanic or Asian if greater than or equal to 50% of the population was of that particular race and ethnicity. The remaining CTs were classified as Integrated when no predominant group existed.
2. Poverty: a CT was classified as high poverty if greater than or equal to 20% of households residing within the CT reported an income below the federal poverty level (FPL); medium poverty if between 10-20% of the households reported below FPL income; low poverty if $< 10\%$ of the households residing within the CT reported below PFL income.

3. A 15-category combined race/ethnicity and poverty variable was constructed, combining each race/ethnic group with a poverty level as a composite variable for use in regression analysis.
4. CTs were categorized as urban if they fell within a metropolitan Statistical Area (MSA). All others were considered rural.

Statistical Analysis

All continuous variables, presented as mean +/- standard deviation, were compared by using analysis of variance (ANOVA) with Bonferroni post hoc correction. Categorical variables were expressed as percentages and were compared with the use of the Chi-square test. For all tests, significance was accepted as p value <0.05 .

Multivariable count regression models were employed to examine the association between the counts of three types of food stores with neighborhood characteristics including total population, poverty level, as well as the combined poverty/race and ethnicity variable. Negative binomial logarithmic regression models with custom estimate Dispersion Parameters were used instead of Poisson regression models (with fixed Dispersion Parameter of 1) due to over-dispersion of our count data.¹⁴ Incident rate ratio (IRR) and 95% confidence interval (CI) were reported as the main output of the regression models. All statistical analyses were performed using SPSS version 22 software (IBM, Armonk, New York).

Results

Descriptive Summary Statistics

The analysis included 83,350 CTs. Table 1 summarizes CT distribution based on poverty levels (low, medium, and high), urbanicity (urban vs rural), and the five major race/ethnic groups (NH White, NH Black, Hispanic, Asian, and Integrated). Compared to 2000 Census data,⁸ NH White CT decreased from 69.9% to 67.4% of all CTs, NH Black CTs remained stable at 7.8%, while Hispanic CTs increased from 4.7% in 2000 to 9.9% in 2020.

Table 1. Summary of United States 2020 Census Tract Characteristics by Poverty, Urbanicity and Race/Ethnicity

Census tracts		NH White (N=56,192, 67.4%)		NH Black (N=6,531, 7.8%)		Hispanic (N=8,258, 9.9%)		Asian (N=873, 1.0%)		Integrated (N=11,496, 13.8%)		Total (N=83,350)	
		Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
Poverty	Low	32182	57.3	893	13.7	1588	19.2	533	61.1	4568	39.7	39764	47.7
	Med	17524	31.2	1636	25.0	3026	36.6	217	24.9	3843	33.4	26246	31.5
	High	6486	11.5	4002	61.3	3644	44.1	123	14.1	3085	26.8	17340	20.8

	Rural	21344	38.0	723	11.1	785	9.5	19	2.2	1373	11.9	2424	29.1
	Urban	34848	62.0	5808	88.9	7473	90.5	854	97.8	1012	88.1	5910	70.9
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Eleven and a half percent of all NH White CTs (up from 7.9% in 2000), 61.3% of all NH Black CT (70.7% in 2000), and 44.1% of all Hispanic CT (71.5% in 2000) fell within the High poverty category. While 38.0% of NH White CTs were rural, Black (88.9%) and Hispanic (90.5%) CTs were predominantly in urban areas.

Rural CTs had more convenience stores (2.22 ± 2.10), fewer Grocery stores (0.78 ± 1.05) and fewer Supermarkets (0.14 ± 0.41) than Urban CTs. Both convenience stores and grocery stores increased in number with increasing level of poverty, while the average number of supermarkets per CT exhibited a reverse trend, decreasing in low poverty CTs (0.28 ± 0.60), followed by medium poverty (0.24 ± 0.55), with the lowest number in high poverty CT (0.18 ± 0.47) (see Table 2).

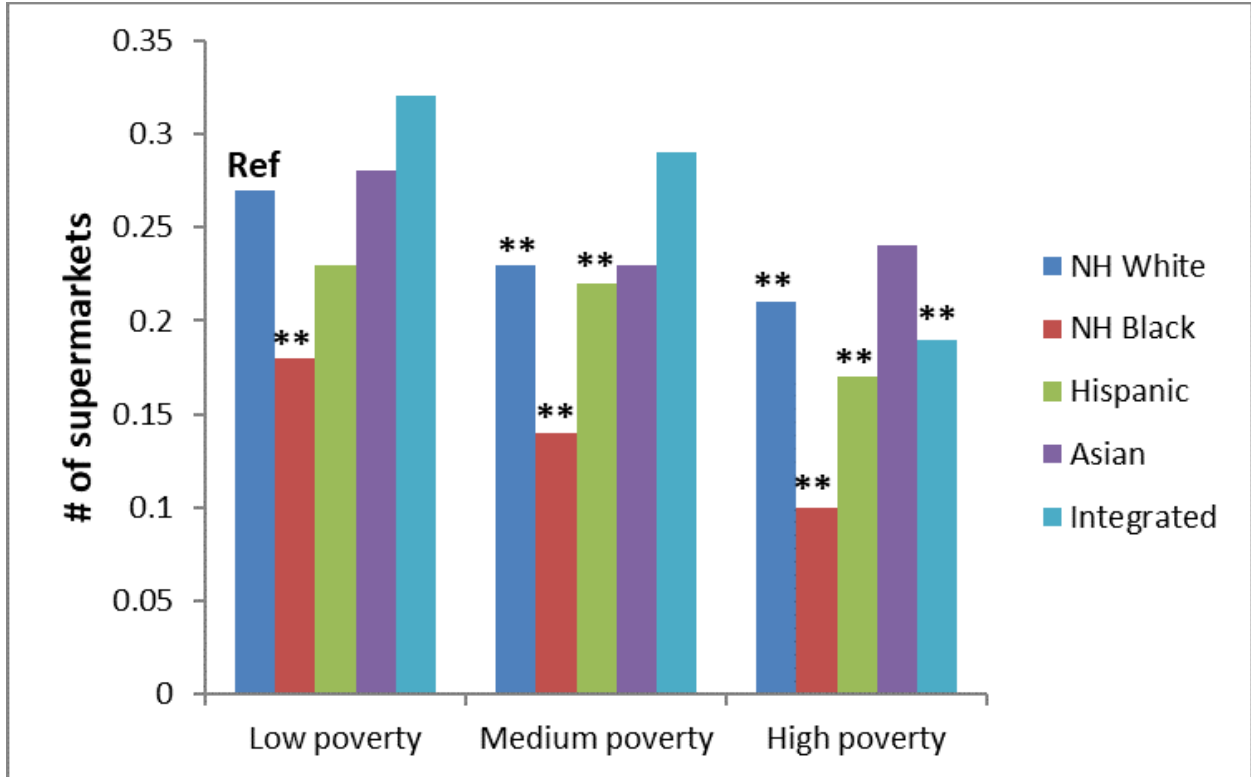
Table 2: Number of Each Category of Food Stores per Census Tract Based on Urbanicity, Poverty Level and Race/Ethnicity.

	Convenience stores (mean \pm SD)	Grocery stores (mean \pm SD)	Supermarkets (mean \pm SD)
Full sample	1.80 \pm 1.94	0.87 \pm 1.26	0.24 \pm 0.56
Rural	2.22 \pm 2.10	0.78 \pm 1.05	0.14 \pm 0.41
Urban	1.62 \pm 1.84	0.90 \pm 1.33	0.29 \pm 0.60
Low poverty	1.41 \pm 1.64	0.64 \pm 1.01	0.28 \pm 0.60
Medium Poverty	2.11 \pm 2.06	0.96 \pm 1.27	0.24 \pm 0.55
High poverty	2.20 \pm 2.18	1.25 \pm 1.58	0.18 \pm 0.47
Predominantly NH White	1.83 \pm 1.92	0.74 \pm 1.06	0.25 \pm 0.57
Predominantly NH Black	1.92 \pm 2.14	1.06 \pm 1.39	0.12 \pm 0.39
Hispanic	1.70 \pm 1.87	1.31 \pm 1.68	0.20 \pm 0.50
Asian	0.68 \pm 1.06	1.13 \pm 1.92	0.26 \pm 0.64
Integrated	1.69 \pm 1.95	1.06 \pm 1.49	0.28 \pm 0.60

NH: non-Hispanic; SD: standard deviation

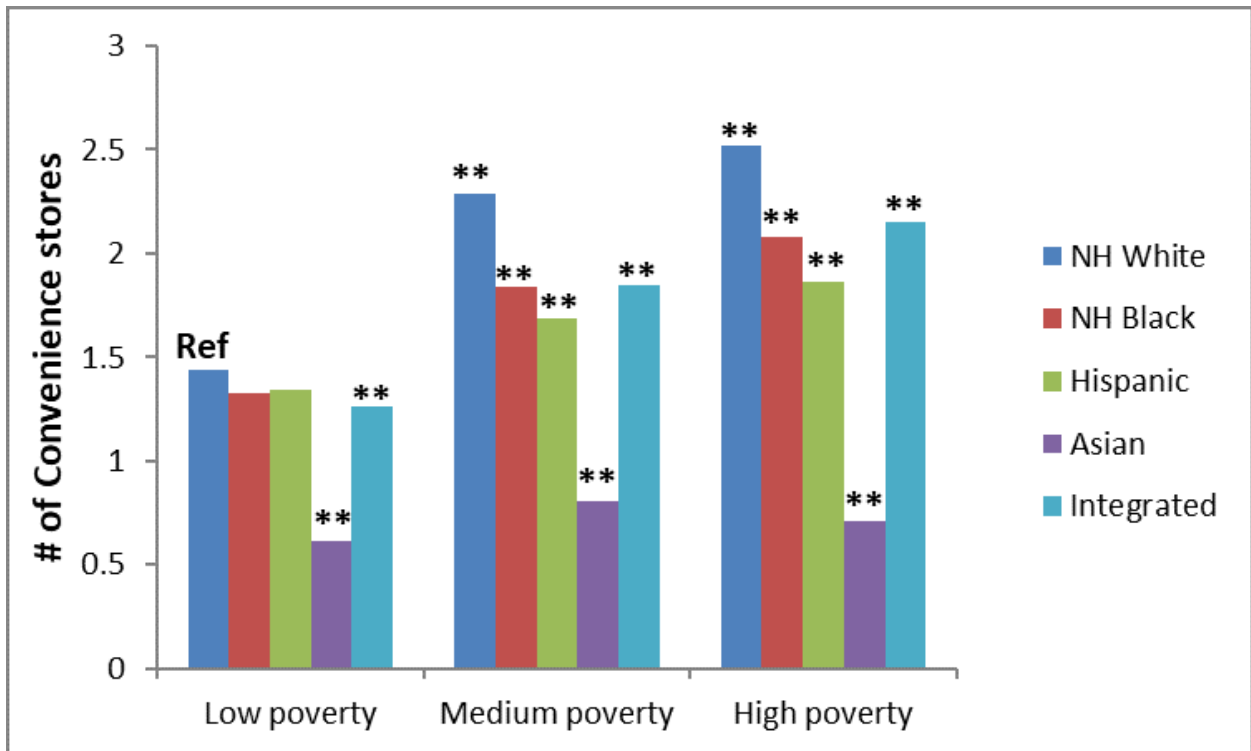
Predominantly NH Black CTs had the most convenience stores the and lowest number of Supermarkets when compared to each of the other groups with Bonferroni correction. For small grocery stores, Hispanic CTs had the most grocery stores and NH White CTs had the fewest, while the mean numbers of small grocery stores in NH Black (1.06 ± 1.39), Asian (1.13 ± 1.92) and Integrated CTs (1.06 ± 1.49) were statistically non-significantly different from each other (see Table 2). Store statistics for each of the 15 combined Race/Ethnicity/Poverty subgroups are shown in Figures 1-3.

Figure 1. Average Count of Supermarkets by Census Tract Poverty Level and Racial/Ethnic Composition, 2020 US Census.



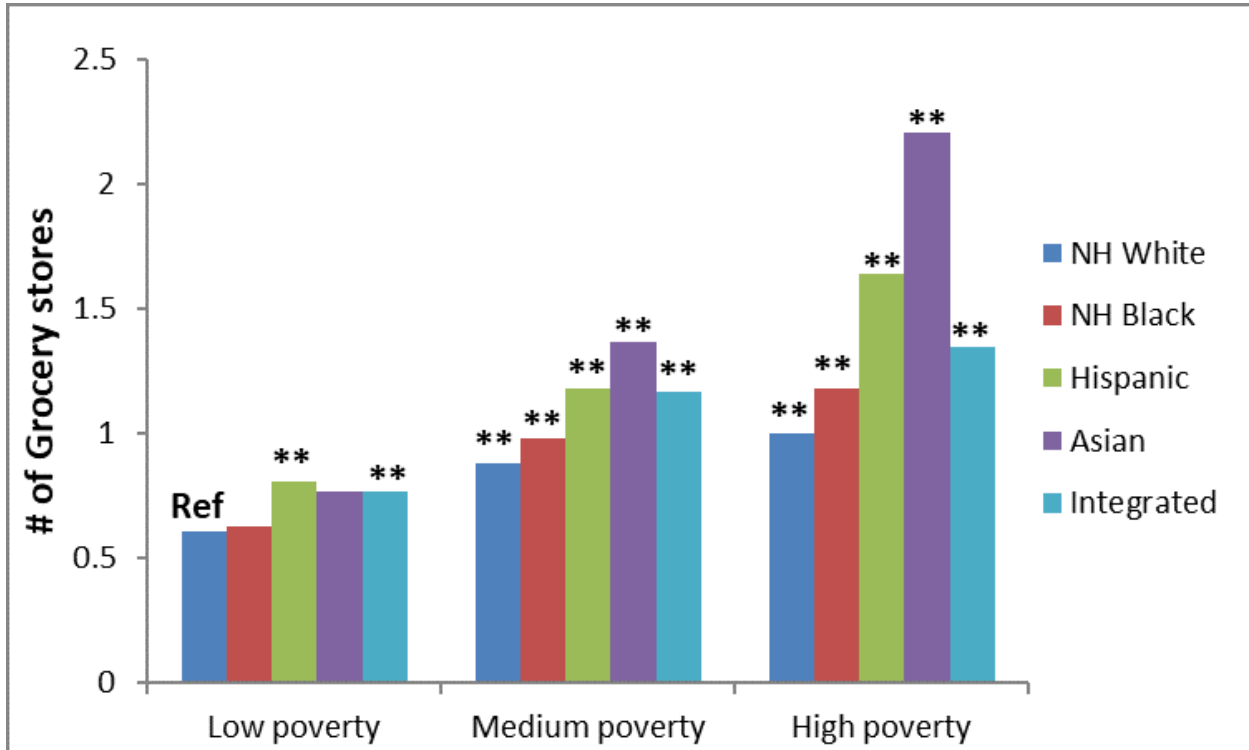
** represents $p \leq 0.001$ when compared to the Reference Group.

Figure 2. Average Count of Grocery Stores by Census Tract Poverty Level and Racial/Ethnic Composition, 2020 US Census.



** represents $p \leq 0.001$ when compared to the Reference Group.

Figure 3. Average Count of Convenience Stores by Census Tract Poverty Level and Racial/Ethnic Composition, 2020 US Census.



** represents $p \leq 0.001$ when compared to the Reference Group.

Regression Models

Results from the negative binomial regression models (Table 3) demonstrated that with predominantly NH White/low poverty CTs as reference, supermarkets decreased with rising poverty levels within NH Black and Hispanic CTs, while no significant differences were observed within NH White low and medium poverty CTs ($p=0.651$), high poverty group and reference group Asian CTs ($p=0.223$), or low poverty group and reference group Integrated CTs ($p=0.30$). NH Black CTs were more severely impacted than the Hispanic CTs, with the lowest IRR among each poverty level. The NH Black/low poverty CTs (IRR 0.57 [0.48, 0.67]) had the fewest supermarkets among the low poverty and medium poverty CTs, only statistically non-significantly better than the Hispanic/high poverty group (IRR 0.55 [0.50, 0.60]).

Table 3: Incidence rate ratios (IRR) for three types of food stores in 83,350 nationwide US Census tracts, 2020

Predominant Race/Ethnic Group	Convenience IRR (95% CI)		Grocery IRR (95% CI)		Supermarket IRR (95% CI)	
	Ref	p-value	Ref	p-value	Ref	p-value
NH White/low poverty	Ref	p-value	Ref	p-value	Ref	p-value

NH White/ medium poverty	1.62 (1.59, 1.65)	<0.001	1.52 (1.48, 1.56)	<0.001	1.01 (0.97, 1.05)	0.651
NH White/ high poverty	1.92 (1.88, 1.98)	<0.001	1.79 (1.73, 1.85)	<0.001	0.93 (0.87, 0.99)	0.016
NH Black/ low poverty	1.01 1.02 (0.94, 1.09)	0.741	1.06 (0.96, 1.17)	0.287	0.57 (0.48, 0.67)	<0.001
NH Black/ medium poverty	1.43 (1.36, 1.51)	<0.001	1.67 (1.57, 1.79)	<0.001	0.48 (0.42, 0.55)	<0.001
NH Black/ high poverty	1.77 (1.71, 1.83)	<0.001	2.16 (2.07, 2.25)	<0.001	0.38 (0.34, 0.42)	<0.001
Hispanic/ low poverty	0.94 (0.89, 0.99)	0.028	1.28 (1.19, 1.37)	<0.001	0.68 (0.61, 0.77)	<0.001
Hispanic/ medium poverty	1.19 (1.15, 1.24)	<0.001	1.85 (1.77, 1.94)	<0.001	0.64 (0.59, 0.70)	<0.001
Hispanic/ high poverty	1.40 (1.36, 1.45)	<0.001	2.68 (2.58, 2.79)	<0.001	0.55 (0.50, 0.60)	<0.001
Asian/ low poverty	0.45 (0.39, 0.51)	<0.001	1.22 (1.09, 1.38)	<0.001	0.79 (0.66, 0.95)	0.011
Asian /medium poverty	0.63 (0.53, 0.75)	<0.001	2.24 (1.92, 2.63)	<0.001	0.65 (0.48, 0.89)	0.007
Asian/ high poverty	0.59 (0.46, 0.76)	<0.001	3.89 (3.23, 4.70)	<0.001	0.78 (0.52, 1.16)	0.223
Integrated/ low poverty	0.88 (0.85, 0.91)	<0.001	1.21 (1.15, 1.26)	<0.001	0.93 (0.88, 0.99)	0.30
Integrated/ medium poverty	1.33 (1.29, 1.38)	<0.001	1.88 (1.80, 1.96)	<0.001	0.90 (0.84, 0.97)	0.004
Integrated/ high poverty	1.69 (1.63, 1.76)	<0.001	2.32 (2.22, 2.43)	<0.001	0.69 (0.63, 0.75)	<0.001

The findings for grocery stores were uniform: for all 15 subgroups, the number of grocery stores increased in stepwise fashion with increasing levels of poverty among each race/ethnic subgroup. At low poverty level, Hispanic/Low poverty CTs had the highest grocery store IRR at 1.28 [1.19, 1.37], while NH Black/low poverty CTs (IRR 1.06 [0.96, 1.17]) were not significantly different from the reference group ($p= 0.287$). Asian/medium poverty had the highest IRR at 2.24 [1.92, 2.63], and Asian/high poverty had the highest IRR at 3.89 [3.23, 4.70] within the medium and high poverty groups, respectively.

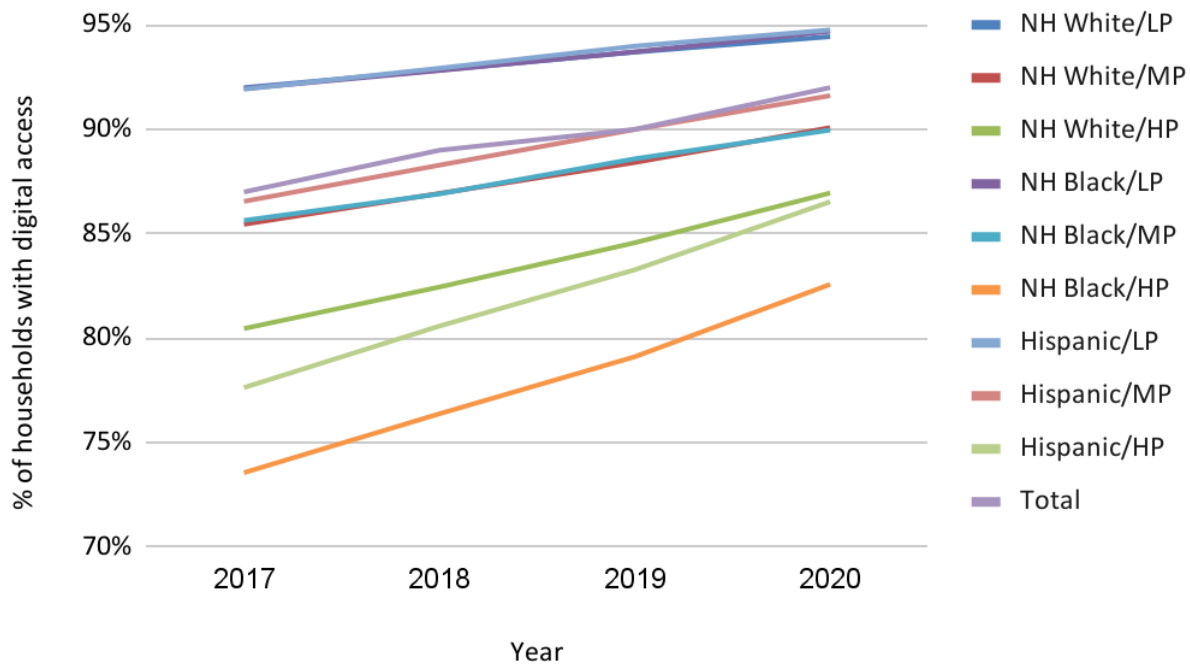
For all racial/ethnic groups, the number of convenience stores increased with rising levels of poverty. NH White/high poverty had the highest IRR (1.92 [1.88,1.98]), followed by NH Black/high poverty (1.77, [1.71, 1.83]), Integrated/high poverty (1.69, [1.63, 1.76]), and Hispanic/high poverty (1.40, [1.36, 1.45]). Asian neighborhoods at all poverty levels had significantly lower numbers of convenience stores, including the Asian/High poverty group with IRR of 0.59 [0.46, 0.76], $p<0.001$, when compared to the reference group.

Trends in urban samples (including 59,106 CTs) were similar to the nationwide sample and were not reported. The rural sample (including 24,244 CTs), NH White CTs made up 88% of the group, NH Black represented 4%, Hispanic 3.3%, Asian 0.1%, and Integrated 5.7%, respectively. Given the skewed distribution and suboptimal model fit parameters, multivariate count regression modeling was not performed on rural samples alone.

Computer and Smartphone Access

As online grocery ordering becomes an increasingly common grocery access strategy, the percentage of households with one or more types of computing devices including smartphones within each major race/ethnic group was tallied from 2017 to 2020 (Figure 4). NH Black/high poverty led all subgroups with the largest absolute increase of 9.02% from 73.56% in 2017 to 82.58% in 2020, followed by the Hispanic/high poverty group with an 8.90% absolute increase (from 77.63% in 2017 to 86.52%).

Figure 4. Percentage of Households with at Least One Computing Device Including Smart Phone Based on Race, Ethnicity and Poverty Levels, From 2017 to 2020.



NH: non-Hispanic; LP: low poverty; MP: medium poverty; HP: high poverty.

Discussion

Multiple studies have shown that living in neighborhoods without access to high-quality food (“food deserts”) predisposes residents to worse dietary intake and consequently diet-related adverse health outcomes such as obesity, hypertension, type 2 diabetes, and other cardiovascular diseases.^{2,15} Policy action and intervention strategies have been implemented to achieve equitable access to healthy foods across the U.S. Most notable is the Healthy Food Financing Initiative.¹⁶ Authorized by the 2014 Farm Bill, and reauthorized by the 2018 Farm Bill,¹⁷ HFFI has been funding innovative food retail and food system enterprises that seek to improve access to healthy food in underserved areas. The results of both research and policy interventions were mixed, with some reporting positive changes while others did not.¹⁸ It was noted that stores in high-poverty, non-White neighborhoods often survived for a shorter duration of time than those in wealthy neighborhoods.¹⁰ One study reviewed six cases of failed food store interventions in food deserts⁹ but could not identify a unifying rationale to explain why inner-city grocery store interventions were not successful. For those that did survive, one study reported that supermarkets opening in a food desert led to little improvement in the net availability of healthy foods, thus challenging the underpinnings of policies such as the HFFI.² The concept of geographic food access was further challenged by a study reporting that supermarket access actually improved though income did not, resulting in a net increase in low-income, low-access census tracts observed between 2010 and 2015,⁶ suggesting that income and resource constraints may be greater barriers to accessing healthy food retailers than simple proximity.

In this study, the IRR [95% CI] for Black/high poverty CTs was 0.38 [0.34, 0.42], compared to the reference group of White/low poverty CTs, a 62% lower accessibility. Even the Black/low poverty group, despite being at the same level in terms of income as the reference group, had significantly lower IRR (0.57 [0.48, 0.67]). The IRRs based on the 2000 US census data from the

Bower study⁸ were 0.30 [0.26, 0.34] (Black/high poverty) and 0.59 [0.45, 0.77] (Black/low poverty), respectively, indicating minimal improvement over the past 20 years. This pattern was also seen in Hispanic groups as well, albeit to a lesser degree. Despite 20 years of intense policy and community interventions aimed at improving food access equity, and despite a notable improvement in poverty in minority groups (61.3% of all NH Black CTs and 44.1% all Hispanic CTs belonged to the high poverty categories in 2020, an improvement from 70.7% and 71.5%, respectively), the lack of significant improvement to supermarket accessibility in the most vulnerable neighborhoods warrants close examination and creative rethinking of current strategies and policies. Challenges of opening and maintaining supermarkets in food desert neighborhoods are multifactorial and have shown resistance towards interventions. Innovative strategies are urgently needed to address this national health disparity. The COVID-19 pandemic-related rise in unemployment, volatility in supply chains and lost access to school meals all led to a doubling of food insecure households in 2020.¹⁹ According to a Pew Research Survey, though the digital lives of Americans with lower and higher incomes remain markedly different, smartphone ownership has stood out with the highest and fastest growth in low-income individuals (at 76% in those making <\$30,000/year household income, as compared to 59% for desktop or laptop computer, and 57% for home broadband).²⁰

Smartphones have the potential to close or at least narrow the digital divide among low-income, minority individuals with traditionally low technology adoption rate. With the 2020 Census data, our analyses observed the same trend. Ownership of any type of computing device including smartphones in predominantly Black/high poverty areas saw the largest absolute increase from 73.6% of households in 2017 to 82.6% in 2020. The implication of this trend is profound. With the challenges of opening and retaining a traditional supermarket store in low-income minority neighborhoods, online grocery shopping (e-grocery), which received an unforeseen boost from the COVID-19 pandemic, appears to offer a unique opportunity for exploration. Online grocery sales jumped from \$53.19 billion in 2019 to \$110.72 billion in 2020, a 108.2% increase.²¹ Of the 2,500 participants surveyed, 78% used their mobile devices when placing orders and 77% ordered from big box retailers like Costco, Wal-Mart, or Kroger. Online grocery shopping appears well positioned to serve the low-income minority residents living in food deserts; the e-grocery platforms are less location sensitive and technology dependent, two major hurdles for these communities to adopt this new way of grocery shopping. Significant knowledge and measurement gaps exist in terms of consumer behavior towards online grocery shopping and logistical constraints of delivery zone coverage. Further feasibility/cost-effectiveness evaluation, education, outreach, and policy changes are needed to assess whether app-based online grocery shopping is a viable option to overcome the multiple challenges posed by the lack of easy access to brick-and-mortar supermarkets in food desert neighborhoods.

Conclusions

Our findings suggest that, similar to 2000 Census data, neighborhood poverty status and racial/ethnic composition are independently associated with accessibility of high, medium, and low-quality grocery stores. Poor predominantly Black neighborhoods remain most limited in their access to high-quality food items from Supermarket stores, despite improved poverty levels in minority groups and 20 years of targeted policy interventions. Fast-rising smartphone ownership in low-income minority residents offers the promise to explore online grocery shopping as an alternative to overcome the hurdles posed by poor access to traditional offline stores.

Limitations

There are several limitations of this study. First, this study is based on the assumption that individuals prefer to shop at the food store closest to their homes. Recent research, however, has shown that the average American household often bypasses the closest stores in favor of their preferred store further away,¹⁹ thus challenging the validity of traditional food access mapping and analysis, this study included. Second, commercial databases like ReferenceUSA™ have potential classification biases and lack complete information on certain proprietary, privately owned franchises. Furthermore, community-driven food security measures such as fruit stands, farmers' markets, and community gardens are often not included in traditional food access classification systems. Lastly, using census tracts to map food stores may run into classification ambiguity problems as food retailers tend to run along census tract boundaries adjacent to busy and easily accessible roads, resulting in potential undercounting of stores in certain neighborhoods.⁸ Despite these limitations, this study highlights the persistent disparities of food store accessibility as a function of neighborhood socio-economic-demographic characteristics and the urgent need for intervention.

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