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Neighborhood Food Environment Associated with Cardiometabolic Health among Predominately Low-income, Urban, Black Women

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Objectives: This study sought to: 1) understand how the perceived food environment (availability, accessibility, and affordability) is associated with cardiometabolic health outcomes in predominately low-income Black residents in urban neighborhoods with limited healthy food access; and 2) examine the association of shopping at specific store types with cardiometabolic health outcomes.

Methods: We report on cross-sectional data from 459 individuals participating in the Pittsburgh, PA Hill/Homewood Research on Neighborhoods and Health (PHRESH) study. Mean participant age was 60.7 (SD=13.9); 81.7% were female. We used logistic regression to examine associations between three factors (perceived fruit and vegetable availability, quality, and price; primary food shopping store characteristics; and frequency of shopping at stores with low or high access to healthy foods) and cardiometabolic and self-rated health.

Results: Adjusting for sociodemographic characteristics, participants with higher perceived fruit and vegetable accessibility (AOR:.47, 95%CI: .28-.79, P=.004) and affordability (AOR:.59, 95%CI: .36-.96, P=.034) had lower odds of high blood pressure. Shopping often (vs rarely) at stores with low access to healthy foods was associated with higher odds of high total cholesterol (AOR:3.52, 95%CI: 1.09-11.40, P=.035). Finally, primary food shopping at a discount grocery (vs full-service supermarket) was associated with lower odds of overweight/obesity (AOR:.51, 95%CI: .26-.99, P=.049).

Conclusions: These results suggest that both perceived accessibility and affordability of healthy foods are associated with reduced cardiometabolic risk factors in this urban, low-income predominantly Black population. Additionally, discount grocery stores may be particularly valuable by providing access and affordability of healthy foods in this population. *Ethn Dis.* 2021;31(4):537-546; doi:10.18865/ed.31.4.537

Keywords: Neighborhood Food Environment; Cardiometabolic Health; African Americans; Food Retail Stores

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Introduction

Disparities in cardiometabolic risk factors by income and race are well-established. Low socioeconomic status (SES) has been associated with poor nutritional health, high levels of obesity, and higher rates of cardiovascular disease and diabetes.[1-3] Known racial and ethnic differences in cardiovascular disease presentation, risk factors, and treatment have also been previously reported.[4] For example, non-Hispanic Blacks are twice as likely as non-Hispanic Whites to have high blood pressure and diabetes even after adjusting for sociodemographic factors.[4,5]

Due to racial segregation and other historical policies (eg, urban renewal) rooted in structural racism, the neighborhood environment often perpetuates socioeconomic and racial disparities. For example, Black US residents are four times more likely to live in low SES neighborhoods than Whites. Further, neighborhood SES has been associated with the prevalence of multiple cardiovascular risk factors.[6]

Food Environment

Improving the neighborhood food environment has been suggested as a potential policy-level intervention to positively influence dietary behaviors and improve cardiometablic health, particularly among vulnerable populations.[1, 7–11] The perceived food environment can be conceptualized by three main dimensions[7]: 1) availability (the adequacy of the supply of healthy and nutritious food; eg, a large selection/high quality fruit and vegetables); 2) accessibility (the loca-

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tion of food supply and ease of getting to that location); and 3) affordability (the prices of food and people's perceptions of worth relative to cost).

Easy access to supermarkets has been associated with better perceived availability of produce and low-fat foods and with higher intake of healthy foods.[1,12] Communities lacking healthy food sources such as supermarkets, supercenters, or large grocery stores are considered low access, or food deserts.[13] Previous studies have shown mixed results with the question regarding supermarket proximity and diet; moreover, there are mixed findings regarding the effect of supermarket proximity on diabetes control and glycated hemoglobin (HbA1c) levels.[14,15]

The purpose of this study was to: 1) understand how the perceived food environment was associated with cardiometabolic health outcomes in predominately low-income Black residents in urban neighborhoods…; and 2) examine associations between cardiometabolic health outcomes and shopping at specific store types.

The presence of other retail food shopping store types, including corner stores, gas stations, and small independent stores has been associated with worse perceptions of access to healthy foods.[12,16–18] Another store type gaining popularity in recent years, the discount grocery store (eg, Aldi and Lidl), may provide greater access to healthy foods than other stores (eg, convenience stores and dollar stores), but less so than supermarkets. Environmental public health studies reporting on discount grocery stores have only recently been published, and none examine their effect on health outcomes in low-income communities.[19]

Food Environment Inequities

Individuals in predominantly minority neighborhoods experience greater environmental barriers toward maintaining a healthy diet compared with individuals in mixed-race neighborhoods.[20] A national study found that predominantly Black neighborhoods have fewer supermarkets than White neighborhoods.[2] Socioeconomic disparities also exist, as one study found that Black women with higher per capita incomes are more likely to shop at supermarkets, which was also associated with increased fruit and vegetable intake.[21] These neighborhood differences by SES in the availability of food and economic barriers toward purchasing food may partially explain why groups with lower SES have poorer diets and more diet-related diseases compared with higher SES groups.[1]

Prior research has largely focused on: a) understanding the associations between food store usage and diet, self-reported health, and obesity outcomes[21–24]; and b) understanding the association between geographic food environment availability and cardiometabolic health outcomes.[25–29] However, studies have seldomly examined the association between type of food store usage and cardiometabolic health outcomes (high blood pressure, high blood sugar, high cholesterol, and low HDL). Given the limited research in this area, the purpose of this study was to: 1) understand how the perceived food environment (availability, accessibility, and affordability) was associated with cardiometabolic health outcomes in predominately low-income Black residents in urban neighborhoods that have limited food access; and 2) examine associations between cardiometabolic health outcomes and shopping at specific store types (full service grocery stores, discount grocery stores, wholesale clubs, specialty stores, and convenience stores).

Methods

Study Population

Participants for this study were obtained from the Pittsburgh Hill/Homewood Research on Neighborhoods and Health (PHRESH) study. The PHRESH Study is a longitudinal natural experiment examining various neighborhood investments, including a full-service supermarket, in

a predominantly Black, low-income, urban neighborhood in Pittsburgh, PA, as compared with a demographically matched comparison neighborhood. Baseline data for the PHRESH Study were collected in 2011, and post-intervention assessments were conducted in 2014, 2016, and 2018. The 2011 cohort of residents was recruited originally as a random sample of household primary food shoppers in the two urban neighborhoods. Detailed methods of the PHRESH study including study design, methodology, and primary findings have been published elsewhere.[23]

To be eligible for the current cross-sectional analyses, participants were required to have completed a household interview and provided a blood sample in 2018. Of the 711 with a household interview, a total of 459 PHRESH study participants also had a blood sample and were considered eligible for this study. Based on demographic factors and household interview responses, these participants were not significantly different than the 252 participants interviewed in 2018 who did not provide a blood sample but appeared to have a higher percentage of individuals self-reporting high blood pressure (79% vs 68%) and with a BMI ≥ 25 kg/m^2 (81% vs 72%).

Household Interviews

Community data collectors administered a 90-minute interview within a participant's home or a selected community setting (May - November 2018). Socio-demographic factors measured included: neighborhood of residence (Hill/Homewood/Other); years lived in neighborhood; sex (male/female); marital status/living with partner (yes/no); highest education level (less than high school, high school, some college/tech, college/grad degree); race/ethnicity; and age. Due to a very small number of missing values in marital status/living with partner, years lived in neighborhood, and income, these three variables were imputed using a single draw or imputation from PROC MI.[30] Our imputation model included predictors that were correlated with nonresponse and the imputation variable. Participant height, weight and blood pressure were also measured, and participants were invited to participate in a blood draw. If the participant consented, a trained study phlebotomist collected 10 mL of blood while the participant was seated. Due to feasibility concerns, participants were not required to fast prior to the blood draw. Assays were sent to the University of Pittsburgh Heinz Nutrition Laboratory at the Graduate School of Public Health and the University of Pittsburgh Medical Center (UPMC) Presbyterian hospital. Participants signed consent forms for both the household interview and the blood draw. All study protocols were approved by the RAND Corporation's Institutional Review Board and the University of Pittsburgh's Institutional Review Board.

Independent Variables

Perceptions of Access to Fruit and Vegetables

Participants stated how much they agreed with four different statements about perceived fruit and vegetable availability in their neighborhood on a scale of 1-5 (1=strongly disagree to 5=strongly agree): It is easy to buy fruit and vegetables in my neighborhood; there is a large selection of fruit and vegetables in my neighborhood; the fruit and vegetables in my neighborhood are of high quality; and the price of fruit and vegetables in my neighborhood is acceptable to me.[31] Each variable was dichotomized into agree (strongly agree and agree) and disagree (strongly disagree, disagree, and neither agree nor disagree) based on how the variables were distributed.

Store Type

Using a four-point scale, participants rated how frequently (never-often) they went to 11 different types of food retail venues to buy food. Examples of store types for each category (eg, Supercenter: Walmart) were provided for clarification. For analyses, the scale was collapsed into a categorical weighted scale with answers: never (0); occasionally and sometimes (1); and often (2).

Food retail venues were classified into two categories, low-access and high-access to healthy foods, based upon prior objectively collected PHRESH store audit data.[24] Convenience stores, neighborhood stores, dollar stores, and drug stores were classified as low access to healthy foods and discount grocery stores, supercenters, wholesale clubs, full-service supermarket, specialty grocery stores, meat or seafood markets, and fruit and vegetable stores/farm stands were classified as high access.

A count variable was created to represent frequency of shopping (ie, never=0, occasionally and sometimes=1, and often=2) at low

and high healthy food access stores. Shopping frequency responses at low access to healthy food stores were summed together to create a summary score, and the same approach was used to create a summary score for high access to healthy food stores. The max available summed score for both variables was categorized into "rarely," "sometimes," and "often" to represent frequency of shopping at low access and high access to healthy food stores.

Major Food Shopping

Participants provided the name and address of the store where they did their major food shopping. Seven categories were represented: Discount grocery store (eg, Aldi's); supercenter (eg, Walmart); wholesale club (eg, Sam's Club); specialty grocery store (eg, Whole Foods); full-service supermarket (eg, Giant Eagle); meat or seafood market; and fruit and vegetable store (eg, farmer's market). Due to similarities, store type was collapsed into 4 categories: Discount grocery store; supercenter or wholesale club; full-service supermarkets; and specialty store (specialty grocery store, meat or seafood market, and fruit and vegetable store). Participants reported the number of times they visited this primary store for major food shopping in the past month and the main reason they did their major food shopping at their primary store: 1) quality of food; 2) price; 3) convenience of location; and 4) other attributes including choice of items, customer service, cleanliness, or fuel perks (monetary incentives for gas to shop at a particular grocery store).

Outcome Variables

Self-rated Health

During the interview, participants rated their health on a 5-point scale from excellent to poor. This variable was dichotomized into good health (good, very good, and excellent) and fair/poor health.[32]

Body Mass Index

BMI was calculated from participant's measured height and weight. Height was measured with no shoes on to the nearest 1/8 inch using a carpenter's square (triangle) and an 8' folding wooden ruler marked in inches. Weight was measured to the nearest 1/10 pound using a Seca Robusta 813 digital scale. BMI was calculated from measured height and weight and categorized into normal weight ($18.5 \leq BMI < 25$ kg/m^2) and overweight/obesity (≥25 kg/m^2).

Blood Pressure

Blood pressure was measured using an automated blood pressure monitor after the participant was seated for five minutes. Three measurements were taken, and the average of the last two measurements were used to calculate average systolic and diastolic blood pressure. High blood pressure was defined using American Diabetes Association (ADA) criteria as SBP ≥140 mm Hg or DBP ≥90 mm Hg or currently taking blood pressure medication.[33]

Blood Draw Variables

ADA criteria was used to define blood draw outcomes.[33] High blood sugar was considered as HbA1c ≥6.5% or taking medication; high cholesterol was considered as a total cholesterol of ≥200 mg/dL or taking medication, and ≤40mg/dL was considered to be low HDL.[33] Participants provided a list of current medications to the data collector.

Statistical Analyses

Univariate descriptive statistics were calculated to characterize participants' sociodemographics, food shopping perceptions and habits, and health outcomes. Odds ratios were calculated from logistic regression models to quantify the associations between: 1) perceived fruit and vegetable availability, quality, and price; 2) frequency of shopping at low and high healthy food access stores; and 3) primary food shopping store type and reason for shopping there, and cardiometabolic and self-rated health outcomes, respectively. Multivariate models were used to provide estimates of associations that accounted for important covariates. To account for the design of the PHRESH study we included an indicator of neighborhood as a covariate in all multivariate models. Additional individual-level covariates included age, annual income, education, marital status, and years lived in neighborhood (1-88 years). Each model included one independent variable, one outcome variable, the neighborhood indicator, and all covariates. The basic assumptions of logistic regression were confirmed. All first level interactions were tested, and none were significant. All analyses were performed in STATA 16.

Results

Characteristics of Study Participants

The mean (SD) age of participants (n=459) was 60.7 (13.93)

years, 81.7% (n=375) of participants were female, and 92.8% of participants (n=426) were Black or Mixed-Black (Table 1). Additionally, 14.6% (n=67) of participants were either married or living with their partner, 88.5% (n=406) had a high school education or higher, and the median income per household member was $12,500 (IQR: $6250-$17500). Participants reported living 32 years in their neighborhood, on average.

The majority of participants reported doing their primary food shopping at a full-service supermarket (68%; n=312). Some chose their primary food shopping store due to the quality of food (31.5%; n=144) or the convenience of its location (27%; n=123). Most commonly, participants visited their primary food shopping store 2 to 3 times a month (49%; n=224) (data not shown).

Of the participants, 77% had high blood pressure (interviewer-measured) or were on blood pressure medication at the time of the study. Also, the majority of participants had overweight/obesity (81%). Additionally, 34% of participants had high blood sugar or were on diabetes medication, 45% had high cholesterol or were on cholesterol medication, and 31% had low HDL. Lastly, 37% of participants reported poor self-rated health.

Table 1. Characteristics of PHRESH Study participants providing blood samples (2018 assessment; N=459)

Variable	n (%)
Neighborhood	
Hill District	305 (66.45)
Homewood	108 (23.53)
Other	46 (10.02)
Years lived in neighborhood, mean (SD)	32.43 (22.85)
Sex	
Female	375 (81.70)
Male	84 (18.30)
Race	
Black or Mixed-Black	426 (92.81)
Other	29 (6.37)
Marital status [a]	
Not married	392 (85.40)
Married or living with partner	67 (14.60)
Highest education level	
Less than high school	53 (11.55)
High school	176 (38.34)
Some college/tech	173 (37.69)
College/grad degree	57 (12.42)
Age (mean, SD)	60.7 (13.93)
Income per household member, thousands [a] median (IQR)	12.5 (6.25,17.50)
BMI	
Normal weight, 18.5<= BMI <25 kg/m^2	87 (19.08)
Overweight/obesity, ≥25 kg/m^2	369 (80.92)
High blood pressure[b]	
No	95 (20.70)
Yes	354 (77.12)
High blood sugar[c]	
No	302 (65.80)
Yes	157 (34.20)
High cholesterol[d]	
No	254 (55.34)
Yes	205 (44.66)
Low HDL (<=40mg/dL)	
No	315 (68.63)
Yes	144 (31.37)
Self-rated health[e]	
Excellent/very good/good health	288 (62.75)
Fair/poor health	171 (37.25)

a. Variable was imputed to account for missing values
b. High blood pressure: SBP≥140 mm HG or DBP ≥90 mm Hg or currently taking high blood pressure medication
c. High blood sugar defined as HbA1c ≥6.5% or on diabetes medication
d. High cholesterol defined as total cholesterol ≥200 mg/dL or on cholesterol medication
e. Self-rated health was dichotomized into good health (good, very good, and excellent) and fair/poor health

Accessibility and Affordability of Fruit and Vegetables and Health Outcomes

As shown in the fully adjusted model in Table 2, individuals who agreed (vs disagreed) that it was easy to purchase fruit and vegetables in their neighborhood had lower odds of high blood pressure (AOR=.47, 95%CI: .28, .79, P=.004) and lower odds of poor/fair self-rated health (AOR=.59, 95%CI: .39, .90, P=.013). Additionally, individuals who agreed (vs disagreed) that fruit and vegetables in one's neighborhood were affordable (good price) also had lower odds of high blood pressure (AOR=.59, 95%CI: .36, .96, P=.034) and of poor/fair self-rated health (AOR=.64,

Table 2. Adjusted odd ratios (95% CI)[a] for relationship between predictors related to perceived fruit and vegetable availability, quality, and price and cardiometabolic outcomes

	High blood Pressure[b]	High Blood Sugar[c]	High Cholesterol[d]	Low HDL[e]	Overweight/ Obesity[f]	Poor/Fair Health[g]
	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)
Easy to buy fruit and vegetables (Y vs N)	.47 (.28, .79)[i]	1.08 (.71, 1.64)	1.33 (.89, 1.98)	1.23 (.80, 1.87)	1.05 (.63, 1.74)	.59 (.39, .90)[h]
Large selection of fruit and vegetables (Y vs N)	.66 (.41, 1.06)	.96 (.64, 1.44)	1.27 (.86, 1.86)	1.13 (.75, 1.70)	1.05 (.64, 1.71)	.67 (.45, 1.01)
High quality fruit and vegetables (Y vs N)	.86 (.53, 1.39)	1.02 (.69, 1.53)	1.20 (.81, 1.77)	1.06 (.70, 1.60)	1.25 (.76, 2.07)	.62 (.41, .94)[h]
Good price for fruit and vegetables (Y vs N)	.59 (.36, .96)[h]	1.05 (.70, 1.60)	1.24 (.83, 1.84)	.92 (.60, 1.40)	.89 (.54, 1.47)	.64 (.42, .97)[h]

5-point Likert scale variable survey questions were collapsed: Agree (agree and strongly agree) or Disagree (strongly disagree, disagree, and neither agree nor disagree)
Each cell represents a single model with the single outcome variable, single independent variable, and all covariates
a. Adjusted for age, sex, adjusted income, marital status, education, neighborhood, years lived in neighborhood
b. High blood pressure: SBP≥140 mm Hg or DBP ≥90 mm Hg or currently taking high blood pressure medication
c. High blood sugar defined as HbA1c ≥6.5% or on diabetes medication
d. High cholesterol defined as total cholesterol ≥200 mg/dL or on cholesterol medication
e. Low HDL defined as HDL≤40 mg/dL
f. Overweight defined as BMI ≥25.0 kg/m^2
g. Self-rated Health Status 5-point Likert scale variable was collapsed: Poor (fair and poor) and Good (good, very good, and excellent)
h. P≤.05
i. P≤.01

95%CI: .42, .97, P=.036). Participants who agreed (vs disagreed) that there was access to high quality fruit and vegetables in their neighborhood also had lower odds of poor/fair self-rated health (AOR=.62, 95%CI: .41, .94, P=.023). No significant associations were found between access and affordability of fruit and vegetables and other health outcomes.

Primary Shopping and Associations with Health Outcomes

Individuals reporting their primary food shopping location as a discount grocery store (vs full-service grocery) had lower odds of overweight/obesity (AOR=.51, 95%CI: .26, .99, P=.049). Additionally, individuals reporting higher monthly frequency of visits to a primary food store had lower odds of low HDL (AOR=.74, 95%CI: .55, .98, P=.036). Individuals who reported choosing a primary food store based on price (vs quality of food) had twice the odds of high total cholesterol (AOR=2.02, 95%CI: 1.19, 3.45, P=.010). Reporting primary food shopping at specialty stores and supercenters or wholesale clubs (vs full-service grocery) were not significantly associated with lower odds of poor health outcomes. (Table 3)

Shopping Frequency at Stores with High/low Access to Healthy Food and Associations with Health Outcomes

As also shown in Table 3, individuals reporting shopping often (vs rarely) at stores with low access to healthy foods had higher odds of high cholesterol (AOR=3.52, 95%CI: 1.09, 11.40, P=.035). Individuals who reported shopping often (vs rarely) (AOR=.36, 95%CI: .15, .85, P=.021) and sometimes (vs rarely) (AOR=.58, 95%CI: .36, .92, P=.023) at stores with high access to healthy foods had lower odds of poor/fair self-rated health. No significant associations with other examined health outcomes were identified.

Discussion

Overall, this study population had a higher prevalence of high blood pressure, high blood sugar, high cholesterol, low HDL, and overweight/obesity compared with the US adult Black population.[34,35] The findings from this study suggest that among a

Table 3. Adjusted odd ratios (95% CI)[a] for relationships between predictors related to the primary food shopping store or frequency of shopping at stores with high or low access to healthy foods and cardiometabolic outcomes

	High blood pressure[b]	High blood sugar[c]	High cholesterol[d]	Low HDL[e]	Overweight/ obesity[f]	Poor/fair health[g]
	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)	AOR (95%CI)
Primary food shopping store						
Discount grocery store vs full-service grocery (ref)	.60 (.32, 1.15)	1.49 (.83, 2.68)	1.54 (.87, 2.72)	1.11 (.61, 2.02)	.51 (.26, .99)[l]	.67 (.36, 1.22)
Supercenter/wholesale club vs full-service grocery (ref)	1.07 (.51, 2.22)	.97 (.52, 1.84)	1.21 (.66, 2.21)	1.19 (.65, 2.21)	.67 (.31, 1.44)	1.08 (.59, 1.97)
Specialty store[h] vs full-service grocery (ref)	.84 (.28, 2.56)	.51 (.16, 1.59)	1.70 (.67, 4.35)	1.23 (.46, 3.26)	1.12 (.31, 4.09)	.52 (.16, 1.64)
Times visited primary food store past month	1.15 (.83, 1.61)	1.22 (.92, 1.62)	1.08 (.83, 1.41)	.74 (.55, .98)[l]	.97 (.69, 1.36)	.92 (.69, 1.22)
Reason chose to do food shopping at primary store						
Price vs quality of food (ref)	.89 (.47, 1.68)	1.22 (.70, 2.11)	2.02 (1.19, 3.45)[l]	1.04 (.60, 1.81)	.89 (.45, 1.76)	.96 (.55, 1.66)
Convenient location vs quality of food (ref)	.96 (.51, 1.80)	.97 (.57, 1.64)	1.14 (.69, 1.89)	1.29 (.77, 2.17)	.74 (.40, 1.37)	.78 (.46, 1.30)
Other attributes[i] vs quality of food (ref)	1.08 (.53, 2.22)	.95 (.53, 1.72)	1.11 (.63, 1.97)	1.08 (.60, 1.95)	1.00 (.48, 2.10)	.93 (.51, 1.68)
Frequency shopping at stores with low access to healthy food[j]						
Sometimes vs rarely (ref)	1.48 (.87, 2.58)	.80 (.51, 1.27)	1.12 (.72, 1.73)	.74 (.46, 1.17)	.95 (.55, 1.64)	1.10 (.70, 1.71)
Often vs rarely (ref)	.57 (.18, 1.81)	1.23 (.35, 4.29)	3.52 (1.09, 11.40)[l]	1.62 (.52, 5.07)	.74 (.18, 3.02)	.59 (.17, 2.08)
Frequency shopping at stores with high access to healthy food[k]						
Sometimes vs rarely (ref)	1.46 (.82, 2.58)	.86 (.53, 1.39)	1.06 (.67, 1.69)	1.02 (.62, 1.67)	.90 (.51, 1.59)	.58 (.36, .92)[l]
Often vs rarely (ref)	.94 (.40, 2.23)	.90 (.39, 2.09)	.98 (.45, 2.16)	1.51 (.68, 3.34)	.90 (.51, 1.59)	.36 (.15, .85)[l]

a. Adjusted for age, sex, adjusted income, marital status, education, neighborhood, years lived in neighborhood. Each cell represents a single model with the single outcome variable, single independent variable, and all covariates
b. High blood pressure defined as SBP ≥140 mm Hg or DBP ≥ 90 mm Hg or taking blood pressure medication
c. High blood sugar defined as HbA1c ≥6.5% or on diabetes medication
d. High cholesterol defined as total cholesterol ≥ 200 mg/dL or on cholesterol medication
e. Low HDL defined as HDL≤40 mg/dL
f. Overweight defined as BMI ≥25.0 kg/m^2
g. Self-rated Health Status 5-point Likert scale variable was collapsed: Poor (containing answer options fair and poor) and Good (containing answer options good, very good, and excellent)
h. Specialty store: Specialty grocery store, Meat or seafood market, and fruit and vegetable store
i. Other: choice of items, customer service, cleanliness, and fuel perks
j. Low access stores: convenience stores, drug stores, neighborhood stores, and dollar stores
k. High access stores: discount grocery stores, supercenters, wholesale clubs, grocery stores, full-service supermarkets, meat or seafood markets, and fruit and vegetable stores or farm stands
[l] P≤.05

Pittsburgh sample of urban, predominantly low-income Black residents, higher perceived access to fruit and vegetables in one's neighborhood, choice of primary food shopping store, and frequency of shopping at stores with high access to healthy foods were associated with lower odds of poor cardiometabolic health. We found evidence that greater accessibility and affordability of healthy foods was associated with lower odds of both poor cardiometabolic and self-rated health. This analysis adds to current literature suggesting that neighborhood food environments with increased access to healthy foods are associated with positive dietary behaviors and cardiometabolic health.[7,36] Our results are supported by a strong study design and clinically measured outcomes.

The relationships between fruit and vegetable access and affordability with blood pressure and perceived health were the most consistent findings in this study. The ease of buying fruit and vegetables and paying a rea-

sonable price for them were associated with 50% and 40% reduced odds of having high blood pressure, respectively. Results were similar for self-rated health; with close to 40% lower odds of self-reported poor health for individuals reporting ease of buying, good price, and large selection of fruit and vegetables, respectively. These findings are relevant, given the large disparities in high blood pressure and other indicators of cardiovascular health for non-Hispanic Blacks compared with non-Hispanic Whites.[4]

Some prior studies (including the primary PHRESH study results) suggest that opening supermarkets in food deserts do not necessarily result in increased fruit and vegetable intake for neighborhood residents.[22,37] However, a previous study among both low and high SES primary food shoppers suggested that reducing fruit and vegetable prices in supermarkets could significantly increase consumption.[38] Along with previous food environment studies, our findings suggest that interventions for low-income Black populations involving the food environment should consider strategies for improving convenience and affordability of fruit and vegetables.

Discount grocery stores, which gained popularity in 2008 after the recession, focus on low-cost operations and merchandising using competitive prices within a small store format and own-brand products.[39,40] As the widespread use of discount grocery stores is recent, there is limited literature understanding the effects that shopping at a discount grocery store has on diet and overall health.[19] Our results suggested that there were nearly 50% lower odds of overweight/obesity for individuals reporting a discount grocery store as their primary food shopping store. This supports and adds to the small body of literature, which has suggested that discount grocery stores may be an important correlate of good dietary and cardiometabolic health in low-income populations due to their offering of low-priced, healthy foods.[17,41]

Previous quasi-experimental longitudinal studies, including the PHRESH study, found that opening a supermarket in a low-income primarily Black community did not improve BMI or fruit and vegetable intake.[22,23] However, while supermarkets may increase the availability of healthy food, they do not necessarily provide them at affordable prices. Although the selection of foods (including fruit, vegetables, and other healthy foods) is more limited at discount grocery stores than supermarkets, available foods are offered at lower prices.[24] For reference, Aldi, the most prevalent discount grocery store in the United States (and in close proximity to our urban study neighborhoods), has a $13 lower price per basket for 40 common foods compared with Walmart.[40,42] From previous study results we know that most of this population chose their primary food shopping stores based on prices rather than quality of food, further supporting our findings that because of their affordable prices, discount grocery stores may be valuable toward good dietary and cardiometabolic health in low-income populations.[17,41]

These results also suggest that shopping at small stores with low access to healthy foods is associated with much higher odds of having high cholesterol. This is consistent with existing studies suggesting a link between low access stores and poorer cardiometabolic health.[16,24] Interestingly, in this cohort shopping sometimes and often at stores with high access to healthy foods was associated with 60% and 30% lower odds of self-rated poor health, while relationships with specific cardiometabolic outcomes were less consistent. Our findings support prior research pushing for interventions that attempt to curb unhealthy food purchases at stores with high access to healthy foods and replace them with healthier purchases toward producing meaningful improvements in diet and cardiometabolic outcomes.[18] These results suggest further research should be aimed toward understanding how direct food choices made at stores impact cardiometabolic health.

Strengths and Limitations

The primary strength of this study is that it is one of the first studies, to our knowledge, to examine the association between the food environment, specifically type of food store usage, and measured cardiometabolic outcomes. Most previous studies examine diet, self-reported BMI, and self-reported cardiometabolic outcomes while we report on clinic-measured cardiometabolic outcomes including blood pressure, blood sugar, cholesterol, and BMI. Additionally, most studies in the literature examine the geographic food environment, but our study specifically relates individual usage of different food stores to measured cardiometabolic outcomes.

One of the main limitations of the study is that it is cross-sectional,

limiting causal inferences. There was also some self-selection in the study population, as those who participated in the blood draw were more likely to have high blood pressure and more likely to be overweight compared with those who did not. Also, while this study has limited generalizability as this was a primarily low-income, Black, older, unmarried, and female population, the study design and population allow us to determine specific areas of future research and intervention that can be tailored to help improve health in this at-risk population.

Conclusion

This study shows that interventions aimed at improving general and cardiometabolic health through the food environment should consider focusing on improving not only the accessibility, but also affordability of fruit and vegetables within primarily low-income, urban, Black populations. Although more research is also needed to verify the relationship between shopping at discount grocery stores and cardiometabolic health outcomes, our results suggest that interventions centered around discount grocery stores could be particularly valuable by providing both high access and affordability of healthy foods.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Corona, Troxel, Ghosh-Dastidar, Gary-Webb; Acquisition of data: Corona, Dubowitz, Troxel, Gary-Webb; Data analysis and interpretation: Corona, Dubowitz, Troxel, Ghosh-Dastidar, Rockette-Wagner, Gary-Webb; Manuscript draft: Corona, Dubowitz, Troxel, Ghosh-Dastidar, Rockette-Wagner, Gary-Webb; Statistical expertise: Corona, Ghosh-Dastidar; Acquisition of funding: Corona, Dubowitz, Troxel, Ghosh-Dastidar, Gary-Webb; Administrative: Corona, Dubowitz, Troxel; Supervision: Dubowitz, Troxel, Rockette-Wagner, Gary-Webb

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