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Diet And Perceptions Change With Supermarket Introduction In A Food Desert, But Not Because Of Supermarket Use

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ABSTRACT Placing full-service supermarkets in food deserts—areas with limited access to healthy food—has been promoted as a way to reduce inequalities in access to healthy food, improve diet, and reduce the risk of obesity. However, previous studies provide scant evidence of such impacts. We surveyed households in two Pittsburgh, Pennsylvania, neighborhoods in 2011 and 2014, one of which received a new supermarket in 2013. Comparing trends in the two neighborhoods, we obtained evidence of multiple positive impacts from new supermarket placement. In the new supermarket neighborhood we found net positive changes in overall dietary quality; average daily intakes of kilocalories and added sugars; and percentage of kilocalories from solid fats, added sugars, and alcohol. However, the only positive outcome in the recipient neighborhood specifically associated with regular use of the new supermarket was improved perceived access to healthy food. We did not observe differential improvement between the neighborhoods in fruit and vegetable intake, whole grain consumption, or body mass index. Incentivizing supermarkets to locate in food deserts is appropriate. However, efforts should proceed with caution, until the mechanisms by which the stores affect diet and their ability to influence weight status are better understood.

The US obesity epidemic may partly be explained by geographical differences in food availability within the country.¹ To reduce such differences, many policy solutions have focused on eliminating “food deserts,” or neighborhoods whose residents have limited access to healthy food options.² Residence in a food desert has been associated with the consumption of an unhealthy diet and increased risk of obesity.^{3,4}

It has been argued that supermarkets provide access to a variety of healthy and affordable food and that the absence of a nearby supermarket increases people’s reliance on convenience

stores and fast food outlets,⁵ thereby increasing their consumption of discretionary calories—that is, food items with few or no nutrients such as cake, candy, alcohol, sugar-sweetened beverages, and other treats. Some studies have shown that access to a supermarket is associated with a reduced likelihood of obesity.^{6–8}

Residents of low-income, minority, and rural neighborhoods have limited spatial—that is, physical—access to grocery stores and therefore less spatial access to healthful food.^{1,9–11} In the United States, 23.5 million people live in low-income areas (where more than 40 percent of the population has an income at or below 200 per-

cent of the federal poverty level) that are more than a mile from a supermarket or large grocery store.¹²

African Americans are four times more likely than whites to live in a neighborhood without a full-service supermarket.^{1,11–15} This finding has been proposed as an explanation for why African American adults are 1.5 times more likely than white adults to be obese.¹⁶

The Healthy Food Financing Initiative, part of the federal farm bill, is intended to increase the availability of healthy and affordable food in US neighborhoods that currently lack such options. Since 2011 the federal government has invested more than \$500 million through one-time financing assistance in efforts that include the opening of full-service supermarkets in food deserts. Some public health experts have promoted this strategy as a way to improve residents' food purchasing behaviors and diet.¹⁷

Few US studies have actually examined the impact of opening a full-service supermarket in a food desert on food purchasing and diet. One study in Philadelphia found no significant change in residents' fruit and vegetable intake or body mass index (BMI) after the opening of a supermarket.¹⁸ However, there were differences in perceived access to healthy food options. Brian Elbel and coauthors assessed the impact of a new supermarket in New York City on household food availability and children's dietary intake and did not find any consistent changes in either outcome.¹⁹ Both studies had small sample sizes, limited measures of dietary intake, and few measures of contextual factors and additional outcomes that might explain or illuminate their findings, such as what was sold at the new markets, how people used the markets, and whether other neighborhood stores changed.

Given the large government investment in increasing access to supermarkets and the absence of positive findings from existing evaluations, there is a need for more rigorous studies that can assess whether policies that incentivize supermarkets to locate in food deserts can address poor diets among food desert residents and, if so, how. This article tests the impact of a new Healthy Food Financing Initiative–funded supermarket in a low-income food desert on adult residents' diet, obesity (measured by BMI), and perceived access to healthy food. We used comprehensive measures of dietary intake, a large sample size, measures of shopping behavior and perceived access to healthy food, and extensive data on changes in the food environment.

Previous studies may also have overlooked a key factor other than shopping that might change with the introduction of a supermarket:

neighborhood satisfaction. Some research has found an association between perceptions of one's neighborhood and health.^{20–22} We reasoned that a change in neighborhood satisfaction stemming from the opening of a supermarket might explain changes in diet independent of changes in shopping patterns or might provide an indication of other potential health benefits of the store apart from improved diet.

Study Data And Methods

STUDY DESIGN AND PARTICIPANTS The Pittsburgh Hill/Homewood Research on Eating, Shopping and Health study used a quasi-experimental longitudinal design to investigate the effect of opening a Healthy Food Financing Initiative–funded full-service supermarket in an intervention neighborhood compared to a comparison neighborhood that had no plans to open a full-service supermarket. Data collection efforts included extensive surveys of a randomly selected cohort of residents that included two detailed twenty-four-hour dietary recalls administered seven to fourteen days apart.

The two neighborhoods were sociodemographically and geographically matched and had similar food environments at baseline: The intervention neighborhood (the Hill District) was approximately 1.37 square miles and had a population of approximately 10,219; the comparison neighborhood (Homewood) was approximately 1.45 square miles and had a population of approximately 8,300. Yet the neighborhoods were isolated from one another by geographical features such as steep hills and by the routes of public buses.

About 95 percent of the populations of the Hill District and Homewood categorized themselves as African American, and mean annual household income was less than \$15,000 for both neighborhoods. Before the new full-service supermarket opened in the Hill District, the nearest supermarket was, on average, 1.73 miles (standard deviation: 0.35) from Hill District residents and 1.45 miles (SD: 0.35) from residents of Homewood. Distance was computed as the shortest driving distance from residents' homes to the closest full-service supermarket, regardless of whether or not the resident reported shopping there.

Baseline data were collected in the period May–December 2011. Follow-up data were collected in the period May–December 2014. The new full-service supermarket in the Hill District opened in October 2013.

We drew our sample from a list of addresses generated by the Pittsburgh Neighborhood and Community Information System, with sampling

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in the intervention neighborhood stratified by distance to the planned full-service supermarket. Trained residents from each neighborhood were employed as recruiters and data collectors and went to each address to enroll the household's primary food shopper (for the household to be eligible for the study, this person had to be older than age eighteen).

At baseline, 4,002 addresses were randomly selected, and data collectors determined that 2,900 of the addresses were inhabited. Of the 1,956 addresses at which collectors were able to reach a household member, 1,649 (84.3 percent) were eligible to participate, and 1,434 (87.0 percent) of those agreed to do so. We eliminated 62 (4.3 percent) of the baseline surveys because they were not sufficiently complete to be usable, which left a final baseline sample of 1,372.

At follow-up, we were able to reinterview 831 (65.3 percent) of the 1,273 individual households that remained eligible to participate. Reasons for ineligibility included having died before follow-up ($n = 52$), having a physical or mental health condition that prevented the resident from completing an interview ($n = 22$), having moved out of state ($n = 18$), and having moved within the neighborhood but to a new address that could not be found ($n = 6$). We found one individual whose record had been duplicated in the baseline data, and we deleted the duplicate record.

At baseline and follow-up, participants responded to a sixty-minute survey that included questions about healthy food access in their residential neighborhood; their food purchasing practices, such as where they shopped and how often; the transportation they used on food shopping trips; and their sociodemographic characteristics. Dietary intake information was collected through a twenty-four-hour recall administered during the interview and also seven to fourteen days later. The Automated Self-Administered 24-Hour Dietary Recall (ASA24) is designed to be self-administered.²³ However, because our population was extremely low income, we did not want to assume that participants had Internet access or computer literacy. Therefore, data collectors used their laptops, which were connected to the Internet through cellular data cards, to guide participants through the online tool. Data collectors measured participants' height and weight at the conclusion of the interviews.

Participants received \$25 for completing the survey and first dietary recall and an additional \$15 for completing a second dietary recall. Between baseline and follow-up, participants received birthday and holiday greeting postcards,

phone calls with information about when data would next be collected, and invitations to town hall meetings where findings from baseline data were presented. All study protocols were approved by the RAND Corporation's Institutional Review Board.

MEASURES Diet was assessed through the twenty-four-hour dietary recall, which collected data on all food and beverages consumed in the twenty-four hours prior to the survey administration (that is, from the beginning of their day the previous day through the beginning of their day that morning).²⁴ From the dietary recalls, we computed Healthy Eating Index²⁵ scores to measure overall dietary quality based upon compliance with the Dietary Guidelines for Americans. We calculated a single per person score based on the two days of intake.²⁶

Scores on the index range from 0 to 100, with higher scores indicating better diet quality. As general guidance, a score above 80 indicates a good diet, a score of 51–80 reflects a need for improvement in the quality of the diet, and a score of 50 or below indicates a poor diet. Recent estimates are that the average score for the US population is 57.2, and the average score for non-Hispanic African Americans is 55.0.²⁷

We also calculated daily kilocalories (Kcal/day) and intakes of fat (percentage of daily Kcal); added sugars (teaspoons per day); solid fats, alcoholic beverages, and added sugars (percentage of daily Kcal); fruits and vegetables (servings per day); and whole grains (ounces per day).

BMI (kg/m^2) was calculated from participants' height (without shoes) and weight, measured by the interviewer. Interviewers measured height to the nearest eighth-inch using a carpenter's square (triangle) and an eight-foot folding wooden ruler marked in inches. Interviewers measured weight to the nearest tenth-pound using a Seca Robusta 813 digital scale.

Respondents' perceived access to healthy food was assessed through a series of ten questions on a five-point scale (from "strongly agree" to "strongly disagree") about the ease of buying fruit and vegetables, whole-grain food, and low-fat items in their neighborhood and the selection, quality, and price of those foods.^{18,28,29}

Neighborhood satisfaction was measured with the following question: "All things considered, would you say you are very satisfied, satisfied, dissatisfied, very dissatisfied, or neutral—neither satisfied nor dissatisfied—with your neighborhood as a place to live?"³⁰

Food purchasing practices were measured with several items. We asked all participants at baseline and at follow-up, "When you want to buy food, how often do you go to [the following types of stores]?" The types were dollar store, discount

grocery store, convenience store, neighborhood store, supercenter, wholesale club, specialty grocery store, full-service supermarkets, meat or seafood market, fruit and vegetable store or farm stand, and drugstore. Examples of local stores were provided for each. We chose these categories based on definitions from the Food Marketing Institute and the North American Industry Classification System. We confirmed the relevance of the store types with our community advisory boards, which consisted of key resident stakeholders within each neighborhood. Participants could answer “never,” “occasionally,” “sometimes,” or “often.”

We asked respondents about their mode of transportation for major food shopping trips. They could answer “drive,” “jitney” (that is, take an unregulated taxi), “public transportation,” “get a ride,” or “other” (for example, walk).

We collected information on frequency of major food shopping (“How many times did you visit the store you frequent most for major food shopping in the past month?”) and weekly food expenditures per person using an open-ended item (“Approximately how much do you spend on food each week?”), the answers to which were adjusted by household size.

At the follow-up survey only, we asked Hill District residents how often they had visited the new supermarket since it opened. Response options were “more than once per week,” “once per week,” “2–3 times per month,” “once per month,” “a few times,” “once or twice,” and “never.” Those who reported shopping at the new store once per month or more were classified as regular users.

Sociodemographic measures were race/ethnicity, age, sex, mean annual household income, marital status, educational attainment, presence of children in the household, and number of years lived in the neighborhood.

STATISTICAL ANALYSES We examined the comparability of the two neighborhood cohorts at baseline across a variety of measures. For our main analyses, we computed for each outcome the average difference between baseline and follow-up values in the intervention group, the average difference between baseline and follow-up values in the comparison group, and a difference-in-differences estimator indicating how the changes over time in the intervention group compared with those in the comparison group.

In these analyses, we employed an intention-to-treat approach. In other words, we compared differences in average outcomes for the entire intervention group with those in average outcomes for the comparison group, regardless of whether people used the new supermarket. Each value was tested to determine if it was signifi-

cantly different from zero.

To help clarify the basis for our difference-in-differences results, within the intervention neighborhood cohort we also compared changes among regular users of the new supermarket and changes among other participants. Linear regression predicted, in turn, each of the dietary outcomes of interest, BMI, perceived access to healthy food, and neighborhood satisfaction. To correct for preexisting differences between people who chose to use the new supermarket regularly and others in the neighborhood, we controlled for linear and quadratic terms of age, sex, household income, an indicator of children in the household, educational attainment (high school diploma, some college or technical school, or college degree, with less than high school as the reference category), and marital status (married or living with a partner or widowed, divorced, or separated, with never married as the reference category) in these equations.

For the same reason, we examined whether changes in weekly food expenditures, frequency of major food shopping, and use of different types of food stores were related to change in diet across both neighborhoods. To do this, we conducted a series of linear regressions to separately predict change in dietary outcome, with change in shopping behaviors (weekly food expenditures, frequency of major food shopping, and use of a different food store type) as the key predictor and controlling for neighborhood.

Analyses were performed using Proc Surveyreg and Proc Surveyfreq in the statistical software SAS, version 9.2. To ensure that results were generalizable to the baseline sample, the analyses were weighted to account for sample attrition between baseline and follow-up. Attrition weights were the inverse probability of response at follow-up. Estimates included all of the sociodemographic and additional baseline characteristics as predictors.

LIMITATIONS This study had several limitations. First, it was set in two low-income, racially isolated urban neighborhoods. Therefore, findings might not be generalizable to other food deserts whose residents who have different sociodemographic profiles.

Second, because recruitment and enrollment into the study were done in person, less mobile residents (that is, older residents and people in households without children) were more likely to respond and enroll in the study, compared to younger residents and people in households with children.

Third, attrition among participants was relatively high. However, our analysis carefully adjusted for observable characteristics associated

with sample loss to overcome this limitation.

Fourth, in spite of geographical features that made this unlikely, both neighborhoods might have been influenced by introduction of the new supermarket. However, at follow-up, no residents from the comparison neighborhood reported shopping at the new supermarket in the intervention neighborhood.

Fifth, in addition to supermarket expenses, our food expenditure measure included food that may have been purchased away from home or food purchased when dining out. Thus, the measure may not be particularly sensitive to shifts in expenditures based on major food shopping alone.

Finally, the follow-up, which occurred nine to fourteen months after the new supermarket opened, may not have allowed for sufficient time to elapse between the opening of the store and changes in health outcomes such as BMI or obesity status.

Study Results

CHARACTERISTICS OF STUDY PARTICIPANTS Study participants were predominantly female (75 percent), non-Hispanic African American (95.2 percent), not married or living with a partner (82.3 percent), and low-income (mean annual household income was \$13,608; Exhibit 1). The median age at baseline was 53.3 years, and 28.2 percent of the cohort had one or more children in the household. The average BMI of the sample was 30.5 kg/m², and 77.4 percent of the sample met the criteria for overweight (BMI: 25.0–29.9) or obese (BMI: >30.0; data not shown).

On average, the baseline Health Eating Index score or dietary quality for the sample was 48.4 (out of 100.0; data not shown). Baseline calorie intake was 1,796 Kcal/day; fat intake was 36.4 percent of that calorie amount; added sugar was 14.6 teaspoons; and solid fats, alcohol, and added sugars were 33.2 percent of that calorie amount. On average, participants consumed 2.3 daily servings of fruit and vegetables and 0.58 ounce of whole grains per day.

At baseline, 99.1 percent of participants said that they shopped at a full-service supermarket at least occasionally (Exhibit 1). Of all of the store types, the least frequented were specialty grocery stores and neighborhood stores.

CHANGES IN DIET, BODY MASS INDEX, AND PERCEPTIONS Exhibit 2 provides our main difference-in-differences findings (for additional details, see online Appendix Exhibit 1).³¹ This analysis revealed positive differential effects of living in the intervention neighborhood versus living in the control neighborhood on several

components of diet, perceived access to healthy food, and neighborhood satisfaction. But it revealed no change in average BMI, consumption of fruit and vegetables, or consumption of whole grains.

In the intervention neighborhood, we saw a decrease in consumption of kilocalories (–222 Kcal/day); added sugars (–2.75 teaspoons/day); and solid fats, alcohol, and added sugars (–1.38 percent of Kcal/day). In contrast, such consumption either remained the same or increased in the comparison neighborhood. Unexpectedly, consumption of fruit and vegetables and whole grains declined in both neighborhoods. These shifts were statistically indistinguishable from one another (difference-in-differences *p* values: 0.36 and 0.51, respectively).

Consistent with these more specific findings, overall dietary quality declined significantly in the comparison neighborhood but not significantly in the intervention neighborhood. The difference-in-differences was marginally significant.

Average BMI did not change in the intervention neighborhood and increased slightly in the comparison neighborhood, although the difference-in-differences estimate was not significant. We observed no significant changes in the rate of overweight or obesity in either neighborhood and no differential change between the neighborhoods.

There were substantial improvements in the intervention neighborhood for all measures of perceived access to healthy food. There were also some small, occasionally significant, improvements among these measures in the comparison neighborhood, but all differences-in-differences were significant. Similarly, neighborhood satisfaction improved significantly in the intervention neighborhood but not in the comparison one, and the difference-in-differences was significant.

REGULAR USE OF THE NEW SUPERMARKET AND OUTCOMES If the observed relative improvements in diet, perceived access to healthy food, and neighborhood satisfaction among residents of the intervention neighborhood were due to the new supermarket, we might expect to see greater improvement among those who regularly used the store compared to those who did not. Among participants from the intervention neighborhood, 368 (68.3 percent) were classified as regular users, and 171 (31.7 percent) either were nonusers or had visited the new supermarket only a few times since its opening. Thirty-two individuals from the cohort moved out of the Hill District to a different neighborhood between baseline and follow-up and therefore were not included in our analysis of user

EXHIBIT 1
Characteristics Of Participants In The Pittsburgh Hill/Homewood Research On Eating, Shopping, And Health Study At Baseline, May–December 2011

Characteristic	All (N = 831)	Intervention group (n = 571)	Comparison group (n = 260)
Race/ethnicity			
African American	95.2%	94.7%	96.1%
Other	4.8%	5.3%	3.9%
Mean age (years) ^a	53.3	53.1	53.7
Female ^{**}	75.0%	77.4%	69.8%
Mean annual household income ^b	\$13,608	\$13,147	\$14,620
Marital status			
Married or living with partner	17.7%	16.3%	20.7%
Never married	44.0	45.5	40.6
Widowed, divorced, or separated	38.3	38.2	38.6
Educational attainment			
Less than high school	13.4%	14.7%	10.8%
High school diploma	36.5	38.2	32.7
Some college or technical school	35.4	33.5	39.5
College degree	14.7	13.7	17.0
Any children in household	28.2%	28.1%	28.6%
Years lived in the neighborhood (mean) ^{c****}	27.0	31.2	17.8
Residents who reported going to:			
Convenience stores	54.0%	52.1%	58.0%
Neighborhood stores	45.1	44.7	45.9
Dollar stores	75.3	74.3	77.4
Discount grocery stores ^{****}	59.9	52.9	75.3
Supercenters	78.2	77.8	79.1
Wholesale clubs	51.2	50.6	52.5
Specialty grocery stores	30.3	28.5	34.4
Full-service supermarkets ^{****}	99.1	99.8	97.3
Meat or seafood markets	75.5	76.5	73.1
Fruit and vegetable stores or farm stands	64.8	65.2	63.8
Drugstores ^{***}	47.5	51.2	39.2
Type of store used for major food shopping			
Full-service supermarket ^{***}	74.1%	77.2%	67.3%
Supercenter	12.2	11.5	13.8
Fruit and vegetable store or farm stand	0.5	0.4	0.6
Discount grocery store ^{***}	4.9	3.3	8.4
Wholesale club	3.1	2.7	3.9
Other ^d	5.2	4.8	6.0
Transportation to and from major food shopping store			
Drive	38.9%	37.0%	43.0%
Jitney (unregulated taxi)	25.6	26.5	23.7
Public transportation	17.4	18.5	15.0
Get a ride	16.7	16.8	16.4
Other	1.5	1.2	2.0

SOURCE Authors' analysis of data collected in the Pittsburgh Hill/Homewood Research on Eating, Shopping, and Health study. **NOTES** Adjusted for attrition weights. Significance refers to differences in average outcomes between the intervention group and the comparison group. ^aStandard error (SE) for all is 0.7 year, for intervention group is 0.9 year, and for comparison group is 1.3 years. ^bSE for all is \$473, for intervention group is \$567, and for comparison group is \$855. ^cSE for all is 0.8 year and for both intervention and comparison group is 1.1 years. ^dNeighborhood store, specialty grocery store, or meat or seafood market. ** $p < 0.05$ *** $p < 0.01$ **** $p < 0.001$

status.

Exhibit 3 compares changes in each outcome by store-user status (for additional details, see Appendix Exhibit 2).³¹ Although changes were in the expected directions for daily intakes of kilocalories; added sugars in teaspoons; and solid fats, alcohol, and added sugars as a percentage

of kilocalories, as well as for neighborhood satisfaction, regular use of the new supermarket was not significantly associated with any of these outcomes.

However, we did see significant differences between regular users and other participants in the intervention neighborhood in terms of

EXHIBIT 2

Changes In Diet, Body Mass Index, Neighborhood Satisfaction, And Perceived Access To Healthy Food For Study Participants From Baseline To Follow-Up, By Neighborhood

Outcome	Intervention group (n = 571)		Comparison group (n = 260)		Difference-in-differences
	Baseline	Mean change	Baseline	Mean change	
Dietary quality ^a	48.3	-0.39	48.6	-2.59**	2.20*
Mean reported daily intake					
Kilocalories	1,727	-222****	1,861	-44	-178**
Fat (percentage of daily Kcal)	36.3	0.35	36.6	0.51	-0.16
Added sugars (teaspoons)	14.3	-2.75****	15.1	0.58	-3.34**
Solid fats, alcohol, and added sugars (percentage of daily Kcal)	33.2	-1.38**	32.8	1.72**	-3.11**
Fruits and vegetables (servings)	2.3	-0.27****	2.4	-0.13	-0.14
Whole grains (ounces)	0.62	-0.08**	0.50	-0.03	-0.05
Average body mass index (kg/m ²)	30.4	0.13	30.8	0.44**	-0.31
Overweight or obese (%)	77.0	0.08	78.2	-1.42	1.50
Obese (%)	47.9	-1.52	49.3	0.34	-1.86
Neighborhood satisfaction (%)	66.6	13.76****	55.9	2.64	11.10**
Perceived access to healthy food (%)					
Fruit and vegetables					
Easily accessible	16.4	55.88****	22.3	5.12*	50.8****
Large selection	10.2	56.24****	15.4	7.88**	48.4****
High quality	15.6	44.63****	19.3	5.37*	39.3****
Acceptable price	17.2	30.96****	19.3	7.33**	23.6****
Whole-grain products					
Easily accessible	18.5	52.61****	27.3	10.98**	41.6****
Large selection	12.0	47.61****	14.5	12.10****	35.5****
Acceptable price	16.4	37.23****	18.1	9.84**	27.4****
Low-fat products					
Easily accessible	17.2	54.57****	21.9	15.73****	38.8****
Large selection	12.9	47.28****	13.4	14.04****	33.2****
Acceptable price	14.0	38.77****	15.8	11.69****	27.1****

SOURCE Authors' analysis of data collected in the Pittsburgh Hill/Homewood Research on Eating, Shopping, and Health study. **NOTES** The intervention group consists of residents of the intervention neighborhood, the Hill District. The comparison group consists of residents of the comparison neighborhood, Homewood. Mean change is the difference between baseline (May–December 2011) and follow-up (May–December 2014). ^aHealthy Eating Index (see Note 24 in text). * $p < 0.10$ ** $p < 0.05$ **** $p < 0.001$

perceived access to healthy food. For almost all questions about access to fruit and vegetables and to whole-grain and low-fat products, regular users of the store had a bigger positive change, compared to other participants in the intervention neighborhood. A series of sensitivity analyses that classified store use differently (for example, using an ordinal measure of use or other thresholds for “regular user” status) did not change these findings appreciably.

CHANGES IN FOOD PURCHASING PRACTICES AND DIET Given that changes in diet did not appear to be associated with regular use of the new supermarket, we sought other factors that could explain the observed pre-post changes in dietary outcomes. We examined changes in weekly food expenditures, major food shopping frequency, and types of food stores where food is purchased as factors that might explain changes in diet. We found only one significant association: In-

creased shopping frequency at a dollar store predicted an increase in daily fat intake of almost 1 percent of daily kilocalories (Exhibit 4).

Discussion

Using a rigorous study design that accounted for potential confounders and secular trends and included two twenty-four-hour dietary recalls, we found a net positive change in some aspects of diet, perceived access to healthy food, and neighborhood satisfaction among food desert residents whose neighborhood acquired a new full-service supermarket. Although improvements in perceived access to healthy food were significantly greater among regular users of the new supermarket compared to infrequent and nonusers in the intervention neighborhood, changes in diet and neighborhood satisfaction occurred in that neighborhood regardless of fre-

EXHIBIT 3
Changes From Baseline To Follow-Up In Diet, Body Mass Index, Neighborhood Satisfaction, And Perceived Access To Healthy Food In Regular Users Of The New Supermarket And Others In The Intervention Neighborhood

Outcome	Regular users (n = 368)		Others (n = 171)	
	Baseline	Mean change	Baseline	Mean change
Dietary quality ^a	48.84	-0.45	48.16	-0.20
Mean reported daily intake				
Kilocalories	1,759.15	-260	1,644.48	-201
Fat (percentage of daily Kcal)	72.33	0.00	66.66	1.08
Added sugars (teaspoons)	14.76	-3.17	13.05	-2.37
Solid fats, alcohol, and added sugars (percentage of daily Kcal)	33.77	-1.63	32.20	-2.04
Fruits and vegetables (servings)	2.27	-0.32	2.26	-0.11
Whole grains (ounces)	0.62	-0.06	0.65	-0.09
Average body mass index (kg/m ²)	30.34	0.01	30.44	0.16
Overweight or obese (%)	77.69	-0.28	76.22	0.73
Obese (%)	46.95	-1.96	48.81	-2.98
Neighborhood satisfaction (%)	69.42	13.86	66.35	5.14
Perceived access to healthy food (%)				
Fruit and vegetables				
Easily accessible	17.43	59.78	14.83	48.46**
Large selection	12.80	59.40	5.85	48.66**
High quality	17.75	47.12	12.17	41.22
Acceptable price	17.14	34.79	17.03	18.93***
Whole-grain products				
Easily accessible	18.47	57.81	16.23	46.97**
Large selection	13.72	50.68	8.79	43.68
Acceptable price	16.30	42.11	14.96	27.46***
Low-fat products				
Easily accessible	16.17	63.04	16.93	44.74***
Large selection	12.62	54.52	13.12	38.17***
Acceptable price	13.71	43.41	15.77	28.41***

SOURCE Authors' analysis of data collected in the Pittsburgh Hill/Homewood Research on Eating, Shopping and Health study. **NOTES** "Regular users" are those who reported shopping at the new supermarket at least once per month. "Others" are those who shopped there less frequently or not at all. Mean change is the difference between baseline (May–December 2011) and follow-up (May–December 2014). ^aHealthy Eating Index (see Note 24 in text). ***p* < 0.05 ****p* < 0.01

quency of supermarket use. These improvements were also unassociated with any observed changes in other food purchasing practices or changes in BMI.

Contrary to our hypothesis (and the intentions of policy makers) that a supermarket would improve neighborhood residents' consumption of produce, consumption of fruit and vegetables declined in both the intervention and comparison neighborhoods after the new supermarket opened. One reason for this secular trend may be that almost all residents of both neighborhoods shopped before and after the new store's opening at food retail venues that do not aggressively market produce or incentivize purchasing it.

Other aspects of diet did improve in the intervention neighborhood, relative to the comparison neighborhood. Overall dietary quality, as reflected by the Healthy Eating Index, declined in both neighborhoods, but only the decline in the comparison neighborhood was significant.

This pattern suggests the existence of a secular downward trend that was tempered by the introduction of a new market in the intervention neighborhood.

We cannot be sure of the reason for this trend, but it may be specific to the region or to low-income African Americans. At baseline, both neighborhoods had Healthy Eating Index scores that were nearly ten points below the overall US average and several points below the US average for non-Hispanic African Americans. Thus, our participants represent a subpopulation of the United States with particularly significant vulnerabilities and among which dietary trends may be worsening.

We also saw significant differential improvement between the neighborhoods in several specific areas: daily intake of kilocalories; added sugars (in teaspoons); and solid fats, alcohol, and added sugars (as a percentage of kilocalories). It might be easier to change those compo-

EXHIBIT 4

Associations Between Changes From Baseline To Follow-Up In Selected Food Purchasing Practices And Changes In Dietary Outcomes

Survey question	Change in:				
	Dietary quality ^a	Kcal/day	Fat (% Kcal/day)	Added sugars (tsp./day)	SoFAAS (% Kcal/day)
How often do you shop for food?	0.002	-0.067	0.004	-0.083	-0.041
What are your weekly per person expenditures for food?	-0.010	0.054	0.001	0.003	0.012
When buying food, how often do you go to:					
Convenience stores	-0.011	-0.065	-0.002	0.024	0.032
Neighborhood stores	-0.011	0.010	0.028	-0.010	0.004
Dollar stores	-0.017	-0.006	0.086**	-0.022	-0.031
Discount grocery stores	0.066	0.062	0.014	0.009	-0.041
Supercenters	-0.004	-0.027	0.020	-0.052	-0.040
Wholesale clubs	-0.014	-0.001	0.059	-0.047	-0.004
Specialty grocery stores	-0.033	0.027	0.020	0.012	0.025
Full-service supermarkets	-0.013	0.016	-0.028	0.041	-0.025
Meat or seafood markets	-0.018	0.023	0.012	0.027	0.022
Fruit and vegetable stores or farm stands	0.000	0.044	-0.023	-0.020	0.001
Drugstores	-0.024	0.005	-0.041	-0.017	-0.037

SOURCE Authors' analysis of data collected in the Pittsburgh Hill/Homewood Research on Eating, Shopping and Health study. **NOTES** The results shown are regression coefficients from linear regression models that explore the association between change in a food purchasing practice (predictor) and change in a dietary outcome (outcome), where change is assessed between baseline and follow-up. The magnitude of the regression coefficient or beta corresponds to the change in the outcome associated with one unit change in the predictor variable. The linear regression model includes a binary indicator of neighborhood to account for any differences in the two neighborhoods. Baseline is May–December 2011. Follow-up is May–December 2014. Tsp. is teaspoons. SoFAAS is solid fats, alcohol, and added sugars. ^aHealthy Eating Index (see Note 24 in text). ** $p < 0.05$

nents of diet than to change fruit and vegetable consumption. For the most part, the improvements we found reflect decreases in food intake. Recent public health campaigns have focused on reducing sugar intake, and contact with these may have also influenced residents' choice of strategies for improving their diets.³² Such policies and their population effects have been highlighted by Susan Kasangra and coauthors in their report on policies and efforts in New York City that may have also gained national attention.³³

In spite of the changes we found, a key goal of the Healthy Food Financing Initiative was not achieved: We observed no improvement in weight status. However, the nine-to-fourteen-month follow-up to the grocery store introduction may not have allowed sufficient time to observe such changes, which should follow from changes in diet.

To our knowledge, our study is the first to have found significant improvements in multiple dietary outcomes and neighborhood satisfaction among residents of a food desert following the opening of a supermarket. Previous studies of supermarket effects have found improvements in perceptions of healthy food access as well as

economic impacts. In their study of a new supermarket that opened in Philadelphia, Steven Cummins and coauthors found significant improvements in perceived access to healthy food.¹⁸ The Reinvestment Fund reported on the role of store openings in bringing employment opportunities and serving as an economic anchor for other new developments in neighborhoods with low food access.³⁴

Another longitudinal study of the food environment also found mixed results regarding changes in the food environment and diet: Using fifteen years of longitudinal data from the Coronary Artery Risk Development in Young Adults study, Janne Boone-Heinonen and coauthors found that greater supermarket availability was generally unrelated to diet quality and fruit and vegetable intake.³⁵

Another recent analysis that used Nielsen data to track food purchasing found that only a small amount of variation in food purchasing was explained by differences in spatial access to healthful food. Jessie Handbury and coauthors found that even after spatial access was controlled for, systematic socioeconomic disparities in household purchases were the most important factor in food purchasing practices. They found that

even among people who shopped in the same store, those who were from households with higher levels of education purchased more healthful food, compared to shoppers from households with lower levels of education.³⁶

In the absence of any direct associations in our study between regular use of the new supermarket and other food access behaviors and the changes in diet we found, it is possible that other changes in the intervention neighborhood (for example, aesthetic improvements) could explain changes in residents' lifestyles, including dietary habits. Other research has found associations between the perceived and objectively measured social and physical environment of a neighborhood and residential well-being,³⁷⁻³⁹ although these studies have focused mostly on mental health outcomes. Nonetheless, the largest change between the intervention and comparison neighborhoods was the opening of the new supermarket, so that is the most likely cause of the changes in diet we observed.

It seems likely that the mechanism behind the improvements in diet we observed is related to the changes in neighborhood satisfaction and perceived access to healthy food that were also part of our results. Residents were actively involved in bringing the new supermarket to their neighborhood, and public discussions and marketing campaigns accompanied its opening, focusing on the need for healthy food in the community. These may be necessary to influence dietary choices through supermarket introduction. The new supermarket may also have stimulated economic development in the neighborhood and instilled hope among community residents who were heartened by public and private investment in their neighborhood and their health.^{40,41}

Given this pattern of findings, policy makers should still consider placing full-service supermarkets in food deserts, but they should move

forward with increased caution until the mechanisms behind our observations are more clearly identified. Policy makers should include the evaluation of outcomes as a key part of further financing, to provide additional data about effectiveness. This evaluation should include an assessment of mechanisms that might operate at the community level (in other words, that might affect store users and nonusers alike), which appeared to be the case in the intervention neighborhood in our study.

Given the improvements in neighborhood satisfaction we observed, future evaluations should include measures of resident buy-in and community-based advocacy for healthy food options, both of which may lead to feelings of empowerment and subsequently a healthier diet. Similarly, economic renewal and enhanced feelings of hope may be key to supermarket effects and should be measured. Finally, longer-term follow-ups that provide sufficient time for change in weight status should be conducted to determine whether supermarkets can be used to address the national obesity epidemic or are effective only in improving nutrition.

Conclusion

This study is the first to demonstrate that the introduction of a supermarket into a food desert may lead to multiple improvements in the quality of neighborhood residents' diet. Yet these improvements did not appear to be due to regular use of the new supermarket and were not associated with changes in BMI. These findings suggest that continued financing of new supermarket placement is appropriate but should proceed with caution and be coordinated with continued research on placement impacts on BMI and the store- and community-level determinants of impacts on diet-related behaviors and health. ■

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