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The relationship between diet and perceived and objective access to supermarkets among low-income housing residents

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Abstract

In the U.S., supermarkets serve as an important source of year-round produce (Chung & Myers, 1999), and yet access to supermarkets may be scarce in “food deserts,” or poor, urban areas that lack sources of healthy, affordable food (Cummins & Macintyre, 2002). This study examined objective distance to the nearest supermarket and participant-report of supermarket access in relation to fruit and vegetable intake. Street-network distance to the closest supermarket was calculated using GIS mapping. Perceived access was assessed by a survey question asking whether participants had a supermarket within walking distance of home. Cross-sectional survey data were collected from 828 low-income housing residents in three urban areas in greater-Boston. Generalized estimating equations were used to estimate the association between perceived and objective supermarket access and diet. Fruit and vegetable consumption was low (2.63 servings/day). Results suggest that most low-income housing residents in greater-Boston do not live in “food deserts,” as the average distance to a supermarket was 0.76 km (range 0.13–1.22 km). Distance to a supermarket was not associated with fruit and vegetable intake ($p = 0.22$). Perceived supermarket access was strongly associated with increased fruit and vegetable intake (0.5 servings/day) after controlling for socio-demographic covariates ($p < 0.0001$). Patterns of mismatch between perceived and objective measures revealed that mismatch between the two measures were high (31.45%). Those who did not report a supermarket within walking distance from home despite the objective presence of a supermarket within 1 km consumed significantly fewer fruits and vegetables (0.56 servings/day) than those with a supermarket who reported one, even after controlling for socio-demographic variables ($p = 0.0008$). Perceived measures of the food environment may be more strongly related to dietary behaviors than objective ones, and may incorporate components of food access not captured in objective measures.

Keywords

USA; Food access; Neighborhood; Low-income housing; Health behaviors; Perceived measures; Objective measures

Introduction

Today's city-dweller may buy groceries from an array of food retailers including supermarkets, small grocery stores, convenience stores, and specialty food stores. Yet the apparent variety of food sources in neighborhoods can be deceptive, masking another pattern

of urban life: the lack of reasonably priced foods like fruits and vegetables available to residents in large swatches of the urban landscape. These areas have commonly been referred to as “food deserts,” or poor, urban neighborhoods where healthy and affordable food is scarce (Cummins & Macintyre, 2002). In general, supermarkets offer the greatest variety of high-quality fresh produce at the lowest cost (Chung & Myers, 1999; Sallis, Nader, Rupp, Atkins, & Wilson, 1986). Chain supermarkets not only have reliable, year-round offerings of a variety of healthy foods, but their merchandise is more affordable compared to non-chain stores (Chung & Myers, 1999).

Evidence from some U.S.-based studies has linked access to supermarkets with consumption of fruits and vegetables (Morland, Wing, & Roux, 2002; Rose & Richards, 2004; Zenk et al., 2009) as well as overall healthier diets (Laraia, Siega-Riz, Kaufman, & Jones, 2004). Beyond the association with diet, supermarket proximity has been linked with clinically significant health outcomes like obesity and overweight (Morland & Evenson, 2009; Morland, Roux, & Wing, 2006; Spence, Cutumisu, Edwards, Raine, & Smoyer-Tomic, 2009). Notably, the research to-date has largely been comprised of cross-sectional studies, and it is therefore impossible to say whether those with better health were more likely to decide on their residential location based on proximity to a healthy food environment. In contrast to cross-sectional findings, two recent longitudinal U.S.-based studies using time-varying exposures to examine diet (Boone-Heinonen et al., 2011) and body mass index (Block, Christakis, O'Malley, & Subramanian, 2011) did not show an association with supermarket availability. Although supermarkets have been touted as a solution for the problems associated with food deserts (Giang, Karpyn, Laurison, Hillier, & Perry, 2008), more research is needed to determine the precise role of supermarkets in shaping dietary behavior.

Indeed, natural experiments conducted in the U.K. have shown mixed results regarding the impact of opening a large-scale food retailer on fruit and vegetable intake (Cummins, Petticrew, Higgins, Findlay, & Sparks, 2005; Wrigley, Warm, & Margetts, 2003). Overall, there has been less convincing evidence of the “food desert” phenomenon in disadvantaged urban areas of the U.K. (Cummins & Macintyre, 2002; Smith et al., 2010), as well as in Australia and New Zealand (Pearce, Hiscock, Blakely, & Witten, 2008; Pearce, Witten, Hiscock, & Blakely, 2007; Winkler, Turrell, & Patterson, 2006). Considering the specific trajectory of segregation in U.S. cities in the 20th century, the geography of food access may be substantially different outside the U.S. (Walker, Keane, & Burke, 2010). Evaluating actual access among disadvantaged populations in a variety of settings is a critical first step in developing solutions to minimize disparities in dietary behavior.

One of the challenges in synthesizing results from studies of the food environment is the lack of consistent criteria for measuring “food access” among the growing number of studies relying on Geographic Information Systems (GIS) technology. One common inconsistency is the categorization of retail stores included in the analysis. While some studies draw a distinction between chain supermarkets and independent grocery stores (Laraia et al., 2004; Morland et al., 2002), others group all kinds of supermarkets and grocery stores together (Spence et al., 2009). This distinction is important because independent grocery stores can vary substantially in terms of the type, number and quality of products available (Block & Kouba, 2006). It is perhaps wise to distinguish between stores that are known to carry year-round supplies of a variety of affordable produce (Chung & Myers, 1999) and stores in which the produce availability and prices are variable or unknown.

A second, and larger, inconsistency is the variety of data collection methods that are used to assess supermarket exposure. In the current literature, researchers commonly define “food access” based on objective (GIS-based) criteria (McKinnon, Reedy, Morrisette, Lytle, &

Yarooh, 2009), but occasionally access may be determined by participant reports on questionnaires (Inglis, Ball, & Crawford, 2008; Moore, Diez-Roux, Nettleton, Jacobs, & Franco, 2009; Moore, Diez Roux, Nettleton, & Jacobs, 2008; Williams, Ball, & Crawford, 2010). A review of the food environment literature from 1990 to 2007 (McKinnon et al., 2009) suggests that the use of GIS-based measures to ascertain food store locations outnumbers interview or questionnaire-based measures 57 to 10 – a ratio which is not likely to grow smaller as GIS methods become more common.

The legitimacy of relying solely on GIS-based measurements of neighborhoods deserves a closer look. On one hand, objective measures using cutting-edge technology can save time and resources. Mapping the location of neighborhood services using GIS is often quick, and does not require the training and coordination of field staff to gather primary data. On the other hand, GIS techniques are susceptible to misclassification due to inaccuracies in source data. One previous study showed that only about 88% of stores listed on public records were actively trading (Cummins & Macintyre, 2009). The probability that supermarkets and grocery stores are actually located and open where they are listed is in the range of 0.66 (Powell et al., 2011) to 0.84 (Liese et al., 2010) for InfoUSA data, suggesting that it is fairly common to misclassify residents as having geographic access when they do not. Furthermore, the probability that open stores were actually listed in the database has been estimated as 0.71 (Liese et al., 2010) to 0.74 (Powell et al., 2011). This discrepancy introduces bias into the results and suggests that access for some is greater than listings alone would indicate. Such findings emphasize the importance for ground-truthing where possible to avoid such misclassification errors.

Furthermore, the interactions between individuals and their environments are usually more complex and dynamic than can be captured by GIS alone. GIS-based measures are limited in their ability to measure store utilization, or residents' true access to stores. For instance, physical barriers or dangerous traffic may make walking routes to stores unsafe or impossible. Alternately, residents may frequently shop at supermarkets that are outside the geographic limits of "access" assumed by the study (Inagami, Cohen, Finch, & Asch, 2006), particularly if they own a car. Both of these scenarios would result in an underestimation of the impact of proximity to supermarkets on diet.

Considering these limitations, there is some justification for looking beyond GIS-based assessment measures of local environments and including participants' reports about their neighborhood. To date, very little research has directly compared perceived and GIS-based measures of the food environment. One study of three U.S. communities showed that these two measures appeared to be correlated, but not identical (Moore, Diez Roux & Brines, 2008). Another recent study, however, showed that objective access to food stores was unrelated to perceived availability of healthy foods, and that there was an *inverse* relationship between perceived and objective food store availability (Gustafson et al., 2011). Results from other studies which have used both types of measures generally support the idea that perceived access is an important construct that may be associated with dietary behavior (Moore, Diez Roux, Nettleton, & Jacobs, 2008; Sharkey, Johnson, & Dean, 2010), perhaps even above objective measures (Giskes, Van Lenthe, Brug, Mackenbach, & Turrell, 2007; Moore et al., 2009; Williams et al., 2010). It has been suggested that different measures of food access represent different underlying constructs (Moore, Diez Roux, & Brines, 2008), but clearly more research is needed to determine how different measures of food access relate to one another, and how they might be linked to health behaviors.

Overview of the current study

The primary aim of the current study was to examine the relationship between a perceived and objective measure of supermarket access and fruit and vegetable intake among low-

income housing residents in an urban setting. We hypothesized that a shorter distance to the nearest supermarket and reporting a supermarket within walking distance would be associated with greater fruit and vegetable intake. The study also examined patterns of discordance between the perceived and objective measures of supermarket access, and the association of discordance itself with fruit and vegetable intake. The term *positive discordance* was used to describe those who reported living within walking distance of a supermarket even when GIS-based measures did not indicate the presence of a supermarket within 1 km of the participants housing site. *Negative discordance* describes participants who did not report living within walking distance of a supermarket even when GIS-based measures indicated that there was a supermarket within 1 km of the housing site. Examining patterns of mismatch is useful because it allows for a discussion of possible sources of bias associated with different measures. To our knowledge, the terms positive and negative discordance have not been used previously to classify particular types of mismatch, although the concept of measuring concordance is not new (Ball et al., 2008; Gebel, Bauman, & Owen, 2009; Kirtland et al., 2003). We hypothesized that discordance patterns would be associated with fruit and vegetable intake such that participants who were positively discordant would consume more fruits and vegetables and those who were negatively discordant would consumer fewer.

Methods

The research protocol was approved by the Human Subjects Protection committee at the Harvard School of Public Health and informed consent was obtained for participation in the research.

Survey data

Individual-level data including the outcome and covariates were obtained from the Health in Common (HIC) study, which assessed the social determinants of cancer risk in low-income housing residents in the greater-Boston area. This cross-sectional study collected survey data from 828 low-income residents in 20 housing sites, both public ($n = 14$) and private ($n = 6$), in Cambridge, Chelsea, and Somerville, Massachusetts. The Resident Survey assessed a range of questions pertaining to the experience of the residents in their home, as well as demographics, health behaviors and health indicators. The survey was conducted in English (53.7%), Spanish (23.7%), and Haitian Creole (19.6%) between February 2007 and June 2009.

A multistage cluster design was used to sample households from housing sites and to select adults from within households (Kish, 1965). In the smaller housing sites, a census method was used to recruit one participant from each household. In the larger housing sites, a random selection of households formed the sampling frame in order to assure a reasonably equal number of participating households at each site. Trained Survey Assistants, each bilingual in either English–Haitian Creole or English–Spanish, visited each of the selected households in an attempt to recruit participants for participation in the study and to conduct a face-to-face survey. The response rate averaged 49% across the 20 sites (27–64%).

Geographic data

Geographic measures of the food environment were obtained from Esri Business Analyst, a GIS technology that relies on data from InfoUSA (Omaha, NE) – a business listing file of over 12 million public and private U.S. companies that is updated annually. Business Analyst geocodes business listings and allows data to be extracted by North American Industry Classification System (NAICS) codes. Geographic data were obtained for supermarkets for the years 2007, 2008, and 2009. There was no change in the listing of

supermarkets in the geographic area defined by the study; 2009 data were selected for use in the remainder of the analysis.

Store locations in the greater-Boston area were extracted from Business Analyst if they had an NAICS code beginning with 44511 or 445110. Although these codes extract a list of both grocery stores and supermarkets, only supermarkets were included in the study. Small grocery stores have been shown to possess a high degree of variability in the variety and quality of their merchandise in other contexts (Block & Kouba, 2006) and this was confirmed in preliminary analyses of this study. Restricting the sample to supermarkets offered the best way to assure that food outlets included in the sample were reasonable sources of healthy food. Supermarkets included large, regional chain food markets (e.g., Shaw's, Stop & Shop), including chain discount supermarkets selling produce (e.g., Save-a-Lot). In this urban setting there were no supercenters (e.g., Walmart) selling fresh produce within 1 km of a housing site. To further assure reasonable comparability of supermarkets, stores were audited for the availability of 22 common fresh fruits and vegetables, and all chain supermarkets sold at least 80% of the items on the list. In addition to chain supermarkets, two large non-chain stores with "supermarket" in their names were audited for inclusion; one of these was included because the fresh produce selection included 21 of the 22 common items and it was judged that this store would be more accurately characterized as a supermarket than a small grocery store. Direct observation was used to verify that all supermarkets included in the sample were present where they were listed. One supermarket identified through Business Analyst listings had closed at the time the direct observation took place in 2010, but newspaper records verified that it was still open at the time of data collection.

Distance to a supermarket

Distance to a supermarket was defined as the shortest street-network distance in kilometers from the centerpoint of each housing site to the nearest supermarket. This distance was calculated by using the "closest facility" function in Arc GIS v. 9.3.1 to model the shortest walking route between each housing site and the closest store. Members of each housing site were assigned the same distance to a supermarket.

Perceived access to supermarket

Perceived access to a supermarket was a dichotomous variable assessed by asking residents whether they had a supermarket "*within walking distance*" of their homes. This survey question was a simplified version of the Neighborhood Environment Walkability Scale (NEWS) (Saelens, Sallis, Black, & Chen, 2003). Test-retest reliability for the original scale was 0.66 for supermarkets.

Objective access to a supermarket

Residents who had a supermarket within 1 km of the centerpoint of their housing site were defined as having access to a supermarket according to the objective measure. The goal was for this distance to represent "walking distance" so that there would be reasonable comparability between the GIS-based measure and what participants reported on the survey – or a "match" between the perceived and objective measures. One previous study (McCormack, Cerin, Leslie, Du Toit, & Owen, 2007), which compared perceived and objective distance to services, found that individuals were best at accurately assessing the distance to destinations (including supermarkets) when those destinations were between 750 and 1500 m from their house. A cut-point of 800 m was initially considered based on findings at this distance in previous studies (Spence et al., 2009; Zenk et al., 2009), but preliminary analyses indicated that 800 m would be too conservative and would result in artificially high levels of discordance, since most participants did report a supermarket

within walking distance. Instead, a cut-point of 1 km (just over 0.6 miles) was selected. This distance corresponds to about a 12.5 min walk at 4.8 km per hour (3.0 miles per hour), according to estimates in the built environment literature (Ainsworth et al., 2000).

Fruit and vegetable consumption

Diet was assessed in the Resident Survey by a modified version of the Prime Screen (Rifas-Shiman et al., 2001), which is a brief version of the Semiquantitative Food Frequency Questionnaire (SFFQ) (Rimm et al., 1992). Six survey items asked participants to rate the frequency of consumption within the last week of 100% orange or grapefruit juice, other 100% juices, not counting fruit drinks, other fruit, green salad (with or without other vegetables), other vegetables (not counting potatoes), and baked, boiled, or mashed potatoes. Response categories (*never, once, 2–4 times, nearly daily, and twice or more daily*) were converted into servings per day (0, 0.14, 0.43, 1 and 2 servings, respectively), and summed to create the average number of servings per day. The shorter version of this measure has been validated against the SFFQ with adequate comparability (0.60) and reproducibility (0.70) (Rifas-Shiman et al., 2001).

Analysis

Univariate and bivariate statistics were calculated for sociodemographic variables thought to be potential confounders in the relationship between supermarket access and diet. These included income, age, gender, car ownership, household size, country of origin, race/ethnicity, food insecurity (whether a participant reported that in the last 12 months there was ever a time when there was not enough money for food) and town of residence. Based on these preliminary analyses, potential socio-demographic confounders were selected for inclusion in the final model. Model building for the main analyses consisted of three steps: (1) Modeling the bivariate relationship between each measures of supermarket access and fruit and vegetable intake; (2) adjusting these models for income and country of origin; (3) adding in additional covariates.

Given the multilevel structure of the data (individuals nested within housing sites), a generalized estimating equation (GEE) was used in all models to account for potential clustering of the outcome responses by housing site. This type of model uses an exchangeable working correlation structure where observations within a site are assumed to be equally correlated. GEE was a more appropriate choice for the analysis than a multilevel model due to the substantive interest in estimating the overall relationship between distance and diet over and above analyzing the differences between housing sites. Statistical analyses were conducted in SAS v. 9.2 (Cary, NC).

Results

Table 1 shows the characteristics of the study sample ($n = 743$). The vast majority of participants were female (80.6%), roughly equally distributed by age, and living in a household with an average size of 3. Notably, 38.9% reported food insecurity. About half of participants owned a car. Participants were 42.8% Hispanic, 36.2% Black Non-Hispanic, 11.7% White Non-Hispanic and 9.3% Other. The majority was born outside the U.S., predominantly Haiti (22.8%) and other Latin American countries (22%). The average distance to a supermarket was 0.76 km; most participants (82.9%) reported having a supermarket within walking distance. On average, participants reported consuming 2.63 servings of fruit and vegetables daily.

Results of the bivariate relationship between participant characteristics and fruit and vegetable consumption reveal few significant associations (Table 2). Those who reported

having a supermarket within walking distance consumed more servings of fruit and vegetables daily than those who did not report having a supermarket within walking distance ($p < 0.0001$), while those who experienced food insecurity consumed less compared to those without food insecurity ($p = 0.01$). Participants from Haiti reported fewer servings of fruits and vegetables ($p = 0.02$), and those who reported an income of greater than \$500 weekly reported more ($p = 0.02$). However, p -values were not significant for an overall effect of country of origin or income on consumption patterns (not shown).

An analysis of the relationship between distance to a supermarket, perceived access to a supermarket, and fruit and vegetable intake using GEE is presented in Table 3. Distance to a supermarket was not associated with fruit and vegetable intake in the bivariate analysis ($p = 0.22$) (Model 1a) and controlling for two sets of covariates did not substantially alter the results (Models 1b and 1c).

Perceived access to a supermarket, however, was strongly associated with fruit and vegetable intake ($p < 0.0001$) (Model 2a), and remained statistically significant after controlling for income and country of origin (Model 2b) and all covariates (Model 2c). Those who reported access to a supermarket consumed about 0.5 servings a day more than those who did not report access.

Overall discordance between GIS-based measures of access and participant-perceived access was high at 31.5% (Table 4). Participants were defined as having access to a supermarket if they lived within 1 km of a supermarket, as measured by the street-network distance between the nearest supermarket and the centerpoint of the participants' housing site. Positive discordance was rather common (21.1%), and about twice as common as negative discordance (10.4%).

The association between discordance patterns and fruit and vegetable intake is presented in Table 5. Those who were negatively discordant consumed fewer fruits and vegetables than those who had a supermarket and reported one ($p < 0.0008$) after controlling for covariates, with a difference of 0.56 servings per day. There was no statistically significant association between positive discordance and fruit and vegetable intake, but the association went in the expected direction, with members of this group consuming more fruits and vegetables than those who were positively concordant. Those who were negatively concordant had, on average, slightly lower fruit and vegetable consumption in the bivariate analysis, but this result was not statistically significant after controlling for covariates (0.09). Despite these differences between groups, the overall p -value for equality of the four groups was not significant in either model. Individual characteristics were overwhelmingly unrelated to discordance patterns and are not included in the results.

Discussion

Based on the results, it seems that low-income housing residents in greater-Boston generally do not live in food deserts. Fruit and vegetable consumption was low, despite the apparent adequacy of geographic access to supermarkets. The strong relationship between perceived access to a supermarket – but not objective access – and fruit and vegetable intake suggests that these measures may be tapping into different constructs related to food access, and, furthermore, that perceived dimensions of food access might be of some importance to health behaviors.

Measurement of access to supermarket and grocery stores has overwhelmingly and increasingly employed objective GIS-based measures, which can be problematic in circumstances where geographic measures are ill-defined or conflict with non-geographic forms of access. Thus far, few studies that focus on the food retail environment have used

more than one assessment technique in the same study, but those that have shown results that are consistent with the findings of the current study and suggest that results may vary to some degree according to the method of exposure assessment (Gustafson et al., 2011; Moore, Diez Roux, Nettleton et al., 2008; 2009; Williams et al., 2010).

Measured individual characteristics were largely uncorrelated with discordance patterns, yet there may be a variety of other reasons for the discrepancies in perceived and objective access in the current study. Broadly, discordance might be attributed to (1) systematic directional biases in one or both of the measurement tools, (2) unmeasured neighborhood environmental factors, (3) unmeasured individual tastes or cognitive processes.

One of the most glaring measurement concerns is that 1 km may not represent the correct cut-off point to capture “walking distance” in the objective measure. Careful consideration went into the selection of the cut-off point, but there still may be enough variability in people's perceptions of “walking distance” that it cannot be captured by a single cut-off value. Although previous studies have raised concerns about the accuracy of secondary geographic data sources (Liese et al., 2010; Powell et al., 2011), the research team confirmed the location of all stores in the study area. The likelihood that low sensitivity biased the results is very small, given the familiarity of the researchers with the small study area, the prominence of supermarkets on urban streets, and the tendency for changes in supermarkets to be well-publicized in urban areas.

The perceived measure may be limited in that respondents may not be very adept at reporting what is within walking distance in their neighborhood – a common challenge of self-reported measures. It is also possible that respondents had very different ideas about how to define a supermarket than the researchers did, and therefore included other kinds of stores in their responses. The exclusion of small grocery stores from the objective measure makes this a possibility, but participants were asked about access to small grocery stores in conjunction with convenience stores in another question in order to distinguish them from supermarkets.

Beyond the limitations of the exposure measure, it may be that other unmeasured neighborhood environmental features play a large role in people's report of food retailers within walking distance. Residents who live in aesthetically pleasing areas, or those who had routes with superior walkability or less crime, might report better access because they generally encounter fewer barriers to shopping in their neighborhood. Indeed, the high variability of discordance rates between sites (which ranged between 0 and 98 percent) supports the idea that geographic access might actually look very different in different neighborhoods. However, objective walkability and crime were not measured empirically in this study.

Supermarket characteristics such as food prices or food selection, too, may influence whether people report access. The supermarkets in the study area ranged from discount supermarkets to retailers specializing in high-end and organic produce. In one site, a high-end supermarket was situated directly across the street from the main entrance of a small low-income housing site, yet 7.1% of residents reported that they did not have a supermarket within walking distance. It is improbable that these residents had not seen the store across the street; more likely, residents were reporting on a level of access that was beyond the geographic. Although GIS-based measures may be well-suited to capturing the *availability* of food stores, perceptions of the environment may incorporate additional dimensions of access, including affordability, product acceptability, and accommodation of the stores to meet the needs of these local residents (Charreire et al., 2010; Penchansky & Thomas, 1981). Perceived measures are well-suited to incorporate many of the environmental

realities that reflect true access, and in this sense, they hold an “objective” capacity that GIS-based measures may lack.

A variety of individual tastes and cognitive processes may have also contributed to the mismatch between perceived and objective measures. Perceived access could reasonably be seen as a reflection of innate preferences for certain eating habits. However, participants were asked on the survey how concerned they were about eating healthily, and this measure of health concerns was not associated with perceived access to a supermarket or with consumption of fruits and vegetables. Another alternative is that residents who were aware that their consumption of fruits and vegetables was low may have engaged in self-justification by reporting that they did not have access to healthy foods. The significant association between negative discordance and lower fruit and vegetable intake provides some support for this explanation.

Finally, the mismatch between perceived and objective measures may be attributable to cognitive dissonance, or the notion that holding two contradictory ideas or beliefs about their neighborhood leads some participants to report imprecise perceptions (Festinger, 1957). People may hold ideas about their environments that are favorable, but at odds with the realities of their neighborhoods. It is possible, then, that some residents might alter perceptions in order to resolve the cognitive dissonance of living “in a good neighborhood” and living, at the same time, “in a neighborhood without access to essential services.” The fact that most residents at every site reported supermarket access, and that positive discordance was more than twice as common as negative discordance, suggests that cognitive dissonance may explain some of the discordance in reporting access, although measurement and other environmental issues likely also play a role.

Particularly noteworthy may be the group of negatively discordant participants, who did not perceive access to a supermarket even when one was present within 1 km (and sometimes much less). Participants who fell into this category were more likely to be over 60 years old and report low self-rated health (data not shown), implying that at least one individual characteristic – namely, mobility – may alter perceptions of access. However, no other individual characteristics (BMI, gender, race, car ownership, income, country of origin) were linked to either negative or positive discordance. It may be that other *unmeasured* individual and environmental factors (for instance, familiarity with the neighborhood or walkability) might predict discordance. Given that this group consumed more than half a serving of fruits and vegetables less than average, identification of other factors that predict discordance would be useful for shaping ideas for intervention – for instance, arranging transportation for individuals with limited mobility. Other intervention strategies to promote the use of food retail outlets that sell healthy foods might range from the simple (creating neighborhood resource maps) to the more complex (promoting safer walking routes or public transportation) depending on other correlates of discordance.

Limitations

The current study has a number of limitations. First, as in the majority of studies conducted to ascertain the effect of the food environment on health, the data are cross-sectional, which limits causal inference as temporal precedence of the exposure has not been established and reverse causation cannot be ruled out. Second, the assessment tool used to capture fruit and vegetable intake is limited in its ability to assess the full range of differences in the amount of fruits and vegetables that different participants report consuming, as the short-form version of the FFQ does not have a range of categories for foods that are recommended in large quantities, beyond “more than once a day.” Furthermore, the dietary measure asked about intake only in the last week, so it does not account for seasonality and could exhibit more within-person variability than a year-long measure. Third, supermarkets are not always

the only source of produce for residents; other sources of produce beyond supermarkets (such as farmers markets, green grocers, and quality smaller grocery stores) may contribute substantially to the fruit and vegetable intake of residents, yet these sources of produce are not included in the current analysis. The measure of perceived access of small grocery stores was grouped with convenience stores, so we were unable to evaluate the contribution of small grocery stores as a source of fruits and vegetables. If residents primarily use these alternate sources of produce to buy fruit and vegetables, it could be a reason for the lack of association between supermarket distance and diet. Fourth, given the findings that low-income housing residents were not located in food deserts, the study was limited in its ability to determine the effect of lack of food access on diet. We also cannot conclude that distance to food stores is not important to dietary choices in other contexts, as there was simply not enough variability in supermarket distance to comment on the effects of this geographic indicator when distances are more substantial. Fifth, housing sites were occasionally large with numerous buildings. Because building addresses contained within sites are often not geocoded correctly, we used the centerpoint of each housing site to calculate the distance from each apartment building to the nearest supermarket. Finally, given the lack of significant difference that was found between concordance groups, we did not conduct post-hoc analyses that would have been able to compare two categories to each other rather than to all the others combined. Hence, the results provide only preliminary evidence for the effect of concordance patterns on fruit and vegetable intake.

Strengths

Despite these limitations, this study has a number of strengths. First, because the study was restricted to low-income housing residents, it eliminates a substantial portion of the heterogeneity in diet given correlations between dietary patterns and income (Berrigan, Dodd, Troiano, Krebs-Smith, & Barbash, 2003). Second, the concordance of timing between data collection of participant responses and geographic indicators has been a major limitation of previous research relating the food environment to health, as gaps between these measures have occasionally spanned up to six years (Morland et al., 2006). Mismatch between perceived and objective measures cannot, therefore, be attributed to changes in supermarket location between the data collection points of the two measures. An additional strength of the study is the use of generalized estimating equations in the analysis, which accounts for clustering of the outcome by site. Finally, careful consideration was used in deciding what constitutes reasonable access to a supermarket. Housing sites could be mapped with relative accuracy and are considerably smaller than census tracts or postal codes that have often been the geographic unit of analysis in similar studies. Site validation of supermarkets was used due to the relatively small geographic study area.

Conclusion

In general, low-income housing residents in greater-Boston do not live in food deserts and appear to have geographic access to supermarkets. Fruit and vegetable intake, however, is low and not associated with geographic access. Perceived measures may have limited comparability with objective measures, but also may incorporate important psychosocial, environmental and financial information about the participant that can be difficult to measure and may be crucial for depicting the true food environment. These less obvious dimensions of access may apply not only to the food environment, but also more broadly to other areas of public health, where participant-report of access to health services, built environment features, or social support may depict a reality untapped by objective measures. Overall, the results from this study imply that perceived measures of the food environment might serve as important predictors of dietary behaviors.

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Table 1Characteristics of the study sample ($n = 743$).

	Mean	SD	Min	Max
Fruit and vegetable intake (servings/day)	2.63	(1.54)	0.00	9.00
Household size	2.99	(1.45)	1.00	9.00
Distance to supermarket (km)	0.76	(0.32)	0.13	1.22
	<i>n</i>			%
Gender				
Female	599			80.62
Male	144			19.38
Age (yrs)				
18–29	135			18.17
30–39	201			27.05
40–49	148			19.92
50–59	131			17.63
60+	128			17.23
Weekly income				
\$0–\$100	73			9.83
\$101–\$250	225			30.28
\$251–\$500	253			34.05
\$501–\$750	98			13.19
<\$750	94			12.65
Food insecurity				
No	454			61.1
Yes	289			38.9
Race/ethnicity				
Hispanic	318			42.8
White Non-Hispanic	87			11.71
Black Non-Hispanic	269			36.2
Other	69			9.29
Country of origin				
USA	241			32.44
Puerto Rico	88			11.84
Haiti	169			22.75
Latin America	163			21.94
Other	82			11.04
Car ownership				
No	360			48.45
Yes	383			51.55
Town				
Chelsea	235			31.63

	Mean	SD	Min	Max
Cambridge	396			53.3
Somerville	112			15.07
Reported supermarket within walking distance				
No	127			17.09
Yes	616			82.91

Table 2FV intake (servings/day) by individual characteristics ($n = 743$).

	Mean	SD	<i>p</i> -value
Gender			
Female	2.62	(1.52)	(<i>ref</i>)
Male	2.67	(1.62)	0.73
Age (yrs)			
18–29	2.43	(1.51)	(<i>ref</i>)
30–39	2.72	(1.51)	0.09
40–49	2.66	(1.50)	0.17
50–59	2.67	(1.64)	0.15
60+	2.62	(1.54)	0.34
Weekly income			
\$0–\$100	2.38	(1.36)	(<i>ref</i>)
\$101–\$250	2.57	(1.44)	0.21
\$251–\$500	2.58	(1.50)	0.17
\$501–\$750	2.88	(1.77)	0.02
<\$750	2.83	(1.70)	0.02
Food insecurity			
No	2.73	(1.60)	(<i>ref</i>)
Yes	2.46	(1.41)	0.01
Race/ethnicity			
Hispanic	2.67	(1.43)	(<i>ref</i>)
White Non-Hispanic	2.43	(1.46)	0.62
Black Non-Hispanic	2.59	(1.68)	0.18
Other	2.85	(1.49)	0.14
Country of origin			
USA	2.72	(1.68)	(<i>ref</i>)
Puerto Rico	2.56	(1.30)	0.22
Haiti	2.33	(1.49)	0.02
Latin America	2.71	(1.45)	0.82
Other	2.90	(1.55)	0.48
Car ownership			
No	2.58	(1.56)	(<i>ref</i>)
Yes	2.67	(1.52)	0.35
Town			
Cambridge	2.71	(1.65)	(<i>ref</i>)
Chelsea	2.55	(1.35)	0.12
Somerville	2.50	(1.49)	0.62
Reported supermarket within walking distance			
No	2.22	(1.50)	(<i>ref</i>)
Yes	2.71	(1.53)	<0.0001

	Mean	SD	<i>p</i> -value
Distance to a supermarket (km)	0.25 ^a	(0.21)	0.23
Household size	-0.01 ^a	(0.04)	0.78

^aDifference in FV servings per 1 unit change.

Table 3

GEE models of distance to supermarket (Models 1a–c) and perceived access to supermarket (Models 2a–c) on FV intake ($n = 744$).

	Model 1a			Model 1b			Model 1c			Model 2a			Model 2b			Model 2c		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Intercept	2.43	(0.16)	<0.0001	2.31	(0.24)	<0.0001	2.28	(0.28)	<0.0001	2.22	(0.10)	<0.0001	2.10	(0.22)	<0.0001	2.10	(0.24)	<0.0001
Distance to supermarket (km)	0.25	(0.21)	0.23	0.21	(0.17)	0.22	0.23	(0.18)	0.21									
Perceived supermarket access										0.50	(0.12)	<0.0001	0.51	(0.10)	<0.0001	0.48	(0.12)	<0.0001
Weekly income																		
\$0–\$100				<i>ref</i>			<i>ref</i>						<i>ref</i>			<i>ref</i>		
\$101–\$250				0.16	(0.15)	0.28	0.13	(0.15)	0.40				0.11	(0.15)	0.48	0.07	(0.15)	0.66
\$251–\$500				0.16	(0.14)	0.25	0.14	(0.14)	0.34				0.13	(0.15)	0.39	0.08	(0.14)	0.56
\$501–\$750				0.48	(0.22)	0.03	0.47	(0.22)	0.03				0.44	(0.22)	0.05	0.39	(0.22)	0.08
<\$750				0.40	(0.23)	0.08	0.33	(0.25)	0.18				0.37	(0.24)	0.13	0.28	(0.25)	0.26
Country of origin																		
USA				<i>ref</i>			<i>ref</i>						<i>ref</i>			<i>ref</i>		
Puerto Rico				–0.13	(0.14)	0.37	–0.03	(0.15)	0.86				–0.08	(0.16)	0.60	–0.04	(0.15)	0.77
Haiti				–0.34	(0.18)	0.05	–0.50	(0.19)	0.01				–0.40	(0.17)	0.02	–0.51	(0.19)	0.01
Latin America				0.01	(0.17)	0.96	0.06	(0.19)	0.77				–0.00	(0.16)	0.98	0.03	(0.18)	0.86
Other				0.20	(0.26)	0.45	0.14	(0.25)	0.56				0.20	(0.26)	0.46	0.14	(0.26)	0.58
Age (yrs)																		
18–29							<i>ref</i>									<i>ref</i>		
30–39							0.30	(0.19)	0.12							0.33	(0.19)	0.08
40–49							0.29	(0.17)	0.10							0.31	(0.18)	0.08
50–59							0.36	(0.18)	0.05							0.35	(0.19)	0.07
60+							0.34	(0.22)	0.13							0.35	(0.23)	0.13
Gender																		
Female							<i>ref</i>									<i>ref</i>		
Male							0.00	(0.13)	0.97							–0.01	(0.13)	0.92
Food insecurity																		
No							<i>ref</i>									<i>ref</i>		
Yes							–0.26	(0.12)	0.02							–0.21	(0.11)	0.05

	Model 1a			Model 1b			Model 1c			Model 2a			Model 2b			Model 2c		
	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value	β	SE	p-value
Town																		
Cambridge							<i>ref</i>	.								<i>ref</i>	.	
Chelsea							-0.25	(0.13)	0.05							-0.21	(0.14)	0.13
Somerville							-0.07	(0.14)	0.60							-0.17	(0.16)	0.29

Table 4

Frequency of mismatch between perceived and objective measures of supermarket access.

	<i>n</i>	%
Negative discordance	77	10.35
Positive discordance	157	21.10
Negative concordance	50	6.72
Positive concordance	460	61.83

Table 5

GEE models of perceived and objective mismatch and FV intake ($n = 744$).

Bivariate model				Model controlling for income, age, country of origin, gender, food insecurity, and town			
Model 1				Model 2			
β	SE	p-value	Overall p-value	β	SE	p-value	Overall p-value
Negative discordance	−0.55	0.15	0.0003	0.06	−0.56	0.17	0.0008
Positive discordance	0.21	0.19	0.26	0.18	0.16	0.28	
Negative concordance	−0.26	0.07	0.0005	−0.18	0.11	0.09	
Positive concordance	.	.	ref	.	.	ref	