

Neighborhood Environments

Disparities in Access to Healthy Foods in the U.S.

Nicole I. Larson, PhD, MPH, RD, Mary T. Story, PhD, RD, Melissa C. Nelson, PhD, RD

Background: Poor dietary patterns and obesity, established risk factors for chronic disease, have been linked to neighborhood deprivation, neighborhood minority composition, and low area population density. Neighborhood differences in access to food may have an important influence on these relationships and health disparities in the U.S. This article reviews research relating to the presence, nature, and implications of neighborhood differences in access to food.

Methods: A snowball strategy was used to identify relevant research studies ($n=54$) completed in the U.S. and published between 1985 and April 2008.

Results: Research suggests that neighborhood residents who have better access to supermarkets and limited access to convenience stores tend to have healthier diets and lower levels of obesity. Results from studies examining the accessibility of restaurants are less consistent, but there is some evidence to suggest that residents with limited access to fast-food restaurants have healthier diets and lower levels of obesity. National and local studies across the U.S. suggest that residents of low-income, minority, and rural neighborhoods are most often affected by poor access to supermarkets and healthful food. In contrast, the availability of fast-food restaurants and energy-dense foods has been found to be greater in lower-income and minority neighborhoods.

Conclusions: Neighborhood disparities in access to food are of great concern because of their potential to influence dietary intake and obesity. Additional research is needed to address various limitations of current studies, identify effective policy actions, and evaluate intervention strategies designed to promote more equitable access to healthy foods.

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Introduction

A growing body of evidence indicates that residential segregation by income, race, and ethnicity contributes to health disparities in the U.S.^{1–7} In addition, substantial research shows disparities in health between urban and rural areas.⁸ Poor dietary patterns and obesity, established risk factors for chronic disease, have been linked to neighborhood deprivation, neighborhood minority composition, and low area population density (as found in more rural areas).^{9–15} Neighborhood differences in access to foods may be an important influence on these relationships. Establishing the presence, nature, and implications of neighborhood differences in the physical availability of more- and less-healthy foods is necessary to properly

inform the development of responsive public health policies and interventions that may help reduce inequalities in health.

Recent reviews have drawn attention to relationships among neighborhood food availability, dietary intake, and obesity, but to our knowledge, a detailed review of disparities in food access has not been completed.^{16,17} For this review, neighborhood is broadly defined to be “the area around one’s place of residence,” and research relating to both micro- (e.g., stores within walking distance from home) and macro-level characteristics (e.g., restaurants within county boundaries) of the physical food environment are considered. This article briefly reviews the current evidence base regarding (1) the relationship between neighborhood access to more- and less-healthy foods and dietary intake and (2) the relationship between neighborhood access to foods and weight status. In addition, this article presents a comprehensive review of disparities across the U.S. according to income, race, ethnicity, and urbanization in neighborhood access to more- and less-healthy foods. Studies relating to both food stores and restaurants are summarized separately and dis-

From the Division of Epidemiology and Community Health, School of Public Health, University of Minnesota, Minneapolis, Minnesota.

Address correspondence and reprint requests to: Nicole I. Larson, PhD, MPH, RD, West Bank Office Building, Suite 300, University of Minnesota, 1300 South Second Street, Minneapolis MN 55454. E-mail: larsonni@umn.edu.

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cussed in terms of their limitations and implications for future research and practice.

Methods

A snowball strategy was used to identify relevant research studies completed in the U.S. and published between 1985 and April 2008. Searches were completed in PubMed and MEDLINE using the following key words: neighborhood; environment; food store; supermarket; restaurant; dietary intake; obesity; overweight; disparity; inequality; deprivation; income; poverty; rural; race; and ethnicity. The references cited in articles ($n=43$) indexed in these search engines were also checked; and all potentially relevant articles were retrieved. To be included in the review; articles had to describe research that addressed neighborhood access to food stores; restaurants; or the types of food and beverage products available in such outlets. This search strategy identified 54 articles relevant to the review objectives.

Results

Retail Food Stores and Dietary Intake

Supermarkets, as compared to other food stores, tend to offer the greatest variety of high-quality products at the lowest cost.^{18–23} In contrast, convenience stores sell mostly prepared, high-calorie foods and little fresh produce, at higher prices.²⁴ Studies of adults^{18,25–29} and adolescents³⁰ have examined associations between neighborhood access to food stores and intake of fruits and vegetables, calories from dietary fat, and overall diet quality. The majority of these studies suggest that neighborhood residents with better access to supermarkets and other retail stores that provide access to healthful food products tend to have healthier food intakes.^{18,25–28,31}

Studies among adults have emphasized the potential impact of access to food stores on dietary intake among minority and lower-income populations. For example, one study among 2392 black and 8231 white Americans aged 49–73 years in the Atherosclerosis Risk in Communities (ARIC) Study showed a direct relationship between living in a census tract with at least one supermarket and meeting the U.S. Department of Agriculture and the U.S. Department of Health and Human Services 2000 Dietary Guidelines for fruit and vegetable intake.²⁵ The observed relationship was stronger among black Americans than among white Americans. The presence of each additional supermarket was related to a 32% and an 11% increase for blacks and whites, respectively, in meeting guidelines for fruit and vegetable intake. At least three other studies among low-income individuals and households have found that better supermarket access or shopping in a supermarket has a direct, positive relationship to markers of a healthful diet.^{26,27,32}

Only one study was found in the review that examined associations between access to retail food stores

and dietary intake among youth.³⁰ Among 204 Boy Scouts (aged 10–14 years) in Texas, fruit and vegetable intake was unrelated to supermarket access but directly related to the distance between home and the nearest convenience store.³⁰ The study suggests that young adolescents with greater access to convenience stores eat fewer fruits and vegetables; however, no studies in older youth, specifically those with driving privileges, were identified.

A smaller body of research has involved an assessment of what products are sold in retail outlets. Of five studies that examined relationships between the physical availability of healthful food products in community food stores and diet,^{18,31,33–35} four reported that greater availability was related to either higher intake or greater home availability of the same foods.^{18,31,34,35} One illustrative study in a random sample of 102 individuals in New Orleans found that each additional linear meter of vegetable shelf space in local small food stores (within 100 meters or one city block of a residence) was related to an increase in vegetable intake of 0.35 daily servings.¹⁸ A trend was also found relating the availability of more fresh vegetable varieties in local stores to greater vegetable consumption. No similar relationships were found for fruit.

Retail Food Stores and Risk for Obesity

Associations between residential access to retail food stores and risk for obesity have been examined among adults,^{28,29,36–38} adolescents,³⁹ and children.^{40,41} Despite some inconsistencies, several studies have shown that better access to a supermarket is related to reduced risk for obesity,^{37,39,40} whereas greater access to convenience stores is related to increased risk for obesity.^{37,39} For example, a study in more than 10,000 adults residing in one of four geographic areas (MS, NC, MD, or MN) found census tracts with access to supermarkets (large, corporate-owned chain food stores) alone or to supermarkets and grocery stores (medium-sized, non-corporate-owned food stores) had the lowest levels of obesity (21%).³⁷ The highest levels of obesity (32%–40%) were observed in census tracts with no supermarkets, with access to only grocery stores or grocery and convenience stores (32%–40%). These relationships were evident despite adjustment for several characteristics of individuals and neighborhoods, including gender, race and ethnicity, income, education, physical activity, and the availability of other retail food stores. Two^{39,40} of three^{39–41} studies in children and adolescents have reported similar findings, indicating that better supermarket access is related to reduced risk for obesity.

Retail Food Stores and Access Inequalities

Given the research indicating that better access to supermarkets and large chain grocery stores contrib-

utes to healthier dietary patterns and reduced risk for obesity, neighborhood disparities in store access are of concern. Despite some inconsistencies, several U.S. studies have shown that residents of rural,^{34,42–46} low-income,^{22,24,34,42,47–54} and minority^{21,25,34,42,47–49,51,52,54–58} communities are most often affected by poor access to supermarkets, chain grocery stores, and healthful food products (Appendix A, online at www.ajpm-online.net). Although not all studies have been able to compare rural and urban communities directly,^{44,46} strong evidence of such disparities was found in a national study representing more than 28,000 ZIP codes across the U.S.⁴² The findings showed that rural and farm areas had 14% fewer chain supermarkets than urban areas. ZIP codes representing low-income areas had only 75% as many chain supermarkets available as ZIP codes representing middle-income areas. Stark racial and ethnic disparities were also demonstrated; the availability of chain supermarkets in predominantly black neighborhoods was found to be roughly one half that in their counterpart white neighborhoods. ZIP codes with higher proportions of Hispanic residents had only 32% as many chain supermarkets available as primarily non-Hispanic neighborhoods.

Some research suggests that disparities according to race and ethnicity may be more prevalent in low-income neighborhoods. A study in metropolitan Detroit showed that the distance to the nearest supermarket was similar across census tracts with $\leq 5\%$ of residents in poverty, regardless of racial composition.⁵¹ However, when census tracts with $\geq 17\%$ of residents in poverty were compared, predominantly black census tracts were on average 1.1 miles farther from the nearest supermarket than were white census tracts. Several studies utilizing in-store observations have shown greater availability and higher quality of fresh produce, low-fat dairy products and snacks, lean meats, and high-fiber bread in predominantly white areas than in nonwhite areas.^{24,34,48,55–57} For example, research in two racially and economically diverse areas of Brooklyn examined the availability of produce across food store types in 166 randomly sampled stores.⁵⁵ The study showed that the majority of inventoried fresh produce varieties (25 of 39) were more widely available in predominantly white neighborhoods than in racially mixed or predominantly black neighborhoods.

Research in adolescents indicating that greater access to convenience stores may contribute to less-healthy food choices and to a greater risk for obesity suggests the need for concern regarding disparities in neighborhoods near schools.^{30,39} At least two studies have reported differences according to income, race, or ethnicity in the availability of food stores in school neighborhoods.^{59,60} The findings showed that a greater number of convenience stores were located near secondary schools in low- versus high-income census tracts and in racial/ethnic-minority versus predominantly

white census tracts.^{59,60} For example, one study reported 50% fewer convenience stores near (within 0.5 miles) schools in high-income census tracts than in low-income census tracts.⁵⁹ Racially mixed census tracts contained 19% more convenience stores near (within 0.5 miles) schools than predominantly white census tracts.

Restaurants and Dietary Intake

Meals and snacks consumed at restaurants account for nearly half of U.S. food expenditures, and diners are expected to spend \$558 billion at U.S. restaurants in 2008.⁶¹ Restaurant meals tend to be more calorie-dense and of poorer nutritional quality than foods and beverages consumed at home.^{62,63} Many consumers lack access to the nutritional information they need to help them make healthful choices at restaurants. Federal and most state laws currently do not require restaurants to provide nutritional information, and nearly half of all restaurants do not provide this information to consumers.⁶⁴ Several studies in adults,^{65–68} adolescents,^{69–72} and children^{67,73} have related frequent eating outside the home to higher intakes of fat, sodium, and soft drinks, and to lower intakes of nutrient-dense foods such as fruits, vegetables, and milk.

More recently, a limited number of research studies in children,⁷⁴ adolescents,^{74,75} and adults^{25,76,77} have found that the area availability of restaurants and restaurant food prices are related to dietary intake. Although access to full-service restaurants has been shown to be related to some improvements in dietary intake, lower fast-food prices, which enable greater consumption, have been shown to be related to some markers of a poor diet. For example, a large, nationally representative study in 72,854 adolescents examined the extent to which restaurant density and meal prices were associated with fruit and vegetable consumption.⁷⁵ Results indicated that better access to full-service restaurants was related to a greater likelihood of fruit and vegetable consumption on all or most days. In contrast, a 10% increase in the price of a fast-food meal was related to a 3% increase in the probability of regular fruit and vegetable consumption.

Restaurants and Risk for Obesity

Research suggests that eating more food from restaurants, particularly fast-food restaurants, is related to greater weight gain and obesity.^{65,66,68,78–84} However, studies examining the relationship between fast-food restaurant availability and obesity have reported mixed results.^{41,74–77,85,86} Three nationally representative state- and county-level analyses of fast-food availability and obesity levels in U.S. adults^{76,77} and children⁷⁴ have reported a direct relationship; areas ranking lowest in obesity tend to have more residents per operating fast-food restaurant. Four other studies that focused on

smaller land area units (e.g., within a ZIP code or within 2 miles of home) have also examined fast-food availability and obesity levels but reported no evidence of a relationship.^{41,75,85,86} Studies examining full-service restaurant availability and obesity have reported no evidence of a relationship,^{41,75,86} and in at least one case, higher restaurant density was associated with lower risk for obesity.⁷⁷

Restaurants and Access Inequalities

Given the identified associations between restaurant access and dietary intake and obesity, other research indicating that fast-food and full-service restaurants may be concentrated in neighborhoods according to their racial and socioeconomic composition is of concern. The majority of U.S. studies^{54,59,60,87–89} have shown the availability of fast-food restaurants to be greater in lower-income and minority neighborhoods than in high-income and predominantly white neighborhoods (Appendix B, online at www.ajpm-online.net). For example, a nationally representative study that examined the availability of restaurants across more than 28,000 U.S. ZIP codes found considerable disparities despite adjustments for population size, urbanization, and region.⁸⁹ In comparison to high-income ZIP code areas, lower-income ZIP code areas were found to have 1.2 times the number of full-service restaurants and 1.3 times the number of fast-food restaurants. Among urban neighborhoods, ZIP codes in predominantly black areas were found to have a higher proportion of fast-food restaurants among all available restaurants than ZIP codes in predominantly white areas.

A small number of research studies have also found that restaurants in affluent neighborhoods provide a greater number of healthy menu options than restaurants located in lower-income neighborhoods.^{47,88} One study conducted in South Los Angeles CA examined promotions and the availability, quality, and preparation of food in 659 restaurants across 19 ZIP codes.⁸⁸ The results showed that almost 40% of restaurants in affluent ZIP code areas provided patrons with five or more healthy preparation options (e.g., broiled, baked, or boiled food) in contrast to only 27% of restaurants in lower-income areas. Similarly, 42% of restaurants in affluent areas offered at least five healthy food choices (e.g., green salad, brown rice, fresh fruit) in contrast to only 36% in lower-income areas.

In addition to the research regarding disparities across residential neighborhoods, at least three studies have reported differences according to income, race, or ethnicity in the availability of fast-food restaurants located in school neighborhoods.^{59,60,90} Given the considerable time that adolescents spend in and around schools, the food environment surrounding schools may influence their eating patterns. Research suggests

that fast-food restaurants tend to be clustered in school neighborhoods; nationwide, 37% of schools are within walking distance of at least one fast-food restaurant.^{59,91,92} Further, there is some evidence that a greater number of fast-food restaurants are located near secondary schools in low- versus high-income and in racially mixed versus predominantly white census tracts.⁵⁹ For example, in one study, there were 32% fewer fast-food restaurants near (within 0.5 miles) schools in high- versus low-income census tracts.⁵⁹

Discussion

The aim of this review is to describe and evaluate research relating to neighborhood differences in the physical availability of food stores, restaurants, and healthy foods. Associations of neighborhood food access with dietary intake and obesity were found to vary according to the type of food store or restaurant. In general, research suggests that neighborhood residents who have better access to supermarkets and limited access to convenience stores tend to have healthier diets and lower levels of obesity.^{18,25–27,31,36–40} Studies that examined the accessibility of restaurants produced less consistent findings; however, some evidence suggests that neighborhood residents who have better access to full-service restaurants and greater cost barriers to fast-food consumption have healthier diets and lower levels of obesity.^{25,74–77} Much of the evidence suggesting a relationship between restaurant accessibility and obesity levels in the U.S. has come from research that focused on land area units larger than neighborhoods (e.g., states, counties). National and local studies across the U.S. have shown disparities according to income, race, ethnicity, and urbanization in neighborhood access to food stores and restaurants. Although additional studies are needed to address various research limitations, completed studies indicate a need for policy action and other intervention strategies to ensure equitable access to healthy foods across the U.S. Recommendations for future research on disparities in access to healthy foods are summarized in Appendix C (online at www.ajpm-online.net).

Common limitations of the studies reviewed here relate to: the validity and reliability of measures; the complexity of defining a relevant neighborhood; and the cross-sectional, observational nature of most research designs. The majority of studies included in this review used commercially (e.g., Dun and Bradstreet, InfoUSA) or publicly available lists (e.g., telephone directories, state departments of agriculture) to identify food stores and restaurants. Few studies identified stores or restaurants by ground truthing or with walking surveys, and only one study was found that reported a detailed comparison of these two methods for measuring residential food environments. That single study reported a considerable discrepancy between the stores

found on publicly available lists and the results of ground truthing in rural Texas; nearly 20% of stores on publicly available lists could not be verified, and 36% of stores in the area were missing from those lists.⁴⁶ Using data from only publicly available lists would have led to overestimations of the distance to the nearest supermarket in nearly 34% of the census block groups and to the nearest convenience store in 13% of the census block groups. Additional studies are needed to determine the potential impact of errors in commercially and publicly available lists on research findings. Research conducted to validate a commercial database of physical activity facilities found only moderate to poor agreement when the database locations were compared to locations determined by a field census; the authors concluded that the patterns of error observed were likely to bias environment–health associations toward the null.⁹³ It may be advisable to use a combination of measures and data sources, when feasible, to reduce errors in the identification of food stores and restaurants.

The common use of automatic geocoding tools (i.e., ArcGIS, Automatch, ZP4, Geolytics, and other software that perform batch or interactive address matching) is of further concern. The geocoding process is vulnerable to various types of error that may be introduced during the preprocessing and matching of addresses to spatial areas.⁹⁴ A few studies have reported address match rates,^{51,58} but very little is known about matching accuracy or the potential impact of positional errors on research findings relating to the food environment. Studies comparing automatic geocoding tools have found considerable variation in the assignment of addresses to census block groups and census tracts. For example, one study found that 28%–36% of addresses geocoded by different tools were not assigned to the same census block group, and 33%–51% of residential addresses were not assigned to the same census tract.⁹⁴ Other studies have further examined the positional accuracy of automated geocoding tools by comparing the assigned latitude and longitude coordinates to assignments determined using the gold-standard method of aerial orthoimagery and found sizable error, especially in rural areas.^{95,96}

Discrepancies between researcher- and resident-defined neighborhood boundaries may be a source of bias in studies relating to food access.^{97,98} Research regarding perceptions of neighborhood boundaries has shown that resident-defined neighborhoods are, on average, four times larger than a census block group.⁹⁷ The average size of a resident-defined neighborhood is comparable to a census tract, but neighborhoods typically include portions of at least two census tracts. Clearly, researchers cannot assume that resident- and census-defined neighborhoods are similar. Discrepancies could result in measurable differences in the social conditions (e.g.,

ethnic/racial composition, average income) occurring within a neighborhood.

A limited number of studies have considered the distance that residents typically travel beyond their neighborhood to purchase food.^{24,36,51,53,87} Among these studies, the definition of a relevant shopping area has ranged from 0.5 to 15 miles. The availability of food along routes to work, school, and other destinations may further influence dietary intake and obesity. Different methods of geocoding and varied buffer sizes could result in substantially different datasets on which study results and recommendations are based. Future research needs to illuminate which food environment areas are most influential and what factors, other than physical proximity, influence people's choices of where to purchase food. Further development of standard measurement protocols and greater reporting on details of the geocoding process are needed in future research studies in order to provide a basis for comparing study outcomes (Appendix C, online at www.ajpm-online.net).⁹⁹

Comparability across studies also depends on the use of standard definitions to classify food stores and restaurants into categories. As summarized in Appendixes A and B (online at www.ajpm-online.net), the studies described in this review have defined categories of food stores and restaurants in various ways. For example, some studies have defined categories of food stores according to the number of cash registers whereas others have categorized stores according to the number of staff employed, the types of food sold, name recognition, or annual sales data.^{43–45,48,55,58} Several studies have similarly used the North American Industry Classification System (NAICS) or predecessor Standard Industrial Classification (SIC) system codes to define categories of stores and restaurants; however, few studies have reported the code numbers included within each category.^{52,54} Further, some research indicates that the business databases from which NAICS and SIC codes are typically drawn may contain many errors.⁹³ Although different data sources do not always provide the same details relevant to the categorization of food outlets, researchers should work toward a consensus on the use of a standard set of definitions, and future studies should aim to fully describe how food store and restaurant categories are defined.

Research studies that complete observations within stores and restaurants can most directly address differences in the physical availability of healthy foods and beverages. It is critical that studies employing direct observation report on methodologic details and the reliability of employed measures. Just half of the studies in this review that reported on direct observations in stores ($n=5$ of 11) and neither study that reported on direct observations in restaurants ($n=2$) were found to include assessments of inter-rater or test–retest reliability.^{19,24,45,48,53} However, growing efforts are being made

to design psychometrically sound measures of food environments within stores²⁰ and restaurants¹⁰⁰ and to develop strategies to promote high measurement reliability.¹⁰¹ The implementation of these tools and strategies in future research will contribute to a better understanding of differences in residential access to healthy food and their implications for health.

The majority of studies included in this review used cross-sectional designs; few longitudinal, multilevel, or intervention studies have been reported. Studies examining relationships among residential food access, dietary intake, and obesity have considered several characteristics of neighborhoods and individuals, including gender, race and ethnicity, income, education, and physical activity. However, several factors contribute to dietary intake and the development of obesity. In order to better understand the relative importance of environmental, demographic, psychological, and social factors, as well as the interaction of these factors, it will be necessary to examine hypothesized pathways of influence and the contributions of each factor within the same study.

Future studies investigating disparities in access to more- and less-healthy food also need to systematically consider covarying characteristics of neighborhoods such as population size, urbanization, region, and commercialization. Several studies included in this review indicate that disparities in access to healthy food vary according to these characteristics of neighborhoods.^{42,89,90} For example, one study found no significant differences in the relative availability of fast-food restaurants by income, race, or ethnicity within a national sample of ZIP codes.⁸⁹ However, when only urban ZIP codes were examined, ZIP codes in lower- versus higher-income and predominantly black areas versus predominantly white areas were found to have a higher proportion of fast-food restaurants among all available restaurants. International comparisons using standardized measures may further help to illuminate qualities of the broad social and political environment that contribute to disparities. In stark contrast to research conducted in the U.S., studies in areas of New Zealand, Australia, Canada, and Scotland show greater availability of supermarkets in lower- versus higher-income neighborhoods.^{102–105}

Additionally, more comprehensive assessments of neighborhood food environments are needed. When only one aspect of the food environment is studied, the results are difficult to interpret, as neighborhoods with greater access to unhealthy food options may also have greater access to healthy food options. A limited number of studies have investigated disparities in access to both food stores and restaurants within the same geographic region and suggest that the nature of neighborhood disparities may differ according to the type of food outlet examined.^{36,47,54,58} Further, the extent to which other factors, such as economic and social char-

acteristics of neighborhoods, may influence accessibility above and beyond physical proximity is an important area for future research.

Despite these research limitations, the studies reviewed here indicate a need for policy action and other intervention strategies to ensure more equitable access to healthy foods across the U.S. Very few studies have evaluated strategies for reducing disparities or improving physical access to healthy, affordable food. Several strategies and policy actions have been proposed to attract supermarkets to underserved neighborhoods, improve the availability of healthy foods such as fruits and vegetables, and reduce access to calorie-dense foods in restaurants (Appendix D, online at www.ajpm-online.net).^{106–110} However, many challenges remain in implementing interventions of this nature. Research designed to evaluate proposed interventions, build broad support for their implementation, and identify other effective means for improving neighborhood access to healthy food should be made a priority.

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Appendix A. Inequalities in access to food stores and healthful food products in the U.S.

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Zenk (2008) ¹	National sample including 31,243 public secondary schools	48,460 convenience stores, defined by proprietary SIC codes	2004–2005 NCESCCD; census 2000 and Census Bureau 2005 population figures; D&B	Schools in predominantly black (>70%) tracts and those in predominantly non-Hispanic white tracts had a similar number of convenience stores within 0.5 miles Schools in middle-income and high-income tracts (based on tertiles of median household income) had 22% fewer and 50% fewer convenience stores within 0.5 miles, respectively, than schools in low-income tracts
Sturm (2008) ²	National sample including 31,622 public secondary schools	Snack and nonalcoholic beverage shops, convenience stores or food marts, off-licenses, alcoholic drinking places, defined by NAICS codes	2003–2004 NCESCCD; InfoUSA	A higher proportion of students eligible for free school meals was associated with a greater likelihood of a school having a convenience store within 400 m A higher proportion of Hispanic students was associated with a greater likelihood of a school having a snack store within 400 m
Sharkey (2008) ³	101 census block groups in six rural counties of central TX	213 supermarkets, grocery stores, convenience stores, discount stores, beverage stores, and specialty food stores, defined by a modified version of 2002 NAICS codes	Ground truthing and camera-based GPS; local/area telephone directories; Internet telephone directories; TX Department of Agriculture	Distance to the nearest food store decreased with increasing socioeconomic deprivation, increasing minority composition, and increasing population density across census block groups Independent of population density, block groups categorized in the highest tertile of minority composition (>39% nonwhite residents) and highest tertile of deprivation (determined by such factors as poverty and education) had the best potential physical access to a supermarket, a supermarket or grocery store, and a discount store
Moore (2008) ⁴	2834 participants in the Multi-Ethnic Study of Atherosclerosis in NC, MD, and NY	Supermarkets, defined by SIC codes, chain name recognition, and >50 employees	InfoUSA	Hispanic participants lived in census tracts with higher densities of supermarkets Low-income participants (determined by per capita income) lived in census tracts with higher densities of supermarkets
Galvez (2007) ⁵	165 census blocks in East Harlem	219 supermarkets, grocery stores, convenience stores, and specialty stores, defined by number of cash registers and the types of food sold	Census 2000; block-by-block walking survey by a single surveyor in 2004	76% of predominantly black (>75%) blocks had no food stores, compared to 15% of predominantly Latino blocks (>75%) and 40% of racially mixed blocks 100% of predominantly black blocks had neither supermarkets nor grocery stores Predominantly black blocks were less likely to have convenience stores than were racially mixed blocks Predominantly Latino blocks were more likely to have convenience stores and specialty food stores than were racially mixed blocks
Morton (2007) ⁶	U.S. national sample by county	Large retailers (supermarkets or supercenters employing ≥50 staff)	1999 U.S. Bureau of the Census ZIP Code Business Patterns data; census 2000	418 counties were identified in which the entire population lived >10 miles from a large retailer (food deserts) Food desert counties in comparison to non-food desert areas were characterized by higher poverty rates, larger percentages of individuals without a high-school degree or GED, lower median family incomes, greater percentages of residents living in sparsely populated areas, and higher numbers of small grocers and convenience stores per capita

Appendix A. *(continued)*

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Powell (2007) ⁷	U.S. national sample of 28,050 ZIP codes	Chain and nonchain supermarkets, grocery stores, convenience stores, defined by primary SIC codes	D&B; census 2000	Low-income (bottom quintile of median household income) ZIP codes had only 75% as many chain supermarkets available as middle-income ZIP codes The availability of chain supermarkets in ZIP codes with higher proportions of black residents was roughly half that in predominantly white ZIP codes Rural (farm and nonfarm) areas had 14% fewer chain supermarkets than urban areas
Wang (2007) ⁸	82 CA neighborhoods defined by a combination of census tracts and block groups, representing 7595 participants in the Stanford Heart Disease Prevention Program (1979–1990)	Chain convenience stores, small grocery stores, ethnic markets, and chain supermarkets, defined using the NAICS and Food Marketing Institute definitions	1980 and 1990 census; State Board of Equalization and telephone business directories for the years 1979–1990	Residents of low-socioeconomic status neighborhoods lived closest to small grocery stores and convenience stores, whereas residents of middle-socioeconomic status neighborhoods lived closer to ethnic markets and supermarkets than residents of other tracts
Moore (2006) ⁹	685 census tracts in NC, MD, and NY	Grocery stores, supermarkets, convenience stores, meat and fish markets, fruit and vegetable markets, bakeries, natural food stores, specialty food stores, and liquor stores, defined by proprietary SIC codes and chain name recognition	InfoUSA; census 2000	Predominantly (>60%) black and racially mixed tracts had more than twice as many grocery stores and fewer supermarkets than predominantly white tracts Low-income tracts (bottom tertile, median income ≤\$25,000) had four times as many grocery stores as the wealthiest tracts and half as many supermarkets In general, low-income and nonwhite tracts also tended to have fewer fruit and vegetable markets and natural food stores
Zenk (2005) ¹⁰	869 census tracts in metropolitan Detroit	160 supermarkets	Michigan Department of Agriculture; paper and online telephone directories; address confirmations by phone; census 2000	The nearest supermarket was markedly farther away in predominantly black tracts (≥63%) and in the most impoverished tracts (≥17% in poverty) compared, respectively, with tracts having few black residents (<2%) and a low percentage of residents in poverty (≤5%) Regardless of racial composition, distance to the nearest supermarket was similar among the least impoverished tracts (≤5% in poverty) In the most impoverished tracts, the distance to the nearest supermarket was an average of 1.1 miles greater in predominantly black tracts than in tracts with few black residents

Appendix A. (continued)

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Morland (2002) ¹¹	208 census tracts in MD, NC, MS, and MN, representing 10,623 participants in ARIC	Supermarkets, grocery stores, convenience stores, and specialty food stores, defined by the 1997 NAICS	1990 census; 1999 data from local health departments and state agriculture departments	Five times more supermarkets were located in census tracts where whites resided than in those where blacks resided Fewer than half as many grocery stores were located in census tracts where whites resided than in those where blacks resided
Morland (2002) ¹²	216 census tracts in MD, NC, MS, and MN, representing the neighborhoods of participants in ARIC	Supermarkets, grocery stores, convenience stores, and specialty food stores, defined by the 1997 NAICS	1990 census; local departments of environmental health and state departments of agriculture	Over 3 times as many supermarkets were located in the highest-income tracts than in the lowest-income tracts (lowest quintile of home values relative to other homes in the area) Higher-income tracts had fewer small grocery stores, convenience stores (without gas stations), and specialty food stores than the lowest-income tracts Four times as many supermarkets were located in predominantly white tracts than in predominantly black (>80% black residents) tracts There were fewer small grocery stores and convenience stores in predominantly white tracts than in predominantly black tracts
Shaffer (2002) ¹³	Central Los Angeles	56 independent and chain grocery stores and supermarkets	American Business Directory online	There were 2.3 times as many supermarkets per household in ZIP codes with 0%–10% of residents living below the poverty line as there were in ZIP codes where that percentage exceeded 40% ZIP codes where the majority (80%–90%) of residents were white had 3.2 times as many supermarkets as those where the majority of residents were black and 1.7 times as many supermarkets as those where the majority of residents were Latino
Chung (1999) ¹⁴	Hennepin and Ramsey counties, MN	526 grocery stores and convenience stores (excluding gas stations), defined by SIC codes and chain name recognition	1994 American Business Directory; 1990 Current Population Survey	Only 22% of chain stores, but nearly half of the nonchain stores, were located in inner-city ZIP codes Chain grocery stores were less likely to be located in poor areas; 89% of all chain grocery stores in the two counties were located in ZIP codes with poverty rates of <10%, but only about 60% of nonchain grocery stores were located in these areas
Kaufman (1998) ¹⁵	36 rural, high-poverty counties of the Lower Mississippi Delta region (AR, LA, and MS)	222 large grocery stores and supermarkets, defined by sales data	1990 census; Food and Nutrition Service data on food stamp issuances and redemptions	Low-income areas had less access to large grocery stores and supermarkets compared to the regional average Over 70% of households eligible to receive food stamps needed to travel >30 miles to reach a large grocery store or supermarket
Alwitt (1997) ¹⁶	53 Chicago ZIP code areas	Small grocery stores, large grocery stores, and supermarkets, defined by SIC codes	1990 Census of Retail Trade; 1995 Prophone CD-ROM telephone database, <i>The Sourcebook of ZIP Code Demographics</i>	Residents of low-income neighborhoods (high poverty and unemployment, and low high-school graduation rates) needed to travel >2 miles to have access to the same number of supermarkets as residents of higher-income neighborhoods Low-income neighborhoods tended to have more small grocery stores, fewer large grocery stores, and fewer supermarkets. However, no differences were found after controlling for purchasing power

Appendix A. (continued)

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Studies including in-store observations				
Morland (2007) ¹⁷	45 census tracts in Brooklyn	50% stratified random sample of 166 supermarkets, small grocery stores, fruit and vegetable markets and delicatessens, defined by store name	NY State Department of Agriculture and Markets; 2004–2005 in-store observations by a trained surveyor; census 2000	Fewer supermarkets and more small grocery stores (bodegas) were in racially mixed and predominantly black neighborhoods (>80% black) than in predominantly white neighborhoods (<20% black residents) A lower proportion of stores in predominantly black neighborhoods carried fresh produce
Liese (2007) ¹⁸	20 census tracts in Orangeburg County, SC	77 supermarkets, grocery stores, and convenience stores, defined by store managers and annual sales	Census 2000; SC Department of Health and Environmental Control; ground truthing; in-store observations by trained surveyors in 2004	40% of rural tracts had at least one supermarket, compared to 67% of urban tracts 60% of rural tracts contained at least one grocery store, whereas none of the urban tracts housed a grocery store 49% of all convenience stores were in rural tracts, 30% in mixed tracts, and 21% in urban tracts Availability of more healthful foods was substantially higher at supermarkets and grocery stores compared to convenience stores
Baker (2006) ¹⁹	220 urban census tracts in Saint Louis MO	81 supermarkets and major-chain grocery stores	2003–2004 in-store observations by trained staff; census 2000	Fewer supermarkets provided the best opportunity to meet dietary recommendations in predominantly black tracts (>75% black residents) than in predominantly white tracts (>75% white residents) Mixed-race or white high-poverty tracts ($\geq 20\%$ poverty rate) and all predominantly black tracts regardless of income were less likely than predominantly white and higher-income tracts to have access to supermarkets offering healthy food choices
Block (2006) ²⁰	Two Chicago area communities: Austin (predominantly black, lower- middle-class) and Oak Park (racially mixed, upper-middle-income)	134 supermarkets, independent groceries, chain drugstores, gas stations, liquor stores with food, convenience stores, dollar stores, and specialty stores, defined by available sales data	InfoUSA; ground truthing; in-store observations by trained surveyors	Almost every resident of Austin lived within 0.25 miles of a grocery store, and all residents lived within 0.5 miles. In contrast, just under half the population of Austin lived >0.25 miles from a supermarket Austin had one chain supermarket for its 117,527 residents. Oak Park had three supermarkets, one for every 17,508 residents Within store types, the mean number of items carried was similar in Austin and Oak Park
Hosler (2006) ²¹	Upstate NY: Four ZIP codes in downtown Albany (41% white, 31% in poverty) and two rural counties (90% white)	256 retail stores, defined by operation at least 7 hours/day, 5 days/week and inventory of ≥ 1 staple item (confirmed by telephone calls in 2003)	Lists of inspected food retailers; online business directories and online farm-fresh product directory; in-store observations in 2003; census 2000	A higher proportion of stores and stores per population in the rural counties stocked low-fat milk and high-fiber bread than in downtown stores A larger percentage of racial/ethnic minorities lived in census block groups without a store stocking low-fat milk and high-fiber bread than did non-Hispanic whites

Appendix A. (continued)				
Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Jetter (2006) ²²	Los Angeles and Sacramento	25 grocery stores and supermarkets, including fresh meat and dairy sections	In-store observations (three times per store over 1 year) by trained surveyors in 2003–2004	Nearly all healthy market-basket food items (e.g., whole wheat breads and grain products, ground beef with ≤10% fat) that were never available in a store were recorded for stores in very low- or low-income ZIP code areas (median household income=\$17,600–\$27,000)
Zenk (2006) ²³	Three selected communities in Detroit and an adjacent suburb that varied in racial/ethnic composition and socioeconomic characteristics	304 chain grocery, large independent grocery, “mom-and-pop” grocery, convenience without gasoline, specialty, and liquor stores	MI Department of Agriculture, in-store observations by trained surveyors in 2002	Produce quality was lower in the predominantly black, low-income community than in the racially heterogeneous, middle-income suburban community The quality difference was only partly explained by community differences in the types of food stores available (e.g., the racially heterogeneous suburban community had the most large grocery stores per population) No statistically significant differences in produce selection or price were found across communities
Horowitz (2004) ²⁴	New York City neighborhoods in East Harlem (6% white) and the Upper East Side (more affluent and 84% white)	324 small (one register), midsize (two–four registers), and large grocery stores (more than four registers)	NY State Department of Agriculture and Markets; in-store observations by trained surveyors; census 2000	Fewer stores were small (65% vs 87%) and more stores were midsize (18% vs 6%) in the Upper East Side than in East Harlem Upper East Side stores were 3.2 times more likely than East Harlem stores to stock the healthy food items examined (low-carbohydrate or high-fiber bread, low-fat milk, fresh fruit, fresh green vegetables, diet or club soda)
Sloane (2003) ²⁵	Los Angeles County: four noncontiguous ZIP code target areas (47% black residents, poverty rate=28%) and a contrast area (8% black residents, poverty rate=17%)	330 convenience stores, grocery stores, and supermarkets	In-store observations by trained surveyors in 2001–2002; census 2000	The target areas had a higher proportion of convenience stores and local markets than the contrast area, which had larger markets that were franchises of regional or national chains Fruits, vegetables, nonfat milk and low-fat snacks were less often available in the target areas as compared to stores in the contrast area. For example, less than three quarters of markets in the target areas sold fresh fruit or vegetables compared to >90% of stores that did in the contrast area
Fisher (1999) ²⁶	53 randomly chosen ZIP codes in NY representing metropolitan, midsize urban, and rural counties	503 food stores selected by random sampling within each ZIP code	NY State Department of Agriculture and Markets; in-store observations in 1994; 1990 census	The average percentage of store shelf space occupied by low-fat milk across all stores in a ZIP code was directly related to median household income The average percentage of low-fat milk shelf space was lower in rural areas and areas in which the majority of the population was nonwhite
Sallis (1986) ²⁷	24 neighborhoods of San Diego, defined by the location of selected schools and resident report	77 supermarkets, “mom and pop” groceries, convenience stores, and health-food stores	Interviews with neighborhood residents; neighborhood and in-store observations by trained surveyors	Residents of middle-income neighborhoods had greater access to low-sodium and low-fat foods than residents of low- and high-income neighborhoods

ARIC, Atherosclerosis Risk in Communities Study; D&B, Dun and Bradstreet; NAICS, North American Industry Classification System; NCESCCD, National Center for Education Statistics Common Core Data; SIC, Standard Industrial Classification

Appendix B. Inequalities in access to restaurants and healthful menu options in the U.S.

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Zenk (2008) ¹	National sample including 31,243 public secondary schools	80,878 fast-food restaurants, defined by proprietary SIC codes	2004–2005 NCESCCD; census 2000 and Census Bureau 2005 population figures; D&B	Schools in predominantly black (>70%) tracts had 30% fewer fast-food restaurants within 0.5 miles than schools in predominantly non-Hispanic white tracts Schools in middle-income and high-income tracts (based on tertiles of median household income) had 16% fewer and 32% fewer fast-food restaurants within 0.5 miles, respectively, than schools in low-income tracts
Sturm (2008) ²	National sample including 31,622 public secondary schools	Limited-service restaurants	2003–2004 NCESCCD; InfoUSA	A higher proportion of students eligible for free school meals was associated with a greater likelihood of a school having a limited-service restaurant within 400 m A higher proportion of Hispanic students was associated with greater likelihood of a school having a limited-service restaurant within 400 m
Simon (2008) ²⁸	1684 public schools in Los Angeles County	2712 fast-food restaurants, representing 18 chains	CA Department of Education; food inspection/safety program databases of Los Angeles County, Pasadena City, and Long Beach City health departments	Fast-food restaurant proximity was inversely related to neighborhood income; schools in areas of the lowest median household income were over three times more likely to have at least one fast-food restaurant within 400 m than schools in the highest income quartile
Galvez (2007) ⁵	165 census blocks in East Harlem	186 full-service and fast-food restaurants	census 2000; block-by-block walking survey by a single surveyor in 2004	Predominately Latino blocks (>75%) were more likely to have full-service and fast-food restaurants than racially mixed blocks
Powell (2007) ²⁹	National sample of 28,050 ZIP codes	69,219 fast-food restaurants and 259,182 full-service restaurants, defined by SIC codes	D&B data for the year 2000; census 2000	Near-low income and middle-income (based on quintiles of median household income) ZIP codes had the highest number of available restaurants with 1.24 and 1.22 times the number of full-service restaurants and 1.34 and 1.28 times the number of fast-food restaurants as high-income ZIP code areas Predominantly black (>70%) ZIP code areas had 58.2% and 59.3% of the number of full-service and fast-food restaurants, respectively, in predominantly white ZIP code areas Suburban ZIP code areas had 1.34 times the number of full-service restaurants and 1.77 times the number of fast-food restaurants, respectively, as urban areas. Rural and farm areas had substantially fewer available restaurants than urban areas In urban areas, near-low income, middle-income, and near-high income versus high-income ZIP code areas and predominantly black versus predominantly white ZIP code areas were found to have higher proportions of fast-food restaurants among all restaurants

Appendix B. *(continued)*

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Wang (2007) ⁸	82 CA neighborhoods defined by a combination of census tracts and block groups, representing 7595 participants in the Stanford Heart Disease Prevention Program (1979–1990)	Fast-food restaurants, defined as national chains that sell inexpensive, quickly served foods such as hamburgers, pizza, and fried chicken	1980 and 1990 census; State Board of Equalization and telephone business directories for the years 1979–1990	Residents of middle-socioeconomic tracts lived closer to fast-food restaurants than residents of other tracts
Block (2004) ³⁰	156 census tracts in New Orleans	155 fast-food restaurants (14 local and national chains)	Orleans Parish Sanitation Department log books; local Yellow Pages phone book; restaurant locator engines on fast-food websites; 1990 census data adjusted to 1999	For every 10% increase in fast-food restaurant density (restaurants per square mile), tract median household income decreased by 4.8%, and the percentage of black residents increased by 3.7%
Morland (2002) ¹¹	208 census tracts in MD, NC, MS, and MN, representing 10,623 participants in ARIC	Fast-food restaurants and full-service restaurants, defined by the 1997 NAICS	1990 census; 1999 data from local health departments and state agriculture departments	More full-service restaurants were located in census tracts where whites resided than in those where blacks resided Fast-food restaurants were approximately evenly dispersed across census tracts where whites and blacks resided
Morland (2002) ¹²	216 census tracts in MD, NC, MS, and MN, representing the neighborhoods of participants in ARIC	Fast-food restaurants, full-service restaurants, carryout eating places, carryout specialty items, bars and taverns, defined by the 1997 NAICS	1990 census; local departments of environmental health and state departments of agriculture	Fast-food restaurants were more prevalent in low–medium income and medium-income tracts than in upper-income tracts (determined by home values categorized into quintiles) All restaurants were more prevalent in racially mixed and predominantly white (<20% black residents) tracts than in predominantly black (>80% black residents) tracts
Studies including a review of menu options Baker (2006) ¹⁹	220 census tracts in Saint Louis, MO	355 fast-food restaurants	Review of corporate restaurant menus; restaurant audits by trained staff; 2000 Census of Population and Housing; 2000 Census of Businesses	Fewer restaurants provided the best opportunity to meet dietary recommendations in predominantly black tracts (>75% black residents) than in predominantly white tracts (>75% white residents) Mixed-race and white high-poverty tracts ($\geq 20\%$ poverty rate) and all predominantly black tracts, regardless of income, were less likely than predominantly white and higher-income tracts to have access to restaurants providing healthy food choices

Appendix B. *(continued)*

Reference	Setting and sample	Food sources examined	Data sources	Summary of results
Lewis (2005) ³¹	Los Angeles County: four noncontiguous ZIP code areas with a significant proportion of black residents (average=35%) and comparison ZIP code areas composed of few black residents (average=8%) and having a higher median household income	Limited-service restaurants and full-service restaurants, defined by NAICS	Trained surveyors; city offices of environmental health; census data	Only 27% of restaurants in target areas were full service compared to 58% in comparison areas Restaurants in comparison areas were more likely to offer five or more healthy preparation options; 39% of restaurants in comparison areas provided healthy options (such as broiled, baked, and steamed foods) compared with 27% in target areas A greater proportion of restaurants in comparison areas (42%) offered five or more healthy options (such as green salads, brown rice, and fresh fruit) than those in target areas (36%)

ARIC, Atherosclerosis Risk in Communities Study; D&B, Dun and Bradstreet; NAICS, North American Industry Classification System; NCESCCD, National Center for Education Statistics Common Core Data; SIC, Standard Industrial Classification

Appendix C. Recommendations for future research on disparities in access to healthy food

- Develop valid, reliable measures of neighborhood nutrition environments
Consensus definitions should be developed to categorize food stores and restaurants according to the information available from common data sources
The potential impact of errors in commercially and publicly available lists on research relating to food store and restaurant access should be determined
Detailed, standard protocols for using geographic information systems should be created so that measures of food environments can be replicated within and among research teams
Reliable tools should be developed for completing direct observations within stores and restaurants and examining the availability of healthy foods and beverages
 - Improve reporting on the definition of variables, measurement protocols, and details of the geocoding process, such as the types of software used, selected sensitivity parameters (spelling and match scores), match rates, spatial units, and buffer sizes
 - Carry out studies to better define relevant buffer sizes and routes for food shopping and restaurant dining in various populations
 - Conduct longitudinal and multilevel studies to increase knowledge regarding the potential for environmental changes to improve dietary intake and reduce obesity in representative samples
 - Implement and evaluate interventions designed to help underserved areas develop retail food markets and increase access to a healthy, affordable food supply
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Appendix D. Proposed strategies for improving access to healthy food^{32–36}

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| Strategies for attracting supermarkets to underserved neighborhoods | <ul style="list-style-type: none">● Conduct needs assessment and market feasibility studies● Assist with site assembly and cleanup● Offer financial incentives such as fee waivers and tax abatements● Assist with parking and public safety issues● Provide shuttle service to stores and develop other transportation options● Facilitate or simplify the development approval process● Recruit and prepare residents for store jobs● Mediate community–store conflicts |
| Strategies for improving the availability of fruits, vegetables, and other healthy foods | <ul style="list-style-type: none">● Establish more farmers' markets and public markets● Increase participation in community-supported agriculture programs● Establish cooperative grocery stores● Connect growers with neighborhood convenience stores, community centers, healthcare clinics, and religious organizations● Develop community gardens● Link emergency food providers to local growers● Establish mobile stores to deliver healthful products to a drop spot or doorsteps● Improve signage and shelf labels that identify healthful food choices● Sell healthful foods at reduced prices |
| Strategies for improving access to healthy foods at restaurants | <ul style="list-style-type: none">● Require fast-food restaurants to be located a minimum distance from youth-oriented facilities (e.g., schools, playgrounds)● Limit the total number of per capita fast-food restaurants in a community● Prohibit drive-through service● Improve the availability and identification of healthful foods on restaurant menus● Offer healthful foods at reduced prices on restaurant menus● Promote healthful foods at the point-of-purchase (e.g., with counter signage) |
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