Food Availability/Convenience and Obesity[1–5]

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ABSTRACT

Neighborhood environments have received considerable attention in recent local, state, and national obesity prevention initiatives, with a particular focus on food deserts, or areas with poor access to healthy foods. Yet, there are inconsistencies in the evidence base, suggesting a nuanced association between neighborhood environment, food availability, diet behaviors, and obesity. There is heterogeneity in associations between environmental exposures and health outcomes across race/ethnicity, gender, region, and urbanicity, which results in complexity in the interpretation of findings. There are several limitations in the literature, including a predominance of cross-sectional studies, reliance on commercial business listings, lack of attention to the process by which diet resources are established and expanded within neighborhoods and the potential for individuals to selectively migrate to locate near such facilities, a predominant focus on residential neighborhoods, and lack of information about the decision-making process underlying purchasing patterns. More research is needed to address the complexity of individual-level residential decision making as well as the purposeful placement of food environment resources across social and geographic space using longitudinal data and complex statistical approaches. In addition, improvements in data quality and depth related to food access and availability are needed, including behavioral data on purchase patterns and interactions with the food environment, and greater attention to heterogeneity across subpopulations. As policy changes to the food environment move forward, it is critical that there is rigorous and scientific evaluation of environmental changes and their impact on individual-level diet choices and behaviors, and their further influence on body weight. *Adv Nutr 2014;5:809–817.*

Define the Issue

Scope. The dimension of food availability/convenience that has received considerable recent attention in the literature is neighborhood access to healthy foods. Neighborhoods that offer access to high-quality foods are theorized to improve individual-level diet and weight outcomes of individuals residing in those neighborhoods. There have been substantial changes in the food environment over the past several decades, which have been broadly linked to dietary behaviors and obesity (1,2). In addition, neighborhood environments have received considerable attention in recent local, state, and national obesity prevention initiatives, with a particular focus on food deserts, or areas with poor access to healthy foods (3–6). However, the largely cross-sectional literature consists of studies that vary in geographic coverage, in methods for assessing environmental exposures, and in statistical modeling of associations, making comparisons across studies complex. In addition, there is heterogeneity in associations between environmental exposures and health outcomes across race/ethnicity, gender, region, and urbanicity, which also results in complexity in the interpretation of findings.

Severity. The ubiquitous access to energy-dense foods and beverages affects the health of individuals around the globe

[1] This article was peer-reviewed and approved by the Reviews, Papers, and Guidelines Committee and Medical Nutrition Council of the American Society for Nutrition (ASN) as part of a series entitled "Research Issues: The Food Environment and Obesity." The article did not undergo a separate editorial peer review by the editors of *Advances in Nutrition* (AN). ASN's journals feature a section called "From the American Society for Nutrition," which is devoted to content that originates from the Society rather than the journals. This article is being published in this section because of its broad interest to the nutrition community and the need to widely disseminate the information contained in the article. Correspondence about articles published in the "From the American Society for Nutrition" section should be addressed directly to ASN (info@nutrition.org) rather than to the AN Editor-in-Chief.

[2] An introduction to this series of articles is being published concurrently in *The American Journal of Clinical Nutrition* and the journal *Obesity*.

[3] Supported by the National Heart, Lung, and Blood Institute (R01- HL114091 and R01-HL104580). P. Gordon-Larsen receives general support from the Carolina Population Center, University of North Carolina at Chapel Hill (grant R24 HD050924 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development).

[4] Author disclosures: P. Gordon-Larsen, no conflicts of interest.

[5] The NIH had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript.

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(7). The relative costs of fruit and vegetables have increased greatly compared with prices of refined grains and sugar, making access to all sorts of processed foods progressively easier along a range of income levels (7–9), although individuals of low income are particularly affected by this price structure (10–13). Overall, food and beverages have become extremely easy to access, with an increasing number of sales from a variety of sources, including vending machines, drug stores, book stores, hardware stores, and big box stores. For example, point-of-sale Scan Track data from Nielsen indicate that 10 billion dollars were spent in 2008 on food items at U.S. drugstores, totaling an estimated 3 trillion calories (B.M. Popkin, unpublished data, 2011).

Characteristics of those affected. Although neighborhood food environments may have some degree of influence on all residents, vulnerable subpopulations may be particularly at risk (14–16), given the observed differential access to food resources (17–23). Yet, there are inconsistencies in the evidence base, suggesting a nuanced association between neighborhood environment and obesity (5,16,24). Differences in availability and costs of healthier food items as well as other individual-level factors may substantially limit the opportunity for healthy eating among less-wealthy individuals. For example, due to perceived cost or other barriers (25), low-income individuals may be more sensitive to cues related to the presence of fast-food restaurants (26). Yet, choice of stores, perceived quality of available produce, and consumer buying patterns also play important roles in the availability of foods in deprived neighborhoods (27). There are also strong differences in access to healthy foods across rural and urban settings (28), although this is a relatively understudied area. This relatively small literature suggests that rural and less-urban areas are just as much, if not more, underserved (29–34). The limited research on food environments of immigrant and Latino populations suggests that such populations are a concern as well (35–37).

Critical Review

The bulk of the literature on this topic comes from cross-sectional observational epidemiologic studies. Thus, this literature base predominantly deals with association as opposed to causation. Similarly, given the cross-sectional body of literature as well as the inherent difficulty of randomization and assignment of an intervention to a neighborhood, the assessment of efficacy and effectiveness is limited. In addition, this is a nascent area of research, with rapid development of data and methodology to deal with research questions related to food availability and convenience in relation to obesity. The literature is limited in several important ways, including the following: *1*) lack of fine-grain, longitudinal data characterizing changes in the food environment and their association with individual-level diet behaviors and obesity; *2*) measurement issues related to characterizing the food environment; *3*) lack of complex statistical models examining each piece of the time-dependent, complex system, accounting for the process by which diet resources are established and expanded within neighborhoods and the potential for individuals to selectively migrate to locate near such facilities; *4*) lack of pathway-based analyses that examine environmental influences on individual-level dietary intake and through this pathway to obesity; and *5*) lack of rigorous evaluation of policy implementation and other alternations to the food environment. These gaps in research limit a full understanding of the nature of the influence of food environments on obesity.

Although neighborhoods that offer access to high-quality foods are theorized to improve the diet, weight, and cardiometabolic profiles of individuals living in close proximity to resources that support a healthy diet, the largely cross-sectional literature has produced mixed results [see reviews and position papers (1,16,23,24,38–41)]. The most heavily studied element of the food environment is supermarkets. Several studies provided support for a positive association between neighborhood access to supermarkets and healthy diets (i.e., closer proximity and healthier diets) (42–46), whereas others did not (47–50). Similarly, some studies found an inverse association between neighborhood access to supermarkets and body weight (51–56), although others did not (55,57,58). Many of these same studies or others did not find positive associations between grocery stores (which are smaller than supermarkets) with diet or inverse associations with weight (46,47,51,52,59–61). There are fewer studies of the association between convenience stores and higher body weight, with some finding positive associations (51,54,56,62) and others finding null associations (52,59). Recent work has begun to address the presence and use of corner stores and the availability of relatively less healthy food options (63–66). It is important to recognize that this body of evidence on the topic of the food environment includes considerable heterogeneity in the observed associations by age, ethnicity, and degree of rural, suburban, or urban development, which makes comparisons across studies difficult.

Other research has focused on access to fast-food restaurants [see reviews (67,68)]. There is evidence of inequities in access to fast-food restaurants, with greater access in low-income (49,69) and minority urban areas (70,71). There has been relatively little study of access to fast food and restaurants with dietary consumption, with generally null results (42,47,72) but positive associations by subpopulation (49). Studies of access to fast food and body weight generally showed null results (52,53,55,59,73–75), although some positive associations between fast-food access and higher body weight were found (46,56,76–79). Again, there was heterogeneity in associations across populations and settings. This heterogeneity might be due to synergistic effects of urban development and neighborhood poverty levels, such that high-density areas have broad access to a wider range of resources across all income levels as a function

of general development and higher population density, whereas access in areas with less development may be quite different. Another possibility is that the access to specific types of foods is not well characterized when looking at access to stores and restaurants. Furthermore, the predominant focus on residential neighborhoods may mask the use of food resources in other settings, such as workplace neighborhoods or the travel corridor between home and work.

Few studies incorporated longitudinal measures of social, built, and economic factors and their relation to health, despite calls for life-course and longitudinal studies (80–82). A recent joint Institute of Medicine–National Academy of Sciences workshop on food deserts found that the cross-sectional research suggested sufficient rationale for the targeted placement of new supermarkets and farmers markets in urban and low socioeconomic status neighborhoods, but the workshop report also noted a lack of longitudinal research connecting targeted placement to improved diet and health (81). Yet, policy has moved forward as part of recent local, state, and national obesity prevention initiatives, with a particular focus on food deserts (3–5,83,84). Clearly, there is interest in ameliorating obesity disparities, but the conceptual and methodologic challenges underlying the evidence base make it difficult to fully understand the likely impact of these policy changes (85).

There are many barriers to achieving a healthy diet given the current food environment, yet individuals of racial/ethnic minority and low socioeconomic status face particularly strong barriers to achieving a healthy diet (19,86–90). Nonetheless, the concept of food deserts has been controversial (91,92). Although individuals of lower income pay more for food (10), several studies suggest that the evidence that impoverished areas have higher access to fast foods and reduced access to supermarkets is mixed (16,23,91,93–95). Indeed, the issue may be more complex than simply providing additional supermarkets and grocery stores, with no additional support for enhancing individual-level behaviors. It is possible that such efforts need to be coupled with promotion, education, and incentives for purchasing healthier foods (49).

Part of the methodologic limitations in this area of research relate to the measurement and characterization of the food environment. Most research defines neighborhoods on the basis of administrative boundaries, such as counties (96), census block groups (97–99), or residential buffers (49,100,101). Although these boundaries are readily and inexpensively available, they are somewhat arbitrary and may not correspond to what the population in situ may consider as a neighborhood. Neighborhood boundaries are complex to define and might be determined by transportation patterns, social networks, proximity to resources, and more. This heterogeneity in definitions of neighborhoods no doubt contributes to mixed findings in the literature. Similarly, the relatively small geographic range of many studies as well as the lack of variation in environment measures (21,22,37,55,79,102–106) might underlie the mixed findings in the literature.

There is also considerable lack of consistency in statistical adjustment for factors correlated with neighborhood sociodemographic characteristics and independently related to food resource availability (16,102,104,107–109). For example, the number and distribution of food resources (e.g., restaurants, supermarkets) relate to general urban development. Scaling resources by population (i.e., resource counts per 10,000 population) (110) may address the placement of commercial establishments according to population density and sociodemographic characteristics. Alternatively, roadway-scaled measures (resource counts per roadway mile) (4,111,112) can represent the concentration of resources along access routes and may help adjust for overall commercial activity, whereas accounting for car ownership can clarify use of local resources (113), and the ratio of fast-food restaurants to other restaurants can clarify restaurant choices (70,76). Improvement of neighborhood environment measures to better isolate the influence of neighborhood food resources is needed.

Another methodologic limitation relates to the interdependence of neighborhoods, food resources, and individuals, which has been largely ignored. Cross-sectional neighborhood environment studies are particularly problematic because neighborhoods and individual behaviors evolve over time through complex, interrelated processes (114). The complexity relates to individual-level residential decision making as well as the purposeful placement of food environment resources across social and geographic space. Both processes have been understudied (115).

On the individual side, financial or social constraints and residential preferences shape residential choice and movement (116). Residential choices occur sequentially and purposefully, and it is possible that individual-level preferences for healthy lifestyles (including diet and physical activity) play into the residential decision-making process (117,118). Residential location choice is a function of consumption of amenities, such as the presence of parks, trails, and recreation facilities (119,120); hedonic property values and wages (121,122); and educational resources, crime, and proximity to stores within walking distance (123). Most research assumes that no selective migration occurs to take advantage of such amenities (115,124,125). In general, cross-sectional studies ignore these dynamic interactions and thus might result in biased estimates of associations between the food environment and obesity-related behaviors (126).

Although these individual-level residential preferences are important, the purposeful placement of food environment resources across social and geographic space is extremely relevant but understudied. City planners themselves selectively choose the locations where facilities will be placed on the basis of a complex set of factors, some of which are

demand-driven (127,128); restaurant site location favors aesthetically pleasing locations for full-service restaurants and high-traffic-volume areas for fast-food restaurants (129), as well as characteristics of nearby residents (130). Yet, within this process, individual-level dietary intake is generally not addressed (131). The issue is relevant in that restaurants and supermarkets may be placed in areas with high demand, thus creating the potential for reverse causality. Similarly, areas with infrastructure and resources may attract residents who are more prone to use these facilities, and if these mechanisms are not accounted for, findings may be contaminated in such a way to either overstate or understate their impact.

To address the complexity of individual-level residential decision making as well as the purposeful placement of food environment resources across social and geographic space, longitudinal data and complex statistical approaches are needed. If there are factors that determine both the outcome (e.g., dietary intake) and facility placement (e.g., grocery stores) and these factors are either unmeasured or not included in the empirical analysis (via incorporation of the selection process into estimation of effects or control for unobservable factors), estimates of the effectiveness related to the placement of diet facilities will be biased (132–134). Similarly, models must account for the possibility that people migrate to take advantage of facilities (132,134), which might similarly bias estimates. Longitudinal data are needed to address individual characteristics that may contribute to these dynamic interrelationships (115). One approach is to control for time-constant unmeasured characteristics (that drive location selection) by using fixed-effects longitudinal models, which condition on each individual, thereby analyzing variation observed within person, over time (115); in essence, each individual serves as his/her own control. Another approach is the use of complex sequential modeling that incorporates the decision-making process into the model (133,134). Ultimately, the field needs to move toward longitudinal data and complex analyses to fully understand the complex relation between the food environment, dietary behaviors, and obesity.

Proposed Future Research Agenda

As reviews on this topic have noted, many of the obstacles to progress relate to the nature and quality of neighborhood-level data (135–137). Given the lack of longitudinal food environment data linked with high-quality longitudinal individual-level health data, there is a clear need for better retrospective data on the introduction, renovation, and closure of food resources. In addition, high-quality data from food stores and restaurants related to purchasing patterns, location decisions, and overall sales would also be very useful in understanding these associations. Given the current focus on residential addresses, there is little understanding of multiple environments (e.g., neighborhoods around workplace or school, travel corridors between home and work) that influence obesity and obesity-related behaviors. Broader studies of locations other than just the residential environment are sorely needed.

Given that most of the published data on the food environment are based on commercial databases, which focus on the presence or absence rather than the quality of services or foods provided, there is a wide gap in fully understanding how individuals use food resources. In addition, the commercial databases provide temporal snapshots of facilities; there is limited detail on the precise timing of opening and closure of facilities and the validity of these commercial sources ranges from good to questionable (138–140). Furthermore, the reliance on traditional facilities for food resources might miss opportunities for the purchase of fresh fruits and vegetables at other locales, such as dollar stores (141), corner stores (64,65,142), or *tiendas* (36), or from fast-food establishments outside of traditional chain locales (143), as well as a variety of understudied food resources, such as hardware stores or drug stores. Indeed, policy is surpassing research in this arena; for example, the White House effort with Walgreens aims to convert at least 1000 of its stores into food oasis stores, selling whole fruits and vegetables, precut fruit salads, green salads, breads, and ready-made meals (84).

Research on food environments and individual-level behaviors is limited by the lack of information about the decision-making process underlying purchasing patterns. The current literature identifies associations between stores and restaurants and obesity or obesity-related behaviors, but few identify the quality of foods offered (56,144–148), purchasing patterns (149), and the types of foods purchased and prepared once purchased. This lack of attention might also underlie the mixed findings for proximity to supermarkets and individual-level diet (81,150). Recent work with attention to both the community and consumer nutrition environment provides much greater detail on dimensions of access and availability of foods (151) and represents a strong direction for future work. There is also a great need for statistical methods that can account for the process by which food and activity facilities are established and expanded as well as selective migration, 2 sources of bias that are unaddressed in the current literature.

Given the complexity underlying the relation between the food environment, individual-level diet behavior, and obesity, a systems-oriented, multilevel framework is recommended (152). Ideally, randomized experimental studies would provide the detail necessary to understand the effects of neighborhood environments on health, yet such studies are unethical or unfeasible (153–155). Innovative study designs, such as natural experiments or randomized trials, are also critical for understanding causal effects of neighborhoods on health (126,156). Despite calls for rigorous experimental designs (1) and some randomized controlled trials in the United Kingdom (91,157–159), there is very little such literature. In 1 of few quasi-experimental studies,

Cummins et al. (160) studied changes in fruit and vegetable consumption after the opening of a supermarket-type store in the United Kingdom and found similar patterns in comparison to a control neighborhood. Cummins et al. (157) reported the greatest improvements in fruit and vegetable intake among those who adopted a new supermarket as their main food store, suggesting that the promotion of existing, new, or improved food resources is an important component of successful policies.

Observational approaches that can mimic randomized controlled trials are another potential direction (155,161). With better methods to precisely measure changes in food environments over time, it may be possible to assess whether environmental supports for healthy diet behaviors translate to improvements in behavioral, and weight, outcomes. Addressing key unmeasured predictors of location selection that vary over time, such as change in marital or employment status (162), requires instrumental variables (163) or simultaneous equation strategies (115) that use longitudinal data, which can provide deeper understanding of these complex relations. Similarly, innovative simulation studies can be useful in predicting changes in weight with policy implementation addressing access to food (164).

However, there are limitations of innovative methods, such as agent-based models, because these computational models are dependent on theoretical or simulated data and relations and typically provide a range of possible outcomes rather than specific predictions (155,165,166). Furthermore, these methods may not handle residential selectivity and measurement error and thus can produce misleading results (133). A hybrid approach that uses simulation methods to trace the effects of key explanatory variables on outcomes through time, and includes attention to parameterization, calibration of equations and algorithms, and transparency of the model (i.e., reporting standards and validation), may increase the utility of agent-based models.

With all of the methodologic advances it is still critical to address heterogeneity in environmental effects. There are clearly subpopulations at high risk of obesity, particularly low-income, ethnic minority, immigrant, and inner city residents. For example, for supermarkets to successfully improve diets, promoting existing resources within target groups may be necessary (158), as seen in recent efforts in New York City with the Healthy Bodegas program (167) and in Philadelphia with the Healthy Corner Store initiative (168). In addition, improving neighborhood resources should be weighed against (or in addition to) alternative approaches, such as taxation, subsidization, or incentives [e.g., reduced-cost exercise programs, sugar-sweetened beverage tax (169)]. Direct comparison of different policy strategies with the use of common health metrics may facilitate evidence-based policy making (170).

As policies, such as the Healthy Food Financing initiative (83), and the introduction of new food stores and changes to current food stores (84) move forward, it is critically important for rigorous evaluation of these changes. Such evaluations have been lacking (81). A team of experts recently put forth a number of recommendations for improving methodologies for environment and policy research, with evaluation of "natural experiments" receiving particularly high recommendation (171). In another article, a set of researchers suggested a set of questions designed to evaluate complex public health and wider social interventions in terms of process and impacts of policy changes (172). Ultimately, these approaches are necessary to fully understand the impact of environmental policies and changes and to maximize the use of scarce resources, particularly in low-income neighborhoods.

In sum, there is a great need for high-quality longitudinal data and rigorous analytical methodologies to fully understand the relation between food availability/convenience and obesity. Improvements in data quality and depth related to food access and availability are clearly needed, as are behavioral data on purchasing patterns and interactions with the food environment, along with greater attention to heterogeneity across subpopulations. There is also a major need for innovative analytical tools for modeling these relations in a multilevel and systems-based approach that can account for residential selectivity and purposeful placement of facilities. As policy changes to the food environment move forward, rigorous and scientific evaluation of environmental changes and their impact on individual-level diet choices and behaviors, and further influence on body weight, is a necessary component.

Acknowledgments

The sole author had responsibility for all parts of the manuscript.

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