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## Changing the Food Environment for Obesity Prevention: Key Gaps and Future Directions

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### Abstract

The food environment has a great impact on the nutritional health of the population. Food environment interventions have become a popular strategy to address the obesity epidemic. However, there are still significant gaps in our understanding of the most effective strategies to modify the food environment to improve health. In this review, we examine key gaps in the food environment intervention literature, including the need for: developing appropriate formative research plans when addressing the food environment; methods for selecting intervention domains and components; incorporating food producers and distributors in intervention strategies; strengthening evaluation of environmental interventions; building the evidence base for food environment interventions in diverse settings; engaging policy makers in the process of modifying the food environment; and creating systems science models to examine the costs and benefits of a potential program or policy on the food environment prior to implementation. In addition, we outline the need for strategies for addressing these issues including conducting additional pilot interventions, developing additional methodologies, and embracing the use of simulation models.

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#### **Conflict of Interest**

Elizabeth Anderson Steeves, Paula Andrea Martins, and Joel Gittelsohn declare that they have no conflict of interest.

#### **Compliance with Ethics Guidelines**

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NICHD or OBSSR.

## Keywords

Food environment; Obesity; Food dessert; Stores; Intervention; Nutrition; Food access

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## INTRODUCTION

Currently 35% of adults in the United States are obese and 33.6% are overweight [1]. In the US, obesity rates have risen rapidly in the past few decades and leveled off in recent years [1]. Despite these improvements, the high prevalence of overweight and obesity remains a severe threat to the health of Americans. At the most basic level, obesity is caused by an imbalance in energy intake and expenditure, however, there are multiple, complex factors that influence this equation. Public health officials generally acknowledge that the rise in obesity in the US occurred too rapidly to have genetic or biological underpinnings as the root cause [2]. This has led scientists to examine societal changes including changes in the food environment, policies, and the food production system as drivers of the obesity epidemic [2, 3]. Over the past 40 years, the U.S. food system and food environment has evolved in a way that now provides a large supply of inexpensive, highly palatable, energy-dense foods that are easily accessible, convenient to consume, and heavily marketed [3]. This type of environment promotes excess caloric intake, and has led experts to conclude that the rise in obesity rates is a natural response to the current environment [3].

The food environment may be defined in two primary ways: as the types of food sources that are accessible to an individual and what consumers are exposed to in those environments (availability of healthy and unhealthy foods, food prices, promotions/marketing, etc.) [2, 4]. For the purposes of this paper, when we refer to food sources, we will primarily be referring to retail food sources (including both traditional [supermarkets, corner stores, convenience stores] and non-traditional [pharmacies, dollar stores, and private homes]) and prepared food sources (fast-food restaurants, sit-down restaurants, carry-outs).

A review of the literature by Larson and colleagues [5] found that increased access to supermarkets was related to improvements in diet quality, fat intake, and fruit and vegetable consumption in studies of both adults and adolescents, however, this relationship is not consistent across all studies [6]. In relationship to obesity, increased access to supermarkets/grocery stores is generally linked to reduced levels of obesity, whereas increased access to convenience stores, corner stores, and fast-food outlets is linked to increased obesity [5, 7–10]. This complex relationship between the food environment and weight status is further compounded by evidence showing that low-income and minority neighborhoods have disproportionately lower levels of access to healthier food sources (i.e. supermarkets) and increased access to less healthy food sources (i.e. fast-food restaurants, convenience stores, corner stores) [5, 11–13], which may contribute, in part, to the disparities seen in obesity rates among groups.

As increasing evidence regarding the relationship between the food environment and obesity has emerged in recent years, the number of interventions targeting different aspects of the food environment has increased accordingly. Despite this growth in the literature, there are still significant gaps regarding evidence-based practices for food environment interventions.

There have been several recent review papers describing interventions focused on the food environment [14–16]. The purpose of this paper is to identify and describe areas that represent gaps in interventions to improve the food environment. The three aims of this paper are to: (1) identify key gaps in the literature related to environmental interventions; (2) describe the current state of the literature around each of these key gaps areas and (3) recommend priority areas in which future work is needed.

## KEY LITERATURE GAPS AND AREAS FOR FUTURE RESEARCH

In the following sections, we will discuss each of the key gap areas that we have identified and we will review the context of each area based upon the currently available literature. We will then go on to provide specific suggestions for areas of future research related to each gap, including pilot studies to be conducted, research to improve evaluation methods, and recommendations for much need work in the area of food environment policy.

### Gap 1: Identification of essential formative research components to develop environmental interventions

Formative research is the process of gathering information to design public health interventions [17, 18]. Formative research can be both qualitative (i.e. in-depth interviews with storeowners and customers, focus groups) and quantitative (i.e. ground truthing different types of food outlets, mapping the distribution chain, surveying food availability and affordability), and often includes a combination of both approaches. Multiple examples exist of the use of formative research to develop environmental interventions [18–25]. Formative research is needed to identify core values for message development, audience segmentation, and identification of the best communications channels [26–30]. Yet few standards have been set for the most optimal types of formative research to aid in the design of interventions to improve the food environment. A few things are clear, the first being that multiple approaches are needed for data collection. In-depth and semi-structured interviews with stakeholders should be complemented by direct observation of the behavior of interest. Group methods (like focus groups or workshops) can provide a means of achieving consensus on specific intervention approaches and materials. In addition to implementing multiple methods of formative data collection, it is also important to assess the views of multiple stakeholders, which in food environment interventions would minimally include both consumers and food source owners/managers. However, the stakeholder list could be expanded to include community and business leaders, local health organizations, food wholesalers/distributors, and more.

Other priority considerations include the need to document and describe the current food environment, usually through an observational audit. This can be achieved by methods as simple as counting the number of different types of food sources in a given geographic area, to more detailed assessments of availability and pricing of specific foods within food sources [19, 20, 31–34].

For many health issues, Rapid Assessment Procedures (RAP) manuals have been developed to guide formative research [29, 35, 36]. RAP manuals are useful when there is a need for formative research, but not sufficient time for traditional, time-intensive formative research

methods [35]. Currently, a RAP manual specific to conducting formative research in the food environment does not exist. Development of such a manual specific to developing food environment interventions would allow for significant gains in addressing this gap in the literature.

### **Gap 2: Selection of domains of focus for food environment interventions**

Great diversity exists in the range of approaches for environmental interventions in retail food stores, ranging from increasing access (through increasing availability of select foods and manipulating pricing), to the use of signage and point of purchase promotions (posters, shelf labels), to direct education (in-store interactive sessions, taste tests), to store staff training. One key issue for researchers as they begin an intervention is identifying which approaches or combination of approaches can create the greatest impact, given limited resources. While this is a key task, a more fundamental decision exists, which is rarely addressed – which food sources are the most appropriate to intervene in? Considerable effort has been made to increase the number of supermarkets and grocery stores in food deserts [6, 37], to improve healthy food availability in corner stores and bodegas [38–41], and to increase the accessibility and use of farmers markets [42–44]. However, national data indicate that Americans spend half of their food budget on prepared foods [45, 46]. To create maximal impact, food environment interventions should target food sources that are most heavily used by consumers. This would indicate restaurants and other prepared food sources as appropriate intervention targets, yet our recent review [15] indicates that most of the very limited research in prepared food sources has focused on menu labeling only, and has not sought to increase availability, offer discounts on healthier options, or worked to improve cooking methods. Future interventions need to focus on addressing issues specific to prepared food sources, but go beyond caloric labeling.

### **Gap 3: Incorporating additional aspects of the food production and distribution network into food environment interventions**

People living in food deserts have limited access to supermarkets, and may have high access to small food sources, such as corner stores and carryout restaurants [47, 48], leading to a shift in terminology to describe these areas that lack supermarket access as “food swamps” rather than “deserts”. While many researchers agree that the corner stores and carry-outs that populate “food swamps” are problematic, what is not commonly considered is that these small food sources do not exist in a vacuum, but instead are constrained by the context of the food environment in which they exist [49]. If commonly used wholesalers and distributors do not carry affordable healthier options, then it is very difficult for small storeowners to stock these foods in their stores. Thus, a key factor in this type of intervention is gaining knowledge of or mapping the food environment of small food sources. One approach would be to utilize social network analysis to examine how and from whom small food stores procure their different food and beverage items. Once this structure is understood, outside possibilities to incorporate other non-traditional food distribution sources like urban farms, community gardens, and non-profits (such as the Baltimore Orchard Project, an organization that provides gleaned produce) could be involved in food environment interventions [50]. In addition to gaining an understanding of the food supply chain used by small food stores, it is equally important to identify evidence-based methods

for incorporating wholesalers and distributors into interventions. In work to date, such players have been largely left out of food environment interventions. Related to this is then determining methods in which policies and regulations can support and promote intervention efforts that move up the chain of the food system.

#### **Gap 4: Identifying the essential areas of evaluation for environmental interventions**

Little consensus exists on exactly how environmental interventions should be evaluated. This is in part due to the fact that intervention components are highly variable. Most often, evaluation has focused at the level of the food source – documenting changes in availability and sometimes pricing of foods. Yet stocking and pricing are not the same as sales. Small storeowners frequently do not track their own sales data, yet, often cite lack of sales and profitability as a barrier to stocking healthier food items [41, 51, 52]. Reporting the impact of evaluations on sales of specific items and well as overall profitability of the store would aid in acceptability of participation in small store interventions [53, 54]. Therefore, improvements are needed in tracking sales of specific foods as part of these interventions, to motivate storeowners to sustain stocking of these items.

Beyond measures of sales, there are several other areas of evaluation that are lacking. Little attention has been paid to modifying the location of food on store shelves [55] or the amount of shelf-space given to healthier or less healthy items [56]; how customers access stores (including transportation as a consideration) [57]; and promotions of selected food items [58].

Improving the evaluation of food environment interventions by expanding the types of outcomes assessed (such as inclusion of sales, store environment, product promotion, storeowner perceptions, and consumer variables), and development of more accurate methods for collecting this data would allow researchers to better assess the outcomes of their research, and allow for stronger research designs in the future.

#### **Gap 5: Determining how best to engage policy makers to create sustainable changes to the food environment**

Use of policy as a tool for preventing and reducing obesity has steadily gained popularity [3, 59, 60]. In relationship to the food environment, public health policy experts suggest several potential policy-level interventions such as modification of zoning laws to incentivize or inhibit the location of food sources; “junk food” taxes; regulating marketing of food products; caloric menu labeling; and regulation or banning of selected food items or components (trans-fat bans, limiting soda sizes) [61, 62].

Much of the current literature provides cross-sectional survey data on policies/regulations and the associated health outcomes [63], and some has looked at the impact of pricing policies (taxation and subsidies) on health outcomes [64]. However, very little is known about the process of engaging policy makers to create policy change related to the food environment. Most of the published literature for small stores interventions, for example, is of small scale projects, although there is a sizeable grey literature as well – with little or no attention to policy change [14, 15].

However, cities and regions are increasingly being progressive in collaboratively creating a policy agenda for improving the food environment. Baltimore City provides an excellent case study for methods in which this engagement can be created and maintained [65]. The food environment policy work began in Baltimore in response to reports showing large disparities in neighborhood-level access to healthy food, with low-income and minority neighborhoods greatly disadvantaged [12]. The response to these reports included a task force that presented ten strategies for improving the food environment, followed by the creation of Baltimore Food Policy Initiative (BFPI). Currently, BFPI supports three full-time staff members, whose positions are housed in within an intra-governmental collaboration between city agencies, and funded through private funding sources [65]. The work of BFPI is supported by the Food Policy Advisory Committee (Food PAC), which is a network of over 45 different member organizations. The BFPI has a goal of increasing access to healthy affordable food in the City's food deserts, and has created several initiatives including: modifying zoning codes to increase urban farming, implementing a "virtual supermarket" grocery delivery program, adopting a prepared retail food initiative in the public markets, promoting community supported agriculture and farmers markets, and supporting a farm-to-school initiative [66]. A unique feature of Baltimore's food policy work is their collaboration with multiple university institutions to allow for rigorous evaluation of the policy and program implementation.

Another prominent example of this is the Fresh Food Financing Initiative (FFFI) in Pennsylvania, which originated in Philadelphia. The FFFI was sparked by an evidence-based report created by a Philadelphia nonprofit organization, the Food Trust, in collaboration with the Department of Public Health and the University of Pennsylvania [67]. The report demonstrated lower access to supermarkets and increased nutrition-related disease burden among low-income neighborhoods, as compared to higher income neighborhoods in Philadelphia. These results were publicized to multiple stakeholders in Philadelphia through a series of reports, which captured the attention of local policy makers, and community members. As a result, the City Counsel encouraged the Food Trust to create a task force to address these issues. The task force consisting of over 40 experts from the government, non-profit, and grocery industry sectors, created 10 key recommendations for reducing these supermarket access disparities. Continued public concern surrounding this issue, engaged state-level policy makers into the discussion and ultimately led to the creation of the FFFI. The FFFI is a state-wide, supermarket financing initiative developed by the state of Pennsylvania, the Food Trust, a community development bank, and a community-based development organization, that provides financial support to supermarket owners in underserved communities through grant and loans. As of 2010, the FFFI provided more than 85 million dollars in loans and grant funding to 88 stores projects across the state of Pennsylvania [67].

### **Gap 6: Expansion of environmental intervention work to include more diverse settings**

While the majority of intervention trials to impact the food environment have taken place in the US and Europe, there is growing evidence that food environments are related to obesity and chronic disease rates in non-Western countries, including work in South Korea [68], Brazil [69], China [70] and others. Yet very little intervention work has taken place in these



settings, with some exceptions. We have conducted food store intervention trials with First Nations [71], American Indians [40], and in the Pacific Islands [72, 73]. Other investigators have worked in low-income Hispanic settings [38, 74, 75].

The feasibility of interventions within small food stores aiming to improve availability of healthy food is being tested in a low-income urban area of Brazil, where a high prevalence of overweight was observed among children up to the age of 10 years and their mothers [76]. Currently a pilot trial is underway in this area to test whether intervention strategies such as the use of signage and point of purchase education, in-store interactive sessions and taste tests, use of incentives to decrease prices and store staff training, are appropriate in a low-income setting of a transitional economy. Consistent with the recommendations of this manuscript, formative research has been conducted in food stores [33] and with members of community organizations in order to select key foods for promotion and determine intervention strategies taking into account socio-cultural characteristics [77]. The next phase of the on-going study will provide information regarding the impact of the intervention on consumer's food purchases and intake, and on food stores stocking and sales.

As the obesity and chronic disease epidemics continue to expand worldwide, there is a great need to develop, test and evaluation intervention strategies in many other settings outside the US and Europe. The food system may differ greatly in these settings, further underscoring the need for substantial formative research in each setting to develop appropriate intervention strategies.

### **Gap 7: Using systems science modeling to simulate impact of different types of environmental interventions**

The causes of the obesity epidemic are multifactorial, and potentially require multi-level and multi-component policies and programs. However, developing, testing, and evaluating obesity interventions aimed at the food environment can cost considerable time, effort, and resources. Moreover, it can be years before the impact of these activities can be determined. Computational simulation models can offer a relatively efficient and effective manner of determining the impact of new data collection and interventions before implementing them in the real world [78–80]. Simulating the effects of an intervention can help determine whether the intervention is worthwhile and how the intervention should be modified and employed [78, 79]. Creating systems science models of the food environment is a cutting-edge research method. While work in this area has been done in relationship to obesity [79–82], there has been less focus given to modeling the impact of the food environment on obesity, and the potential of different policies and programs to effect obesity.

In the current systems models that focus on the food environment, one clear gap is inadequate inclusion of the range of potential food sources. In urban settings, adults and children acquire food from many sources, including retail food sources (including both traditional food sources [supermarkets, corner stores, convenience stores] and non-traditional food sources [pharmacies, dollar stores, and private homes]) and prepared food sources (fast-food restaurants, sit-down restaurants, carry-outs) [52, 57, 83]. Most analytic models have included only one or two food sources, such as supermarkets, but do not reflect the full variety of choices individuals are presented with [11, 84, 85]. Schools have long

been considered a key community institution for addressing the childhood obesity epidemic in our country [86–88], with children consuming a large proportion of their caloric intake at school [83]. Yet schools and after school programs have rarely been included in systems models that address the food environment. Another gap lies in the absence of multi-generational actors in systems models, specifically, agent-based models, where autonomous agents (representing individuals) can be modeled. Children make some food decisions autonomously, but they are still part of households, and are influenced by, and influence their parents. Simulation models should include both adults and children to model intra-household dynamics and decision-making that influence diet and physical activity opportunities.

Systems modeling can allow us to create well informed hypotheses about the most beneficial and cost-effective food environment interventions. They also allow for a creative way to engage with policy makers to model potential impact and consequences of policy strategies prior to implementation. Additional work is needed to create a platform for modeling the food environment that is comprehensive and transferable to multiple regions.

## CONCLUSIONS

The food environment has been cited as one of the main drivers of the obesity epidemic. In response, there has been great interest in interventions and policies targeting the food environment in recent years. While significant progress has been made, researchers in this area have as many questions and information needs as they do answers. In this paper, we have identified seven gaps in the food environment literature. In order to create long term, sustainable change in the food environment we must take steps to develop a more comprehensive knowledge of these areas.

One immediate area to address is to create support and obtain funding for the development of a RAP for developing interventions to improve the food environment. We also propose the development and implementation of a series of pilot studies to gain insight into evidence-based implementation practices. Suggested pilot interventions for expansion include more interventions with prepared food sources (in combination with food stores), and incorporating wholesalers and distributors into multilevel food system change programs. Better evaluation methods are needed, including improved evaluation of the impact of these programs on the food sources themselves (including their sales). The development of systems science simulations of food environments that have the capacity to model the pilot intervention work outlined above is a cost- and time-saving next step for future interventions. The systems models can be design to test the different intervention strategies alone or in combination. In addition to informing intervention strategies, models can be used as a tool for engaging policy makers and to create support and sustainability of intervention components. While there has been significant progress in food environment interventions recent years, this paper outlines multiple gaps that remain unclear and suggests potential next steps in addressing these issues.



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