

Food Environment, Policy and Sugar-Sweetened Beverages Consumption in U.S. Adolescents

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Increased consumption of sugar-sweetened beverages (SSBs) is a critical nutrition problem in the U.S. and has been identified as a key contributor to the current epidemic of obesity among adolescents. Up to date, little is known on how this high level of SSBs consumption can be reduced. Recently, environmental and policy interventions have been advocated as powerful strategies to address the epidemic. While there is a growing consensus that food environments and policies play important roles in influencing individuals' food choice, reviews of studies linking the food environment (i.e. fast food restaurants density, conventional stores density, school cafeteria and vending machines) and policies (i.e. food price and tax) with the SSBs consumption in adolescents indicate the research is equivocal and data for policy making is lacking. In addition, little research has been done to compare the relative importance of the various aspects of food environment in influencing SSBs intake in youth. Part of the research barriers could be lack of database that includes validated measures of multiple environmental and policy factors. In this review, we summarized the environments and policy determinants of SSB consumptions in U.S. adolescents and the challenges in measuring environmental contexture factors. We also proposed the future research directions and believed findings from research in these areas will inform policy and guide future environmental and policy interventions on reducing the SSBs consumption and lower the obesity rate in U.S. adolescents.

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INTRODUCTION

High sugar-sweetened beverages intake has been identified as an important nutrition problem in the United States (U.S.) adolescents. One third of adolescents (34.2%) in the United States (U.S.) aged 12-19 years are overweight or obese.¹ If this trend continues, the current generation could have a shorter lifespan than their parents.² Parallel with the trend of rising adolescent obesity over the past 3 decades, there was a dramatic increase in consumption of sugar-sweetened beverages (SSBs) among U.S. adolescents. National representative data show that 13% of the daily caloric intake (~ 300 kcal/day) for 12-19 year-olds comes from SSBs.³ A large number of studies, both cross-sectional and longitudinal, indicate that high consumption of SSBs is associated with excessive energy intake, poor diet, and higher risk of obesity in the youth.⁴⁻⁷ In addition, consumption of SSBs has been linked with many other health problems such as tooth decay, type 2 diabetes, hypertension, metabolic syndrome, and poor quality of sleep.⁸⁻¹³ It is clear that the combined risks of obesity and other adverse health consequences require a sustained effort to reduce SSBs consumption among adolescents. However, evidence-based knowledge on how to

reduce SSBs consumption is currently unavailable. In this review, we summarized the environments and policy determinants of SSB consumptions in U.S. adolescents and proposed future research directions. This age group needs a special attention because adolescence appears to be the most important period for developing eating habits and for predicting adult hood obesity.¹⁴ In addition, youth at this age is becoming more independent and would like to make their own food choices, and therefore, could be more influenced by the environmental and policy factors.

THE ENVIRONMENTAL AND POLICY DETERMINANTS OF SSB CONSUMPTION

Previous, research on determinants of food consumption in adolescents has predominantly focused on the individual level cognitive (e.g. attitudes, taste preferences, modeling from parents and friends)¹⁵⁻¹⁸ and socioeconomic (SES) factors (e.g., parents' education level, household income).^{16,19} However, more recent research has acknowledged that the physical and policy environments could be major forces in shaping health behaviors and health outcomes.²⁰ While it remains unclear which environmental factors are the major driving force behind the current obesity epidemic, recent empirical work has found that contextual neighborhood factors (i.e., the social and physical characteristics of neighborhoods) are independently associated with weight status over and

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above individual-level social and economic factors.²¹⁻²⁵ Neighborhood contextual factors are likely to have an impact on an individual's weight through their influence on food intake and/or physical activity. Theoretically, increasing food consumption (energy intake) plays a more important role in development of obesity than decreasing physical activity (energy expenditure). Empirically, data from national surveys show that Americans have increased their energy intake by 150-300 kcal/day from 1977 to 1996,²⁶ whereas physical activity remained fairly constant during the same time period.²⁷ Numerous studies have shown that Americans have increased their food consumption through many ways, including increased consumption of highly energy dense foods, increased portion sizes, more frequent consumption of meals away from home or not prepared at home, and increased calories from sugar-sweetened beverages. Importantly, emerging evidence has linked such food consumption changes to the risk of obesity.²⁸⁻³¹ However, what modifiable environmental factors cause such changes in American's food intake is unclear.

Environmental and policy approaches are aimed at changing the physical and sociopolitical environments which provide opportunities and supports to help people change behaviors. For example, neighborhood food environments are thought to influence individual's food choices through the differential

availability of foods and through the variety of opportunities to facilitate or discourage healthy eating.³² A socioecological framework suggests that individual behavior is determined by interactions between individuals and their physical, social, and culture environments.³³ With regards to food intake, dietary choices are shaped by multiple levels of influence, including the distribution of food retail outlets, cultural background, economic capacity, and life stage.³⁴

KNOWLEDGE GAPS OF CURRENT RESEARCH

While there is a growing consensus that food environments and policies play important roles in influencing individuals' food choice, only a few studies have linked the food environment and policies with adolescent SSBs consumption^{14:35-37} and the studies that have been done are not conclusive. As a result, the literature on the effects of environmental and policy changes on SSBs consumption in adolescent is both limited and equivocal. Existing studies typically focus on the school and home environments, little data are available on the other neighborhood settings and policy factors.^{38,39} In addition, it is unclear what aspects of the environment and/policy are more influential than others. Part of the problem could be 1) the lack of valid and reliable measures to assess both individual food consumption and neighborhood level food environment, and 2) not measuring multiple environmental and policy factors in one database.

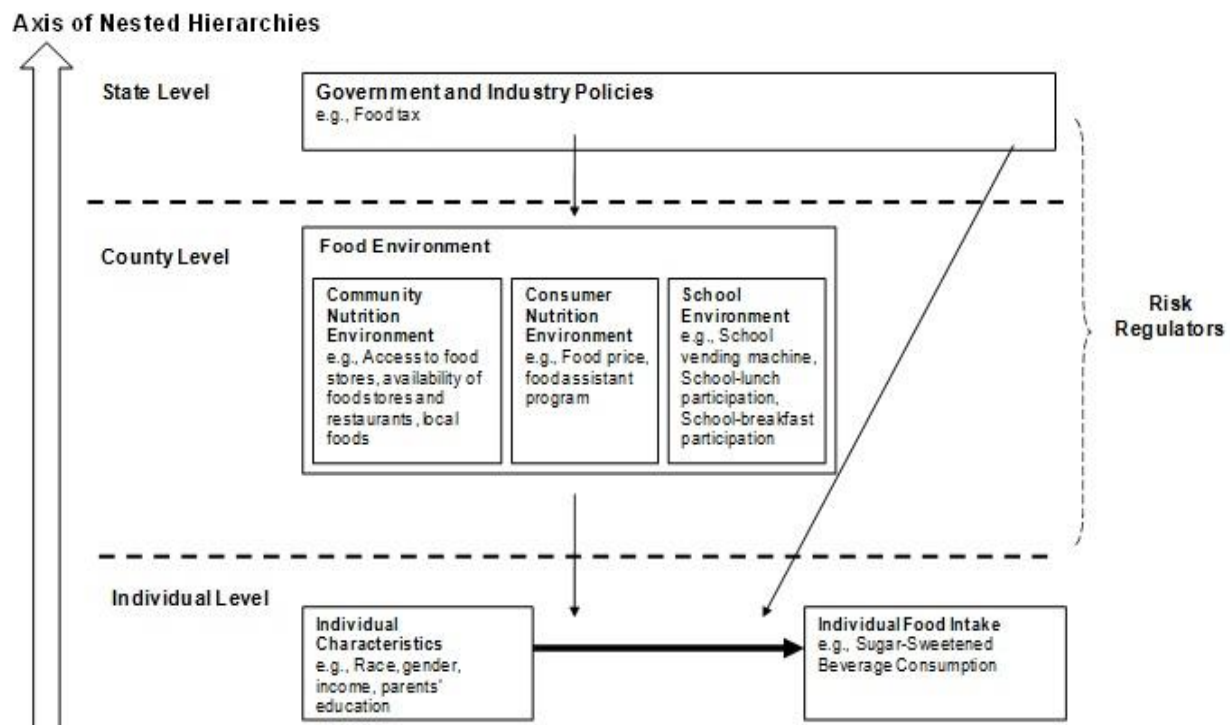


Figure 1. Conceptual model: impact of food environment and policy on food consumption. This is an ecological model to show how eating behaviors (i.e. consumption of SSBs) are influenced by the interplay of multiple factors across different contexts. In this model, individuals are nested within counties and counties are nested within larger jurisdictions (i.e., states) and the food environmental or policy factors are considered as risk regulators which make a particular outcome more or less likely depending on the environmental context. These environmental contexts are affected by the policies of governments and other organizations (e.g. food industry) and influence individual's food consumption through modifying the relationship between classic individual risk factors and the individual eating behaviors and food intakes.

CONCEPTUAL MODEL

To study the influence of environment and policy on SSB consumption, ecological concept model and multilevel analysis should be advocated (**Figure 1**). We propose an ecological model to show how eating behaviors (i.e. consumption of SSBs) are influenced by the interplay of multiple factors across different contexts. In this model, individuals are nested within counties and counties are nested within larger jurisdictions (i.e., states). In this model, the food environmental or policy factors are considered as risk regulators which make a particular outcome more or less likely depending on the environmental context. This type of effect is consistent with the approach to understanding the effect of environmental contexts on health behavior proposed by Glass et al.⁴⁰ In our conceptual model, food environment are classified into three domains (i.e. community nutrition environment, consumer nutrition environment, and school nutrition environment) as proposed by Glaze et al.⁴¹ These environments are affected by the policies of governments and other organizations (e.g. food industry) and influence individual's food consumption through modifying the relationship between classic individual risk factors and the individual eating behaviors and food intakes.

CHALLENGES IN MEASURING AND EXAMINING NEIGHBORHOOD EFFECTS

The fact that the neighborhood environment may influence health is not a new concept,⁴²⁻⁴⁴ what is new are the methods now available to measure and test such effects, as proposed by conceptual models and socio-ecological theoretical frameworks. A variety of technologies for analyzing multilevel and spatial data have emerged in the last three decades, such as Geographic Information Systems (GIS) and hierarchical or multilevel modeling, making it possible to better examine neighborhood influences on health.

Ecological and multilevel studies are two of the most common empirical strategies for investigating neighborhood effects on health.⁴⁵ While ecological studies are valuable for investigating neighborhood effects, they are highly subject to ecological bias (albeit less susceptible at smaller areas of analysis, e.g., county versus state) which arises when individual response / exposure relationships are estimated from data aggregated across groups. The emergence of multilevel or hierarchical modeling and spatial analytic methods has allowed researchers to better examine neighborhood influences.⁴⁵⁻⁵⁰ While some use these techniques to simply account for the correlated observations in multilevel and spatial studies (due to grouping of individuals within an area or neighboring areas), their biggest assets the ability to investigate neighborhood effects. This is done in multilevel modeling by examining the variance in the outcome at the different levels (e.g., neighborhood- vs. individual-level). Spatial techniques have allowed researchers to also examine these relationships in a geographic realm, gaining a more complete picture of neighborhood influences. Spatial hierarchical models also allow the borrowing of strength locally (i.e., among neighboring regions), which in turn leads to more accurate estimates of both the fixed and random

effects in model estimation.⁴⁶ Although both multilevel and spatial techniques have opened up many opportunities to investigation of neighborhood causal effects, they are not without their problems.

Subramanian et al. has outlined critical issues for multilevel analysis.⁵⁰ One is the issue of multiplicity of neighborhood contexts, such that there are multiple spatial and non-spatial contexts within and around which neighborhoods operate and may influence health. Many researchers have not gone beyond the two-level conceptualizations of a multilevel model, yet it is reasonable to assume that health is influenced by numerous levels (e.g., neighborhood, household, and individual). The Modifiable Areal Unit Problem (MAUP)⁵¹⁻⁵² is another issue in multilevel and spatial studies, posing a potential source of error that can affect spatial studies which utilize aggregate data sources.⁵² Geographical data is often aggregated in order to present the results of a study in a more useful context, and spatial objects such as police beat boundaries or census tracts are examples of the type of aggregating zones used to show results of some spatial phenomena.

The MAUP consists of both a scale and an aggregation problem. The scale problem refers to the variation which can occur when data from one scale of areal units is aggregated into smaller or larger areal units. For example, much of the variation seen when comparing census tracts is often lost when the data is aggregated to the county level instead. The aggregation problem becomes apparent when faced with the variety of different ways a county for example can be cut up to yield the same number of smaller areal units. Just as politicians gerrymander the boundaries of a fixed number of congressional districts within a state to ensure that one or the other political party will win each district, different methods of defining boundaries that aggregate residents into neighborhoods can yield different conclusions. Fortunately, there are very few administrative units (e.g., census tracts, block groups) that define neighborhoods and they cannot be modified without much difficulty, and in any case they were originally designed to define neighborhoods.⁵³⁻⁵⁵ However there is still the problem where similar individuals living on opposite sides of the street (i.e., neighbors) are classified as residing in different neighborhoods if their street defines the administrative boundary, even though they should clearly be defined by the same neighborhood. The result is that neighborhoods near each other tend to be similar, leading to spatial autocorrelation and the possibility of type I errors due to variance contraction.

Another obstacle with studies on neighborhood-level influences on health is that of endogeneity, or the fact that the observed effect of a neighborhood-level exposure is not due to exogenous factors in the environment but due to fact that the at risk population chose to reside in the neighborhood because they were attracted by the neighborhood characteristics including the exogenous risk factor. For example, when considering the impact that fast food restaurants in a neighborhood may have on overweight and obesity,⁵⁶ it is not completely clear whether increased availability of fast food

drives increased consumption of fast food or simply reflects the choice of overweight and obese individuals to live in neighborhoods where there are more fast food restaurants, an endogenous effect having nothing to do with the exogenous environment.⁵⁷

An additional challenge in examining neighborhood effects involves incorporating multiple spheres of contextual influence on individual level outcomes which goes beyond traditional multilevel models. Although multilevel and spatial modeling has increased our ability to explore contextual influences on health outcomes, few studies have gone beyond a two-level model. Furthermore, even the multilevel model is limited to the extent that potential causal pathways and reciprocal relationships between levels may be difficult to examine.

CONCLUSION AND FUTURE RESEARCH

To fill the research gaps in this area, it is important to generate a multilevel database and to evaluate the population impact of a variety of environment and policy factors on SSB consumption in U.S. adolescents. With the availability of such multilevel database, researchers can identify environmental and policy factors that are significantly associated with SSBs consumption in adolescents by including multiple factors simultaneously in the multilevel models with adjustment for individual confounders. In addition, it is possible to calculate the population attributable fractions across multiple environmental and policy factors. Lastly, it is important to explore potential combined effects of different environmental and policy factors on SSBs consumption.

Obesity rate in U.S adolescents is reaching an epidemic level and high SSBs consumption is a key contributor for excessive energy intake and the obesity crisis among youth.³ Future research is warranted to inform policy and guide future environmental and policy interventions on reducing the SSBs consumption and lower the obesity rate in U.S. adolescents.

CONFLICT OF INTEREST

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