Fruit and Vegetable Intake and Obesity in Preadolescent Children: The Role of Neighborhood Poverty and Grocery Store Access

Christina Mushi-Brunt, Debra Haire-Joshu, Michael Elliott, and Ross Brownson

ABSTRACT

Background: The prevalence of obesity among children continues to rise. Individual-focused health education efforts have been minimally successful in producing the necessary changes to curb this epidemic. Purpose: The purpose of this study was to examine the relationships between neighborhood characteristics, grocery store availability and accessibility, and parent-reported fruit and vegetable intake and/or weight status. Methods: Data was collected from 797 preadolescent children (ages 6–11) participating in an obesity prevention study. Individual-level variables were daily fruit and vegetable intake and body mass index. Social and physical environment variables included percent of poverty within neighborhoods (census tracts) and mapped grocery store locations. Bivariate analyses were performed to explore relationships. Results: Most (78%) children (mean age=8.1) failed to meet fruit and vegetable recommendations, and 37% were overweight. Nearly 50% of high poverty neighborhoods had no grocery stores within their boundaries. Children in high poverty neighborhoods consumed fewer servings of fruits and vegetables ($t=4.03$, $p<0.001$) than children in low poverty neighborhoods. Discussion: This study demonstrates some associations between neighborhood characteristics, grocery store availability, and child fruit and vegetable intake. Translation to Health Education Practice: Health educators should consider how the social and physical environment may hinder positive health behaviors.

BACKGROUND

Poor dietary intake, including inadequate fruit and vegetable consumption, has been associated with an increase in the risk of developing a number of chronic diseases.[1] The rise in obesity[2,3] has led researchers to explore possible associations with dietary factors.[4] Research evidence for an association between fruit and vegetable intake and overweight among children is conflicting.[5] However, fruits and vegetables remain an important aspect of chronic disease prevention efforts due to the nutritional benefits derived from their consumption.[6] Current research indicates that chronic diseases, including obesity, may develop as early as childhood and track into adulthood.[7] Therefore, intervening during childhood may be critical to reducing the risk of obesity in adulthood.

Despite the abundance of national health education campaigns, many children still do not currently meet the recommended guidelines for certain foods or nutrients, including fruit and vegetable intake.[8] Only 5% of children meet the Food Guide Pyramid recommendations for fruit intake, and just 20% meet recommendations for vegetable intake.[9] Many of the contemporary interventions designed to prevent obesity through healthful food choices have focused on changes in knowledge and attitudes. Unfortunately, the long-term success of these interventions has been classified as

Christina Mushi-Brunt is an assistant professor in the Department of Health Sciences, Indiana University-Purdue University Indianapolis, Coleman Hall 301, Indianapolis, IN 46202; E-mail: cmushi@iupui.edu. Debra Haire-Joshu is a professor at the Obesity Prevention Center, Saint Louis University School of Public Health, 3545 Lafayette Ave., Ste. 300, St. Louis, MO 63104. Michael Elliott is an assistant professor at the Prevention Research Center, Saint Louis University School of Public Health, 3545 Lafayette Ave., Ste 300, St. Louis, MO 63104. Ross Brownson is a professor at the Prevention Research Center, Saint Louis University School of Public Health, 3545 Lafayette Ave., Ste 300, St. Louis, MO 63104.

minimal.[10] A shift in the public health research paradigm points toward an ecological approach; one that examines the role of other influencing factors such as the social and physical environment.[11,15]

The challenge presented in encouraging children to increase their fruit and vegetable intake is that, although they may influence their parents, children do not make household decisions regarding food purchases. Within the home environment, fruit and vegetable availability for children is subject to parental decisions in food purchasing. Food purchase is subsequently influenced by what is available in the local food environment.

The local food environment has been conceptualized as the availability, affordability, and accessibility of food retail stores.[12,13,14] These constructs have been found to be important determinants of dietary intake among adults.[15,16] Furthermore, the neighborhood in which one resides has been associated with food access and availability[17] and food cost and quality.[18] The few studies that have examined the food environment have produced conflicting results regarding differences in availability and access.[14,19,20] There is evidence of less availability of grocery stores within low-income, urban neighborhoods.[21] Current research has shown that low-income status is associated with low fruit and vegetable intake[22,23] and greater risk of obesity.[24] Differential availability of food stores may negatively affect the dietary intake of individuals by limiting access to quality, low-cost healthful foods, including fruits and vegetables.[25] Identifying the differences in availability may provide support for environmental level interventions to complement individual behavior change programs. To date, there is limited research examining the association between grocery store environments and individual dietary patterns.[26] The existing research has focused primarily on the dietary intake of adults.[27] No studies were located that examined the role of the local food environment (grocery stores) on fruit and vegetable intake and weight status among a diverse sample of preadolescent children.

PURPOSE

The purpose of this study was to examine the relationships between grocery store availability and accessibility and (a) parent-reported fruit and vegetable intake, and (b) weight status among the children participating in an obesity prevention program. Fruit and vegetable intake was examined as a proxy for dietary intake. The research questions guiding this study were as follows:

1. Are there sociodemographic differences in fruit and vegetable intake and weight status (as approximated by body mass index) among the preadolescent children in the study?

2. Are there differences in the distribution of grocery stores within the study area?

3. Are neighborhood sociodemographic factors, child fruit and vegetable intake, and child weight status associated with availability and accessibility of grocery stores?

METHODS

Participants

Baseline data from the Partners of All Ages Reading about Diet and Exercise (PARADE) study were used for the analysis. The multiyear intervention study was conducted between the years 2000 and 2004 in a large metropolitan area (population>2,000,000) in the midwestern United States. The study was designed to encourage at-risk preadolescent children (ages 6 to 11) to develop healthy eating and physical activity patterns. The research team collaborated with three tutoring/mentoring community agencies serving "at-risk" children (i.e., those with any one or more of these characteristics: academic deficiencies, behavioral/emotional problems, low-income, and/or minority status). This population was selected because research suggests such children are at greater risk of overweight.[28,29]

The study was conducted in three waves. Waves I and III were conducted during two different school years. Wave II was conducted during one summer to test the effects of a streamlined intervention. Parents of all children participating in the tutoring/mentoring programs at the agencies were provided information regarding the study by community agency project staff and invited to enroll their children. Parents who agreed to enroll their children were then contacted by the research team to obtain consent. Children and the parent who was most frequently responsible for the purchase of food and preparation of household meals (98% mothers) responded to questionnaires prior to and following the intervention. The study and subsequent data analyses were approved by the Institutional Review Board (IRB#10312, 10704).

Child Data Collection

During one of their usual mentoring/tutoring sessions, each child completed a pretest questionnaire assessing their food and physical activity preferences. The measure also addressed home availability and accessibility of fresh fruits and vegetables. The community agencies coordinated their program schedules to include a day for collection of each child's height and weight. Nurses who were part of the research team conducted the height and weight measurements using a standardized methodology. Children were instructed to remove their shoes and outerwear such as jackets or coats. Using a wall-mounted stadiometer, heights were measured and recorded to the nearest 0.5 inch. Weight was measured using a calibrated digital scale and recorded to the nearest 0.5 pound. For two of the agencies, pre-intervention data collection occurred during the beginning of the school year. A third agency collected the data at the beginning of a summer activity program. Following the intervention period (eight months for Waves I and III; three months for Wave II), post-testing occurred and consisted of the same child questionnaire and another round of height and weight measurements. Children received storybooks for their participation in the study.

Weight status. BMI and BMI z-scores were calculated using the Centers for Disease Control and Prevention Growth Charts.[30] Weight status was identified by BMI z-scores. In order to derive these scores, we used BMI data calculated from height and weight measurements. Due to age and gen-

der differences in normal values for BMI, an advantage of using the BMI z-score is that it allows different groups to be more accurately compared.[31] The continuous variable was used for analysis.

Parent Data Collection

A parent survey was developed by the research team and administered by professionally trained telephone interviewers to obtain information about parent and child demographic characteristics and dietary intake. The interviewers contacted each parent and recorded their responses to questions about themselves and their children. The surveys were also conducted pre- and post-intervention. Parents received a $20 grocery store gift certificate for each completed survey.

Demographics

Individual-level demographic correlates of interest for the present study include child age, gender, race, and household income. Each variable (except age) was coded categorically. Race was dichotomized into Black or White; other races (n=27) were dropped from analysis due to small numbers. Self-reported household income included five categories ranging from less than $15,000 to greater than $50,000.

Fruit and Vegetable Intake

The interviewer-administered survey included a 28-item food frequency questionnaire that was developed, pilot-tested, and used to gather information about intake of fruits and vegetables that were geographically relevant to the study population.[32] The entire survey took approximately thirty minutes to complete. The trained interviewers asked parents to report the "number of times" (none, 1 time, 2 times, 3–4 times, 5–6 times, 7 or more times) each food item was consumed by themselves and their children in the previous week. Internal consistency for the instrument was found to be high (Cronbach's α=0.75).[32] We combined the number of times each fruit and vegetable (excluding potatoes and juice) was consumed and divided that value by seven to form a "daily fruit and vegetable intake" variable. Potatoes were excluded to maintain consistency with international recommendations for fruit and vegetable intake.[33] Juices were excluded because some studies suggest that their inclusion may overestimate actual fruit intake.[34] To assess daily recommendation adherence, the variable was dichotomized to identify those children "meeting minimum recommendations" for fruit and vegetable intake (at least 5 servings per day) and those "not meeting recommendations" (less than 5 servings per day).

Local Food Environment

Grocery stores were operationalized using the North American Industry Classification System code number 445110, which is the classification for supermarkets and other grocery stores (except convenience stores).[35] Small, non-chain grocery stores, gas station convenience stores, and liquor stores were not included, as it was hypothesized that these outlets would be less or not likely to carry a variety of affordable fruits and vegetables.[36] Several sources were used to obtain the addresses of the grocery stores, including data from the local chamber of commerce, telephone registries, and grocery store websites. A database was created to store grocery store data.

Residential Neighborhood Disadvantage

The 2000 Census Bureau's Summary File 3 was used to identify neighborhood characteristics. Specifically, data related to percentage of poor and average household income in the census tract was used. Other studies have identified census tracts as a good approximation of neighborhoods.[37] Low poverty neighborhoods were characterized as a census tract with less than 10% of the population living below the federal poverty line. High poverty neighborhoods were defined as census tracts with 10% or more of the population living below the federal poverty line. This categorization has been used in other research.[38,39]

Statistical Analysis

Descriptive analysis was conducted to characterize the study population. Chi-squares, independent samples t-tests, and analysis of variance were performed to identify differences in fruit and vegetable intake and weight status by the local food environment factors. These analyses were performed using Statistical Package for Social Science (SPSS for Windows 11.0, SPSS, Inc., Chicago, Illinois). Maps were created using geographical information system software called ArcView 3.2 (Environmental Systems Research Institute, Redlands, CA) which creates layered maps from multiple data sources. The base map layer consisted of the census tract boundaries. The neighborhood characteristics were then layered over the census tracts to show the poverty level of each tract. The grocery store and study participant addresses were then matched to street maps of the metropolitan area. Of the 1,025 children enrolled in the study, data from 797 children whose addresses could be geocoded to census tracts were included in the analyses for this article. We examined the characteristics of the excluded children and found no significant differences from the children that were included. The resulting layered map contained points symbolizing each grocery store and study participant. The number of grocery stores within each census tract were counted. Using ArcView's nearest distance function, the distance between each study participant and the nearest grocery store was calculated. Analysis of the distribution patterns of weight status were also conducted.

RESULTS

Demographic characteristics of the sampled children are presented in Table 1. The sample contained more Black female children than all other categories. Parent-reported household income was fairly evenly distributed. Most children (78%) failed to meet daily fruit and vegetable recommendations, and nearly 37% of children were at risk of overweight or overweight.

Individual Level

Results indicated a significant relationship between gender and race and weight status. This relationship was most pronounced among the girls in the study. Twenty-six percent of White girls were overweight compared to 54% of African American girls (p<0.05). These results

remained significant after controlling for household income. It was found that the odds of being overweight were two times greater for African American children than for Whites, 1.9 times greater for females than males (Table 1), and three times greater for African American females than all other race and gender combinations. These results were statistically significant ($p<0.05$).

Local Food Environment

The 79 geocoded grocery stores were located in 71 census tracts. Fifty percent of neighborhoods (defined as census tracts) with more than 10% of the population below poverty had no grocery stores within the census tract, whereas only 24.2% of low poverty neighborhoods had no grocery stores within the census tract. This finding was confirmed by results of the geocoded data (Figure 1). Significant differences were observed in grocery store density by mean percentage of poor in the neighborhoods represented by the study population. Nearly twice as many grocery stores were located in low poverty neighborhoods than high poverty neighborhoods.

Fifty-seven percent of children in the study lived less than one mile from the nearest grocery store to their home. When controlling for income it was found that 60.3% of low income children living less than one mile from a grocery store were normal weight compared to 58.2% of those who lived further than one mile. Furthermore 58.5% of high income children living less than one mile from a grocery store were normal weight compared to 64% of those living farther away. Nearly 63% of children in the study lived in neighborhoods classified as high poverty. Table 3 illustrates the differences in mean number of daily fruit and vegetable servings and BMI z-scores based on the neighborhood variables. There were significant differences observed in mean fruit and vegetable intake ($t=4.03$, $p<0.001$) such that children in low poverty neighborhoods ate more servings of fruits and vegetables. The analyses revealed lower fruit and vegetable intake by children living in neighborhoods without a grocery store than those with at least one grocery store.

Table 1. Baseline Demographic Characteristics of Children in Study Sample

Variable	Value
Mean Age (years)	8.05
Race/Ethnicity (%)	
White	39.7
Black	60.3
Gender (%)	
Male	33.4
Female	66.6
Household Income (%)	
Lower income (<30,000)	40.3
Higher income (>30,000)	59.7
Recommended Fruit and Vegetable Intake (%)	
Does not meet recommendation	77.8
Meets at least minimum recommendation	22.2
Weight Status (%)	
Normal weight	63.4
At-risk for or overweight	36.6

Table 2. Estimates of Meeting Fruit and Vegetable (FV) Recommendations and Weight Status for Sampled Children

	Odds of Meeting FV Recommendations (Confidence Interval)	Odds of Being Overweight (Confidence Interval)
Gender		
Male	Reference	Reference
Female	1.14 (0.78, 1.68)	1.81 (1.31–2.45)
Race		
White	Reference	Reference
Black	1.28 (0.83, 1.99)	2.04 (1.44–2.88)

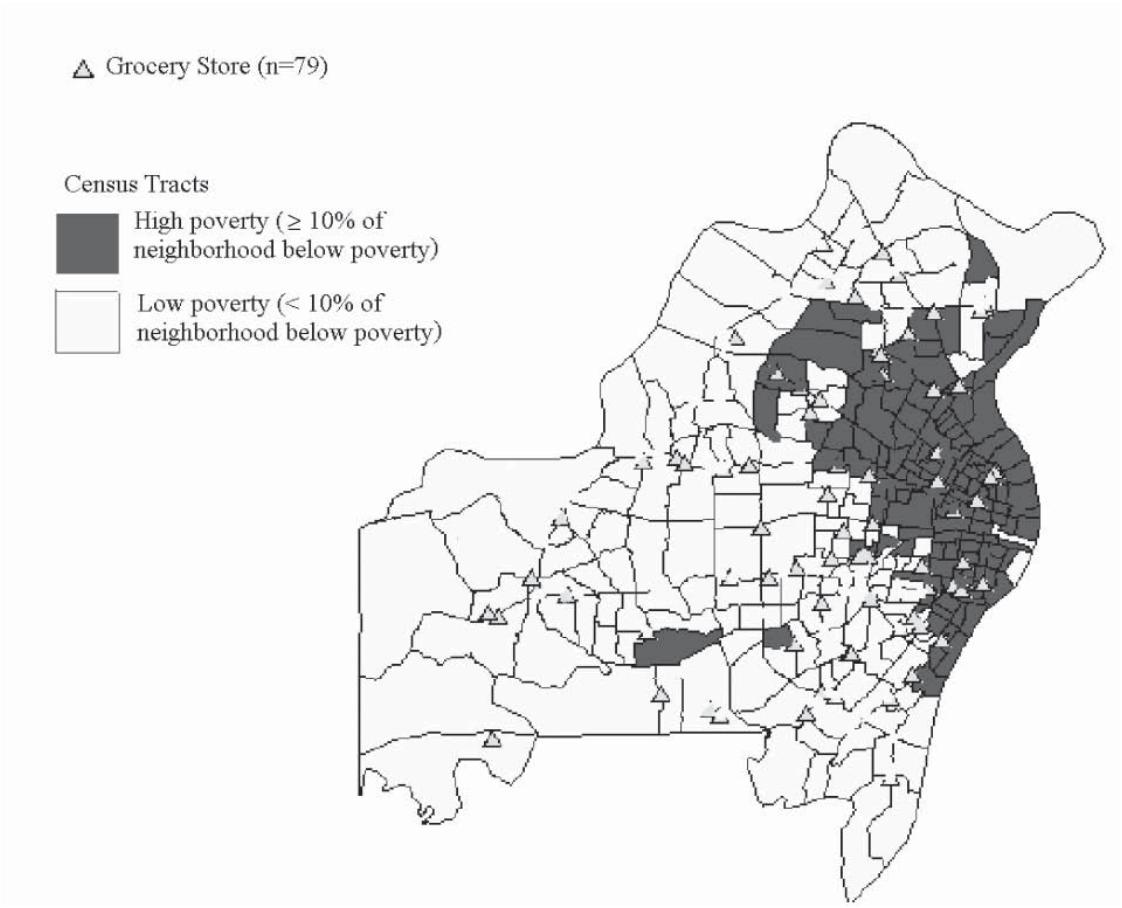
However, this difference did not reach statistical significance. Interestingly, the results also indicate lower fruit and vegetable intake among children residing less than one mile from the nearest grocery store than those living further away.

DISCUSSION

This study demonstrates some associations between the neighborhood characteristics, grocery store availability, and child fruit and vegetable intake. The availability of grocery stores and fruit and vegetable intake among children in the study was significantly different based on neighborhood poverty. It was also determined that most children lived in proximity to grocery stores where their parents could make food purchases.

The first objective of this study was to identify sociodemographic differences in fruit and vegetable intake and weight status among the study population. Our findings indicate that most children failed to meet recommendations for daily fruit and vegetable intake. Consistent with other

Figure 1. Location of Grocery Stores by Census-Travel Tract and Poverty Level



studies, the risk of overweight was found to be greatest for African American female children.[40,41]

The second objective of this study was to assess the distribution of grocery stores within the study area. Grocery stores were prevalent throughout the study area. Most census tracts had at least one grocery store, with a few census tracts having as many as three. The grocery stores that were geocoded were located in both inner city and suburban neighborhoods. This study may reflect grocery store availability in similar large metropolitan cities. Using GIS mapping technology, we were able to graphically depict the availability of grocery stores within the study area. Grocery store density (as defined by counts) was greater in neighborhoods identified as being low in poverty. This finding is consistent with other studies that have identified differences in grocery store density based on neighborhood sociodemographic characteristics.[42]

The third objective of this study were to determine whether there is an association between grocery store density and distance, on the one hand, and fruit and vegetable intake and weight status of children, on the other. Our findings revealed that children who lived in low poverty neighborhoods (where more grocery stores were available and closer to one's home) ate more fruit and vegetable servings per day than did children in high poverty neighborhoods, which had fewer grocery stores. This finding is consistent with those found in studies of adult populations. Rose and Richards found that distance to grocery store was inversely associated with household fruit and vegetable use.[43] A seminal study conducted by Morland and colleagues identified an association between fruit and vegetable intake and supermarket density which was most pronounced among African American adults.[17] A recent study of adults in Los Angeles also noted an association between neighborhood socioeconomic status and BMI with grocery stores as a mediating factor.[44] Although not statistically significant, the finding that children in households where the distance to the nearest grocery store was less than one mile consumed fewer fruits and vegetables indicates that there are other important factors associated with fruit and vegetable intake. These factors may include personal factors such as taste preferences[45] and environmental factors such as parent's food purchase perceptions and behaviors[46] and household availability.[47,48]

There are several limitations of this study.

Table 3. Mean Fruit and Vegetable Intake and BMI Z-Score by Social and Physical Environment Variables

	Mean Number of FV Servings	t, p-value	Mean BMI Z-Score	t, p-value
Neighborhood Poverty				
High poverty (≥10% poor)	2.30		0.69	
Low poverty (<10% poor)	3.16	4.03, <0.001	0.51	1.04, 0.30
Number of Grocery Stores				
No stores	2.57		0.71	
One or more stores	2.82	1.03, 0.30	0.54	1.07, 0.29
Distance to Grocery Store				
Less than one mile	2.59		0.69	
One mile or greater	2.96	1.45, 0.15	0.34	1.67, 0.10

First, we chose to only examine the presence of major grocery chain stores as a measure of the local food environment. The inclusion of smaller independent neighborhood stores and alternative outlets such as farmer's markets and community gardens would have helped to further delineate the relationship between fruit and vegetable intake and the local food environment. There is research suggesting that there is limited availability, poorer quality and higher prices for fresh fruits and vegetables in smaller food stores compared to what is available at larger supermarkets.[49,50,51] However, a recent study reported successfully initiating a community produce market that provides high-quality and affordable fruits and vegetables for a low-income neighborhood.[52]

A second limitation lies in the possibility of inaccuracies in the identification of grocery stores that were geocoded for this study. Store locations were obtained using publicly accessible sources and may not have reflected the actual state of operations of the store. The methodological issues associated with measuring the food retail environment has recently been addressed by Wang and colleagues.[53] Future research should gather such data objectively, through the use of audit tools such as those employed in identifying physical activity resources.[54]

Third, since child fruit and vegetable intake was reported by the parent, it is likely that our data may contain information biases. A previous study reported the use of this methodology.[55] Our study population was school-aged children, which implies that for at least five of the days that parents reported their child's food intake, there is limited or no information about what was consumed during the school day. Additionally, snacking behaviors may not have been observed by the parents, either. Unfortunately, this limitation has significant implications for our study. In the absence of parental actual knowledge (due to not seeing what the child ate or problems with recollection of foods eaten), and with the potential for parents to provide socially acceptable responses, it is conceivable that child fruit and vegetable intake was overestimated in our study. Dietary assessment of children remains a critical issue for nutrition and diet-related studies and is among the most frequently cited limitation of such studies.[56,57]

This study was a cross-sectional design; therefore an additional limitation is that causal inferences cannot be made. The actual direction of the observed relationships is unclear. Two recent studies[58,59] have been published detailing the effects of the introduction of large food stores in neighborhoods without such retail outlets. These studies are the first to explore the effect of an actual retail intervention and may serve as a starting point for determining causal pathways between neighborhood food environments, dietary behavior, and weight status. Interestingly, the authors of the two studies report conflicting findings regarding the effect of the added food store outlets on fruit and vegetable intake.

Finally, this study was conducted in a major metropolitan area; therefore the results cannot be generalized to other settings, such as rural communities, where the variation in availability and accessibility of food stores is limited.[51,60]

TRANSLATION TO HEALTH EDUCATION PRACTICE

The personal and social burden created by obesity and related diseases in childhood calls for health education researchers and practitioners to address these problems through methods beyond individual lifestyle change. The role that the environment plays is one that necessitates further investigation. Applying social ecological approaches to health education research can provide new perspectives on explaining health behaviors and designing more effective health education programs.

Health educators will benefit from gaining knowledge about the role social and physical environments play in supporting or hindering positive health behaviors. Health education research has had some success in family-based interventions addressing household availability and accessibility of fruits and vegetables.[61,62] However, the home availability of fruits and vegetables may be determined by the availability and accessibility of these food items in the neighborhood food environment. A critical next step in this line of research will be to examine the food purchase behaviors of households and determine if associations with the neighbor-

hood food environment exist.

Despite its limitations, this study adds to the growing literature identifying the role of the local food environment on healthy eating and weight status.[63] A particular strength of this study is that it used observed measures of the food environment, namely through techniques such as GIS mapping. Furthermore, it is one of the first studies to explore the association between the neighborhood food environment and childhood diet and obesity. In reviewing the literature, only one study has been published examining the association of the neighborhood food environment and childhood obesity.[64] Future research should further explore barriers to fruit and vegetable purchase at the neighborhood level, specifically addressing the role of the cost of fruits and vegetables in available food stores. Such investigations, coupled with findings from this and similar studies, will aid in informing potential community and policy-level prevention efforts.

REFERENCES

1. Hung HC, Joshipura KJ, Jiang R, et al. Fruit and vegetable intake and risk of major chronic disease. *J Natl Cancer Inst.* 2004;96:1577-1584.

2. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999–2000. *JAMA.* 2002;288:1728-1732.

3. World Health Organization. *Diet, Nutrition and the Prevention of Chronic Diseases: Report of a Joint WHO/FAO Expert Consultation, Geneva, 28 January–1 February 2002.* Available at: http://www.who.int/nut/documents/trs_916.pdf. Accessed July 29, 2006.

4. Tohill BC, Seymour J, Serdula M, et al. What epidemiologic studies tell us about the relationship between fruit and vegetable consumption and body weight. *Nutr Rev.* 2004;62:365-374.

5. Sherry B. Food behaviors and other strategies to prevent and treat pediatric overweight. *Int J Obes.* 2005;29:S116-S126.

6. Van Duyn MA, Pivonka E. Overview of the health benefits of fruit and vegetable consumption for the dietetics professional: selected literature. *J Am Diet Assoc.* 2000;100:1511-1521.

7. Guo SS, Wu W, Chumlea WC, Roche AF. Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. *Am J Clin Nutr.* 2002;76:653-658.

8. U.S. Department of Health and Human Services. *Healthy People 2010: Conference Edition.* 2 vols. Washington, DC: U.S. Department of Health and Human Services; 2000.

9. Brady LM, Lindquist C, Herd SL, et al. Comparison of children's dietary intake patterns with US dietary guidelines. *Br J Nutr.* 2000;84:361-367.

10. Contento I. The effectiveness of nutrition education and implications for nutrition education policy, programs, and research: a review of research. *J Nutr Educ.* 1995;27:277-418.

11. Story M, Neumark-Sztainer D, French S. Individual and environmental influences on adolescent eating behaviors. *J Am Diet Assoc.* 2002;102(3 Suppl):S40-S51.

12. Turrell G, Hewitt B, Patterson C, Oldenburg B, Gould T. Socioeconomic differences in food purchasing behavior and suggested implications for diet-related health promotion. *J Hum Nutr Diete.* 2002;15:355-364.

13. Handy SL, Clifton KJ. Local shopping as a strategy for reducing automobile travel. *Transportation.* 2001;28:317-346.

14. Clarke G, Eyre H, Guy C. Deriving indicators of access to food retail provision in British cities: studies of Cardiff, Leeds and Bradford. *Urban Studies.* 2002;39:2041-2060.

15. French SA, Story M, Jeffery RW . Environmental influences on eating and physical activity. *Annu Rev Public Health.* 2001;22:309-335.

16. Booth SL, Sallis JF, Ritenbaugh C, et al. Environmental and societal factors affect food choice and physical activity: rationale, influences, and leverage points. *Nutr Rev.* 2001;59(3 Pt 2):S21-39.

17. Morland K, Wing S, Diez Roux A, et al. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med.* 2002;22(1):23-29.

18. Topolski R, Boyd-Bowman KA, Ferguson H. Grapes of wrath: discrimination in the produce aisle. *Anal Soc Issues Public Policy.* 2003;3(1):111-119.

19. Chung C, Myers S. Do the poor pay more for food? an analysis of grocery store availability and food price disparities. *J Consum Aff.* 1999;33:276-296.

20. Alwitt LF, Donley TD. Retail stores in poor urban neighborhoods. *J Consum Aff.* 1997;31:139-164.

21. Zenk, SN, Schulz, AJ, Israel BA, et al. Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *Am J Public Health.* 2005;95:660-667.

22. Krebs-Smith SM, Kantor LS. Choose a variety of fruits and vegetables daily: understanding the complexities. *J Nutr.* 2001;131(2S1):487S-501S.

23. Drewnowski A, Damon N, Briend A. Replacing fats and sweets with vegetables and fruits: a question of costs. *Am J Public Health.* 2004;94:1555-1559.

24. Change VW, Lauderdale DS. Income disparities in body mass index and obesity in the United States, 1971-2002. *Arch Intern Med.* 2005;165:2122-2128.

25. Cummins, SJ. The local food environment and health: some reflections from the United Kingdom [letter]. *Am J Public Health.* 2003;93:521.

26. Glanz K, Yaroch AL. Strategies for increasing fruit and vegetable intake in grocery stores and communities: policy, pricing, and environmental change. *Prev Med.* 2004;39(Supp 2):S75-80.

27. Cheadle A, Psaty BM, Curry S, et al. Community-level comparisons between the grocery store environment and individual dietary practices. *Prev Med.* 1991;20(2):250-261.

28. Crosnoe R, Muller C. Body mass index, academic achievement, and school context: examining the educational experiences of adolescents at risk of obesity. *J Health Soc Behav.* 2004;45:393-407.

29. Wang Y, Zhang Q. Are American children and adolescents of low socioeconomic status at increased risk of obesity? changes in the association between overweight and family income between 1971 and 2002. *Am J Clin Nutr.* 2006;84:707-716.

30. Kuczmarski, RJ, Ogden, CL, Grummer-Strawn, LM, et al. *CDC Growth Charts: United States: Advance Data from Vital and Health Statistics: Report No. 314.* Hyattsville, MD: National Center for Health Statistics; 2000.

31. Field AE, Laird N, Steinberg E, et al.

Which metric of relative weight best captures body fatness in children? *Obes Res.* 2003;1345-1352.

32. Nanney MS, Haire-Joshu D, Elliott M, et al. Evaluating changeability to improve fruit and vegetable intake among school-aged children. *Nutr J.* 2005;4:34-40.

33. World Health Organization. *Diet, Nutrition and the Prevention of Chronic Diseases. Technical Report Series No. 916.* Geneva: World Health Organization; 2000. Available at: http://whqlibdoc.who.int/trs/WHO_TRS_916.pdf. Accessed October 2, 2006.

34. Prochaska JJ, Sallis J. Reliability and validity of a fruit and vegetable screening measure for adolescents. *J Adolesc Health.* 2004;34:163-165

35 .U.S. Census Bureau. *2002 NAICS Codes.* Available at: http://www.census.gov/epcd/naics02/def/ND445110.HTM#N445110. Accessed May 10, 2005.

36. Kaufman PR, McDonald JM, Lutz SM, et al. *Do the Poor Pay More for Food? Item Selection and Price Differences Affect Low-Income Household Food Costs.* Washington, DC: U.S. Department of Agriculture; 1997. Available at: http://www.ers.usda.gov/publications/aer759/AER759.PDF. Accessed October 2, 2006.

37. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation an application of census-based methodology. *Am J Public Health.* 1992;82:703-710.

38. Khadduri J, Buron L, Lam K. LIHTC and mixed income housing: enabling families with children to live in low poverty neighborhoods. Paper presented at the Association of Public Policy and Management 26th Annual Research Conference, October 30, 2004. Available at: http://www.prrac.org/mobility/pdf/Khadduri.pdf. Accessed August 20, 2007.

39. Crandall MS, Weber BA. Local social and economic conditions, spatial concentrations of poverty, and poverty dynamics. *Amer J Agri Econ.* 2004;86:1276-1281.

40. Delva J, O'Malley PM, Johnston LD. Racial/ethnic and socioeconomic status differences in overweight and health-related behaviors among American students: national trends 1986–2003. *J Adolesc Health.* 2006:39:536-545.

41. Gordon-Larsen P, Adair LS, Popkin BM. The relationship of ethnicity, socioeconomic factors and overweight in US adolescents. *Obes Res.* 2003;11:121-129.

42. Horowitz CR Colson KA, Hebert PL, et al. Barriers to buying healthy foods for people with diabetes: evidence of environmental disparities. *Am J Public Health.* 2004;94:1549-1554.

43. Rose D, Richards R. Food store access and household fruit and vegetable use among participants in the US Food Stamp Program. *Public Health Nutr.* 2004;7:1081-1088.

44. Inagami S, Cohen DA, Finch BK, et al. You are where you shop: grocery store locations, weight, and neighborhoods. *Am J Prev Med.* 2006;31:10-17.

45. Baxter SD, Thompson WO. Fourth-grade children's consumption of fruit and vegetable items available as part of school lunches is closely related to preferences. *J Nutr Educ Behav.* 2002;34:166.

46. Mushi-Brunt C, Haire-Joshu D, Elliott MB. Food spending behaviors and perceptions are associated with fruit and vegetable intake among parents and their preadolescent children. *J Nutr Ed Behav* (in press).

47. Cullen, KW, Baranowski T, Owens E, et al. Availability, accessibility, and preferences for fruit, 100% fruit juice and vegetables influence children's dietary behavior. *Health Educ Behav.* 2003:30:615-626.

48. Rasmussen MR, Krolner R, Klepp K, et al. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: quantitative studies. *Int J Behav Nutr Phys.* 2006;3:22.

49. Horowitz CR, Colson KA, Hebert PL, et al. Barriers to buying healthy foods for people with diabetes: evidence of environmental disparities. *Am J Public Health.* 2004;94:1549-1554.

50. Jetter K, Cassady DL. Availability and cost of healthier food alternatives. *Am J Prev Med.* 2006;30:38-44.

51. Burns CM, Gibbons P, Boak R, et al. Food cost and availability in a rural setting in Australia. *Rural Remote Health.* 2004;4:311. Available at: http://rrh.deakin.edu.au. Accessed September 25, 2006.

52. Baker EA, Kelly C, Barnidge E, et al. The Garden of Eden: acknowledging the impact of race and class in efforts to decrease obesity rates. *Am J Public Health.* 2006;96:1170-1174.

53. Wang MC, Gonzalez AA, Richie LD, et al. The neighborhood food environment: sources of historical data on retail food stores. *Int J Behav Nutr Phys.* 2006;3:15-19.

54. Brownson RC, Hoehner CM, Brennan LK, et al. Reliability of two instruments for auditing the environment for physical activity. *Journal of Physical Activity and Health.* 2004;1(3):191-208.

55. Byers T, Trieber F, Gunter E, et al. The accuracy of parental reports of their children's intake of fruits and vegetables: validation of a food frequency questionnaire with serum levels of carotnoieds and vitamins C, A, and E. *Epidemiology.* 1993;4:350-355.

56. Livingstone MB, Robson PJ, Wallace JM. Issues in dietary intake assessment of children and adolescents. *Br J Nutr.* 2004;92:S213-222.

57. Goran MI. Measurement issues related to studies of childhood obesity: assessment of body composition, body fat distribution, physical activity, and food intake. *Pediatrics.* 1998;101:505-518.

58. Wrigley NW, Warm D, Margetts B. Deprivation, diet, and food-retail access: findings from the Leeds 'food deserts' study. *Environ Planning A.* 2003;35:151-88.

59. Cummins S, Petticrew M, Higgins C, et al. Large scale food retailing as an intervention for diet and health: quasi-experimental evaluation of a natural experiment. *J Epidemiol Community Health.* 2005;59:1035-1040.

60. Kaufman, P.R. Rural poor have less access to supermarkets, large grocery stores. *Rural Development Perspectives.* 1999;13:19-25.

61. Baranowski T, Davis M, Resnicow K, et al. Gimme 5 fruit, juice, and vegetables for fun and health: outcome evaluation. *Health Educ Behav.* 2000;27:96-111.

62. Cullen KW, Baranowski T, Owens E, et al. Availability, accessibility, and preferences for fruit, 100% fruit juice, and vegetables influence children's dietary behavior. *Health Educ Behav.* 2003;30:615-626.

63. Timperio A, Salmon J, Telford A, et al. Perceptions of local neighbourhood environments and their relationship to childhood overweight and obesity. *Int J Obes.* 2005;29(2):170-175.

64. Sturm R, Datar D. Body mass index in elementary school children, metropolitan area food prices and food outlet density. *Public Health.* 2005;19:1059-1068.