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Community characteristics modify the relationship between obesity prevention efforts and dietary intake in children: The Healthy Communities Study

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Abstract

Background: The influence of community characteristics on the effectiveness of childhood obesity prevention efforts is not well understood.

Objective: Examine the interaction of community characteristics with the relationship between community programs and policies (CPPs) and dietary intake.

Methods: An observational study of 5138 children in grades K-8 in 130 U.S. communities was conducted in 2013–2015. Key informant interviews identified and characterized CPPs. CPP scores were generated for the number of target behaviors (CPP-Behav) and the number of behavior change strategies (CPP-Strat) addressed by all CPPs and CPPs with nutrition goals over the prior 6 years in each community. Dietary intake was assessed by dietary screener and included intake of: sugar from sugar-sweetened beverages; energy-dense foods; fruits and vegetables; whole grains; and fiber. Multivariate statistical models assessed the interactions between U.S. region, urbanicity, community-level income, and community-level race/ethnicity and CPP scores in relation to dietary intake.

Results: CPP-Strat was positively associated with healthier dietary intakes in the Northeast and West, and in high Hispanic communities; the reverse was true in the South, and in high African American and low-income communities. The CPP-Behav was positively associated with healthier dietary intakes in the South and rural areas, and the reverse was true in the West.

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For a complete list of members of the Healthy Communities Study Team, see Strauss WJ, Nagaraja J, Landgraf AJ, *et al.* The longitudinal relationship between community programs and policies to prevent childhood obesity and BMI in children: The Healthy Communities Study. Pediatr Obes 2018;

Conclusion: The relationships between CPP index scores and dietary intake were most strongly influenced by region and urbanicity and to a lesser extent by community-level race/ethnicity and income. Findings suggest that different considerations may be needed for childhood obesity prevention efforts in communities with different characteristics.

Keywords

nutrition; policy; childhood; obesity

INTRODUCTION

Disparities in pediatric obesity by race/ethnicity, region, and socioeconomic status (SES) have not improved over the last decade in the United States.[1, 2] Low-income individuals[1], African Americans, Hispanics, Native Americans, those living in southern states[2], and children living in low SES neighborhoods are among the most affected by obesity.[3] For example, 26% of Hispanic and 22% of non-Hispanic black children have obesity compared to 14% of non-Hispanic white children.[4] Community-based efforts to address the obesity epidemic should be designed to reduce disparities, but could worsen racial/ethnic, regional, and/or SES disparities if lower risk groups are more likely to benefit from population-based initiatives.[1] Disparities in childhood obesity rates warrant rigorous evaluation of the effects of community-based initiatives on these disparities.

A number of health organizations, including the World Health Organization[5], the Institute of Medicine[6], and the Centers for Disease Control and Prevention[7], have recommended a comprehensive policy approach in order to have a meaningful impact on the obesity epidemic. Recommended strategies include providing incentives to food retailers to offer healthier options; increasing farm-to-fork initiatives; restricting the availability and advertising of less healthy options; reducing portion sizes in public service venues; and discouraging the consumption of sugar-sweetened beverages.[7] In 2012, an Institute of Medicine report recommended changes to ensure that healthy foods and beverages are routinely and easily accessible in early childhood education, school, worksite, healthcare, food retail, and physical activity environments.[6]

While multi-faceted community interventions to improve food environments are emerging, their impact on dietary intake among different subpopulations has not been adequately studied. Therefore, it is imperative to identify the most effective community actions to reduce disparities in childhood obesity. The purpose of this paper is to examine the influence of community characteristics (region, urbanicity, income level, and racial/ethnic make-up) on associations between certain aspects of physical activity- and nutrition-related community programs and policies (CPPs) and dietary intake among a national sample of 4–15 year old children in the Healthy Communities Study (HCS).

METHODS

Study design.

The HCS[8–11] is an observational study of children (n=5138) recruited from up to 2 elementary and 2 middle schools in each of 130 U.S. communities (high school catchment areas) between 2013 and 2015. A random population-based sample, stratified by race/ethnicity, income, and region, of 102 communities was supplemented by purposefully selecting 28 communities known for their childhood obesity prevention efforts. Parents provided written informed consent. The study was approved by the U.S. Office of Management and Budget and the Battelle Memorial Institute IRB and was overseen by an NIH-appointed Observational Study Monitoring Board.

Independent measures.

Information regarding CPPs was collected by structured in-person or telephone interviews with 10–14 key informants in each community.[10] Additional information was obtained by abstraction of documents provided by informants. CPPs implemented in the prior 10 years were characterized on several dimensions to create several indices.[10,12] For this paper, we examined the following 2 of the 4 indices described by Ritchie et al,[13] selected because each measured distinctly different aspects of CPPs.

The *strategy index* (CPP-Strat) score is the sum of the unique strategies used in each community from the following 6 options: providing information and enhancing skills; enhancing services and support; modifying access, opportunities, and barriers; changing consequences; modifying policy and systems; and “other”. The maximum score was 6 for each community.

The *behavior index* (CPP-Behav) score is the sum of the unique target behaviors in each community from 11 nutrition behaviors including intake of fruits and vegetables, whole grain foods, breakfast, water, sugar-sweetened beverages, fast food, fat, high-calorie snacks and sweets, and total calories; breastfeeding/infant health; and other (any other dietary behavior related to obesity prevention);[13] and 13 physical activity (PA) behaviors including: walking/biking to/from school; frequency/duration of physical education; moderate to vigorous PA in physical education; PA during school recess or classroom instruction; television watching; recreational computer/internet use; playing inactive video/handheld electronic games; school sports teams; community-based sports teams; other community-based PA; home/family PA; after-school program PA; any other PA-related behavior.[14] The maximum score is 11 for nutrition CPPs and 24 for total CPPs in each community.

We chose not to use the intensity index because it included several dimensions (reach, duration, and type of behavior change strategy) one of which is scored subjectively, i.e. a behavior change strategy is given a higher score as it approaches policy on the education to policy continuum. Therefore, a strong education program (providing information and enhancing skills) would be rated lower than a weak policy. The subjective nature of the rating, and the inclusion of multiple dimensions, make interpretation challenging. We did not examine the count index, because it is simply a count of the number of programs and

policies and therefore was of less interest than the indices that examined program characteristics.

Because associations between CPP scores and dietary intakes were similar for the prior 1, 3, 6 and 10 years[13], only the prior 6 year results were examined for this paper. For each of the 2 selected indices, CPP-Behav and CPP-Strat, scores were generated for all CPPs (those with nutrition and/or PA goals) and for just nutrition CPPs (those with nutrition goals with or without PA goals) for a total of 4 CPP scores examined per community. Scores for PA CPPs were also generated but not examined in this paper due to the focus on nutrition outcomes. All scores were converted to a 0 (lowest) to 1 (highest) scale to enable a direct comparison of regression coefficients for each CPP index. The parameter estimate signifies the difference in the nutrition outcome when comparing the community with the highest versus the lowest observed score.

Dependent measures (dietary intake).

Intakes were measured using a 27-item modified version of the National Health and Nutrition Examination Survey Dietary Screener developed by the National Cancer Institute (NCI).[15] The respondent (parent/adult proxy, child, or combination) was determined by the child's age.[16] Age- and gender-specific scoring algorithms from NCI were used to convert reported intake frequencies to estimated quantities for many food items/groups.[15]

This analysis examines five measures of dietary intake for which a relationship to obesity and impact on health are established.[17, 18]

1. Sugar from sugar-sweetened beverages (SSBs) (tsp/d);
2. Energy-dense foods of minimal nutritional value (EDFs) (times/d);
3. Fruits and vegetables (including legumes, excluding fried potatoes) (FVs) (cup equivalents/d);
4. Whole grains (oz/d);
5. Dietary fiber (g/d).

Analyses were also conducted for total added sugar intake but are not presented here because the results were similar to those for SSBs.

Covariates.

Prior to examining the relationship between CPP scores and dietary outcomes, covariates were identified using least absolute shrinkage and selection operator techniques.[19] The following covariates were included: child gender, race, ethnicity and age; seasonality; annual household income; maximum parent education and employment status; community region (Midwest, Northeast, South, West), urbanicity (rural, urban, suburban); minority community status (≧30% African American or Hispanic); percentage African-American; percentage Hispanic; percentage below poverty level; and percentage unemployed. Parental education and employment status were collected by household survey. Child gender was recorded by research staff. Community-level variables were calculated from the 2009–2013 5-year American Community Survey, area-weighted based on the percent of each census tract that

fell within the community catchment area.[16] Urban is defined as contiguous, built-up areas containing 50,000+ people based on USDA Rural-Urban Commuting Area; suburban is defined as areas in which 30–49% of the population commutes to Urban Core areas for work; rural is defined as population less than 49,999 people and limited commute to Urban Core areas.[16]

Interactions.

For each analysis of the association between CPP index scores and dietary outcomes, interactions with region (Midwest, Northeast, South, West), urbanicity (rural, urban, suburban), community race/ethnicity (at least 30% Hispanic/Latino, at least 30% African American, other), and community income (low, higher) were examined. Low-income communities were defined as areas that qualify for the U.S. Department of Housing & Urban Development's Low-Income Housing Tax Credit; all others are classified as "higher income".

Statistical modeling.

To adjust for missing data, data underwent multiple imputation[20, 21] 20 times using chained equations. Generalized linear mixed models[22] were generated to assess relationships between CPP scores and dietary intake by community characteristic, adjusting for community and child-level covariates, and for correlation among children in the same school and same community (cluster design), including the interaction terms described above. Results are reported for the significance ($p<0.05$) of the interactions and the effect estimates for the associations between CPP scores and dietary intake by community characteristic. Data were analyzed using SAS version 9.4 (SAS Institute Inc. Cary, NC, 2013) and R version 3.3.0 (R Development Core Team, 2016). The R lme4 package was used to fit the mixed models; mice package was used for combining the multiple imputations.

RESULTS

Descriptive findings.

Over 40% of the communities in the HCS were located in the South, with approximately 20% in the Midwest and West and 15% in the northeastern U.S. (Table 1). There were fewer rural communities than suburban and urban. About one-fourth of communities were at least 30% African-American and about one-third were at least 30% Hispanic. About one-third of communities were low-income. Mean CPP-Strat scores varied by community characteristic from 0.56 to 0.65 on a scale of 0 to 1. Mean CPP-Behav scores varied from 0.65 to 0.74. The characteristics of the participating children are described elsewhere.[13]

Interactions.

Table 2 provides the significance level for each interaction between community characteristics and CPP scores in relation to each of 5 measures of dietary intake. In sum, region interacted significantly with: CPP-Strat (total) in relation to all 5 dietary intakes measures, CPP-Strat (nutrition) in relation to intake of EDFs and FVs, CPP-Behav (total) in relation to intake of FVs and fiber, and CPP-Behav (nutrition) in relation to intake of whole grains and fiber. Urbanicity interacted significantly with CPP-Behav (total and nutrition) in

relation to intake of FVs, whole grains, and fiber. Community race/ethnicity interacted significantly with: CPP-Strat (total) in relation to intake of FVs, whole grains, and fiber, and CPP-Strat (nutrition) in relation to intake of whole grains. Community income interacted significantly with CPP-Strat (nutrition) in relation to intake of EDFs, whole grains, and fiber.

Table 2 also provides the effect estimates for the associations between CPP scores and dietary intake by community characteristic (described below).

Region.

Interaction with region was significant for all CPP scores and many of the dietary measures examined (Table 3). Associations of CPP-Strat scores with dietary variables were observed in the expected direction in the Northeast and West; for example a higher total CPP-Strat score was associated with lower SSB intakes (Table 2). Higher CPP-Strat scores were associated with lower intakes of unhealthy items (SSBs and EDFs), in the Northeast, and higher intakes of healthy items (FVs, whole grains and fiber) in the West. In the South, significant associations between total CPP-Strat and all dietary variables were observed, but in the opposite direction: for example, higher total CPP-Strat scores were associated with higher intakes of unhealthy items and lower intakes of healthy items.

Regional differences were also observed for the relationship CPP-Behav scores and healthy but not unhealthy items. The associations between the CPP-Behav scores and healthy food intake were consistently significant in the expected direction in the South and were mostly significant in the opposite direction (for fiber and whole grains) in the West.

Urbanicity.

Significant interactions with urbanicity were observed only for the association of healthy foods and the CPP-Behav scores but not with the CPP-Strat scores (Table 3). In rural communities the associations of the CPP-Behav scores with healthy food intakes were consistently significant in the expected direction: higher CPP-Behav scores were associated with higher intakes of FV, whole grains, and fiber. In suburban areas the associations of the CPP-Behav scores with fiber and whole grain intakes were significant, but in a negative direction and smaller in effect size. Results were mixed for urban areas.

Community race/ethnicity.

Differences by community race/ethnicity in associations of CPP scores with dietary intakes were observed only for healthy food intakes and the CPP-Strat scores (Table 2). In the communities with at least 30% African-Americans there were significant negative associations between both CPP-Strat scores (total and nutrition) with both intakes of fiber and whole grains. Among communities with at least 30% Hispanics there were significant positive associations between both CPP-Strat scores (total and nutrition) and intake of FV, and between the CPP-Strat (total) score and fiber intake.

Community income.

Differences by community income in the association of CPP scores with dietary intakes were only significant for the CPP-Strat (nutrition) score and intakes of EDFs, fiber, and

whole grains (Table 3). The association of the CPP-Strat (nutrition) score with EDF intake was in the expected direction (i.e. negative) in both low- and higher-income communities, but the effect estimate was much larger in low-income communities. The association of the CPP-Strat (nutrition) scores with fiber and whole grain intake was positive in the higher-income communities and negative in the low income communities.

DISCUSSION

Many childhood obesity prevention interventions are implemented in communities across the United States, yet disparities in dietary intake and obesity rates by region, ethnic group, and income level persist.[1–4, 23] Better understanding of whether interventions are having the intended effects, particularly on the most vulnerable populations, is needed.

In recent years, obesity prevention efforts that include both education or behavioral strategies and policy approaches have been increasing and the evidence is mounting to support this multidimensional approach.[5–7,24,25] The findings presented here suggest that the effectiveness of combining different types of strategies on the education to policy continuum as framed by the socio-ecological model for health promotion[26] may vary by community characteristic, including geographic region and population demographics. Specifically, the findings suggest that employing a larger number of strategies (higher CPP-Strat score) such as providing information and enhancing skills; enhancing services and support; modifying access, opportunities, and barriers; changing consequences; and modifying policy and systems may not have the intended effects on dietary intake in the South or among predominately African-American or low-income communities. Conversely in the West, the Northeast, and among predominately Hispanic and higher income communities, interventions with a larger number of these strategies were associated with more favorable dietary outcomes.

A number of hypotheses may explain these differences. For example, it may be that more complex, multi-strategy interventions are less effective in the South, in African-American and low-income communities due to unique aspects of the social or political context that make full implementation of these types of interventions more challenging or less acceptable. For example, in communities with a stronger emphasis on individual responsibility, it may be more challenging to effectively implement more comprehensive approaches that include policy change as well as behavioral strategies. It may also be that multi-strategy interventions are implemented preferentially in higher need communities that confront greater obstacles to change, thereby erroneously creating the impression that comprehensive strategies are less effective in these communities. Multi-strategy interventions are likely more complex to implement and therefore may be more challenging to fully implement in higher need communities; extent of implementation was not measured in this study. Finally, it may be that multi-strategy interventions are designed more commonly in the Northeast and West, for predominately Hispanic and/or mixed income communities and are implemented in other communities without adequate adaptation for local context. Additional studies are needed to test these hypotheses.

Dietary interventions to prevent obesity have varied with regard to the number of dietary behaviors targeted. Some are based upon the belief that behavior change is more manageable with a focus on fewer foods and beverages, while others favor an approach that deals with diet more broadly.[27] The findings presented here suggest that dealing with diet and physical activity more broadly is effective in the South and rural areas, where programs and policies that targeted more foods and physical activity behaviors (higher CPP-Behav) were associated with more favorable dietary intakes. Conversely in the West and suburban areas more favorable dietary intakes were associated with programs and policies that focused on fewer target behaviors (lower CPP-Behav). It is possible that these differences by region and urbanicity reflect differences in local community perspectives. Some communities may be more amenable to approaches that identify individual foods as healthy or unhealthy, whereas others may be more amenable to an approach that addresses dietary intake and healthy lifestyles more holistically. Additional studies are needed to test these hypotheses.

Generally, there were more significant interactions between both region and urbanicity and the CPP scores in relation to dietary intakes than with community race/ethnicity or income. This is not surprising, because all children living in a particular area share the same experience in terms of region and urbanicity. However, children in our sample who live in a census tract that is more than 30% African American or Hispanic or that is predominantly low or higher income may, themselves, not share those traits. These findings also suggest that influence of region and urbanicity are not proxies for race/ethnicity or income but exert some independent influence on the effects of CPPs.

To the authors' knowledge no other studies have examined the influence of region or urbanicity on obesity prevention program effectiveness. However, school socioeconomic status has been shown to influence the impact of school nutrition legislation.[28] Other studies have suggested that neighborhood structural factors including amenities, poverty, and racial composition may influence the impact of obesity prevention interventions.[29, 30]

This study is limited by the cross-sectional design which limits our ability to make causal inferences. Additionally, the independent variables are summary scores of the breadth of two aspects of CPPs but do not include the number of interventions in each category, intensity of intervention activities, extent of implementation, or other characteristics of CPPs that could affect dietary intake and therefore may have contributed to or obscured the associations examined. Further, our community income and ethnicity explanatory variables may not adequately capture differences in communities, as they assess only whether a minority of the population in those areas meet the criteria of interest. Finally, dietary intakes were measured using a self-report screener that may be affected by recall error and reporting bias.

In summary, these findings suggest that there may be differences in the way communities with different characteristics (i.e., region, urbanicity, and community-level race/ethnicity and income) respond to obesity prevention interventions. Specifically, different considerations with regard to the comprehensiveness of strategies used and behaviors targeted may be needed. However, given the limitations of this study, additional studies are needed to confirm these results and better understand the nature of the relationship between community characteristics and the effectiveness of different program design features.

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GWL contributed to study design, CPP and nutrition measures, and drafted the manuscript; WG and LEA contributed to drafting the manuscript and interpretation of results; JK contributed to nutrition measures, quality control, interpretation of results and drafting of the manuscript; KW contributed to study design, nutrition measures, and quality control oversight; RDS contributed to quality control, nutrition measures, interpretation of findings, and editing of the manuscript. WJS contributed to study design, selection of communities, and statistical analyses; AJL and JN performed statistical analyses; DKW contributed to nutrition measures and interpretation of results; HLN and LCN contributed to study design and nutrition measures; JAS contributed to study design and community measures; LDR contributed to study design, nutrition measures, and provided overall study leadership. All authors critically reviewed and approved the final manuscript.

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Abbreviations:

(CPPs)	community programs and policies
(HCS)	Healthy Communities Study
(PA)	physical activity
(FVs)	fruits and vegetables
(SSBs)	sugar-sweetened beverages
(CPP-Behav)	behavior index
(CPP-Strat)	strategy index
(EDFs)	energy-dense foods of minimal nutritional value
(NCI)	National Cancer Institute

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SUMMARY

What is already known about this subject

- There are disparities in obesity, dietary intake and physical activity levels by race/ethnicity, socioeconomic status and region in the US.
- Similar multi-component and multisector approaches to prevention of obesity are implemented across the country in communities with diverse characteristics.
- Little is known about the relative effectiveness of obesity prevention efforts in communities with different characteristics.

What this study adds

- We found that region, urbanicity, community-level income, and community level race/ethnicity modify the association between childhood obesity prevention efforts and dietary intake.
- We identified which aspects of obesity prevention efforts appear to influence the association between childhood obesity prevention efforts and dietary intake in communities with different characteristics.
- Our findings suggest that different approaches to childhood obesity prevention and promotion of healthy eating may be needed depending on region and urbanicity, and to a more limited extent, community income and race/ethnicity.

Table 1.

Distribution of communities and mean CPP index scores by community characteristics (n=130 communities)

Community-level characteristics	Number (%) of com-munities	Community Program and Policy (CPP) Index							
		CPP-Strat[1]				CPP-Behav[2]			
		Total		Nutrition		Total		Nutrition	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Region of U.S.[3]									
Midwest	26(20.0)	0.56	0.05	0.53	0.05	0.68	0.04	0.77	0.04
Northeast	20(15.4)	0.63	0.06	0.68	0.05	0.65	0.07	0.80	0.05
South	55(42.3)	0.62	0.04	0.64	0.03	0.71	0.04	0.81	0.03
West	29(22.3)	0.66	0.05	0.66	0.04	0.74	0.04	0.84	0.03
Urbanicity[4]									
Rural	30(23.0)	0.61	0.05	0.57	0.04	0.74	0.05	0.81	0.04
Suburban	50(38.5)	0.63	0.04	0.66	0.03	0.72	0.03	0.83	0.02
Urban	50(38.5)	0.62	0.04	0.63	0.03	0.67	0.04	0.78	0.03
Community Race/Ethnicity[5]									
High African American	34(26.2)	0.58	0.05	0.62	0.04	0.69	0.04	0.83	0.03
High Hispanic	42(32.3)	0.65	0.04	0.69	0.03	0.71	0.04	0.81	0.03
Other	54(41.5)	0.62	0.04	0.59	0.03	0.71	0.04	0.79	0.03
Community Income[6]									
Low income	50(38.5)	0.58	0.04	0.64	0.03	0.74	0.03	0.83	0.02
Higher income	80(61.5)	0.64	0.03	0.62	0.02	0.68	0.03	0.79	0.02

Abbreviations: CPP=community programs and policies; CPP-Strat=strategy index; CPP-Beh=behavior index

[1]Standardized score from 0–1 based on the number of distinct behavior change strategies utilized by all CPPs within a community in the prior 6 years as described by Collie-Akers et al.[12]

[2]Standardized score from 0–1 based on the number of distinct target behaviors addressed by all CPPs within a community in the prior 6 years as described by Collie-Akers et al.[12]

[3]Midwest includes: IA, IL, IN, KS, MI, MO, MN, ND, NE, OH, SD, WI; Northeast includes: CT, MA, ME, NH, NJ, NY, PA, RI, VT; South includes: AR, DE, DC, AL, FL, GA, KY, LA, MD, MS, NC, OK, TN, TX, SC, VA, WV; West includes: AK, CO, AZ, CA, HI, ID, MT, NM, NV, OR, UT, WA, WY

[4]Urban defined as contiguous, built-up areas containing 50,000+ people based on USDA Rural-Urban Commuting Area; suburban defined as areas in which 30–49% of the population commutes to Urban Core areas for work; rural defined as population less than 49,999 people and limited commute to Urban Core areas.[16]

[5]Defined as having at least 30% of the community population being African American and greater than Hispanic or at least 30% of the community population being Hispanic and greater than African American

[6]Low income defined as tract qualifies for the U.S. Department of Housing and Urban Development's Low-Income Housing Tax Credit (LIHTC); i.e., a poverty rate of at least 25 percent or 50 percent or more of its householders have incomes below 60 percent of the area median household income; higher income defined as tract does not qualify for LIHTC.

Table 2.

Associations between CPP index scores and dietary intake by community characteristics and significance of interaction with community characteristics[1] (n=130 communities)

Effect modifier→		Region				Urbanicity					Community Race/Ethnicity					Community Income				
CPP Index type→		CPP-Strat		CPP-Beh			CPP-Strat		CPP-Beh			CPP-Strat		CPP-Beh			CPP-Strat		CPP-Beh	
		Total	Nutr.	Total	Nutr.		Total	Nutr.	Total	Nutr.		Total	Nutr.	Total	Nutr.		Total	Nutr.	Total	Nutr.
Sugar from sugar-sweetened beverages (tsp/d)																				
Interaction p-value		**0.02**	0.06	0.24	0.39		0.78	0.69	0.11	0.98		0.28	0.93	0.71	0.59		0.08	0.20	0.25	0.21
CPP effect estimates	Midwest	−1.34	−1.88	−1.19	−1.06	Rural	−0.72	−0.64	**−1.52** *	−0.28	Af. Am	−0.34	−0.70	0.25	0.66	High	−0.06	−0.55	−0.40	−0.42
	Northeast	**−2.40** *	−2.41	0.86	1.15	Suburban	−0.75	−1.30	−0.01	−0.11	Hispanic	−1.22	−1.07	−0.46	−0.57	Low	−1.28	−1.48	0.42	0.81
	South	**0.41** *	−0.05	−0.35	−0.11	Urban	−0.27	−0.70	0.29	−0.05	Other	−0.03	−0.93	−0.21	−0.11					
	West	−0.18	−0.31	−0.49	−0.29															
Energy-dense foods of minimal nutritional value (times/d)																				
Interaction p-value		**0.01**	**0.00**	0.18	0.81		0.81	0.50	0.51	0.47		0.49	0.67	0.80	0.34		0.14	**0.04**	0.53	0.46
CPP effect estimates	Midwest	−0.37	−0.53	−0.48	−0.15	Rural	−0.48	−0.15	0.17	0.42	Af. Am	−0.36	−0.36	0.16	0.41	High	−0.12	**−0.04** *	0.09	0.02
	Northeast	**−1.25** **	**−1.38** **	0.46	−0.06	Suburban	−0.28	−0.51	0.05	−0.16	Hispanic	−0.47	−0.45	0.03	−0.23	Low	−0.56	**−0.66** *	0.27	0.31
	South	**0.08** *	**0.13** *	0.17	0.26	Urban	−0.24	−0.16	0.29	0.10										
	West	−0.25	0.03	0.08	−0.06															
Fruit and vegetables (cup/d)																				
Interaction p-value		**0.01**	**0.04**	**0.02**	0.05		0.64	0.90	**0.01**	**0.01**		**0.02**	0.06	0.41	0.76		0.37	0.08	0.60	0.88
CPP effect estimates	Midwest	−0.18	**−0.38** *	0.03	0.00	Rural	−0.10	−0.03	**0.56** **	**0.65** **	Af. Am	−0.17	−0.23	0.03	0.26	High	0.06	0.08	0.14	0.21
	Northeast	0.23	0.11	−0.06	0.09	Suburban	−0.01	−0.08	0.13	0.14	Hispanic	**0.24** **	**0.19** *	0.12	0.12	Low	−0.07	−0.20	0.21	0.18
	South	**−0.17** *	−0.01	**0.38** **	**0.47** *	Urban	0.08	−0.00	**−0.01** *	**0.02**	Other	−0.14	−0.13	0.25	0.25					
	West	**0.34** *	0.20	−0.03	−0.09															
Whole grains (oz/d)																				
Interaction p-value		**0.02**	0.31	0.11	**0.03**		0.33	0.33	**0.004**	**0.01**		**0.00**	**0.00**	0.31	0.64		0.40	**0.02**	0.20	0.15
CPP effect estimates	Midwest	−0.01	−0.05	0.01	0.04	Rural	−0.12	0.02	0.11	0.12	Af. Am	**−0.21** **	**−0.21** **	−0.06	0.01	High	−0.02	**0.04** *	0.04	0.05
	Northeast	0.05	0.02	−0.02	−0.12	Suburban	−0.04	−0.09	**−0.13** **	**−0.16** **	Hispanic	0.01	−0.04	0.06	0.06	Low	−0.07	**−0.12** *	−0.05	−0.09
	South	**−0.16** **	−0.10	**0.07** *	**0.11** *	Urban	0.01	0.01	0.07	0.06	Other	0.03	**0.08** *	0.00	−0.03					

Effect modifier→		**Region**					**Urbanicity**					**Community Race/Ethnicity**					**Community Income**				
CPP Index type→		**CPP-Strat**		**CPP-Beh**			**CPP-Strat**		**CPP-Beh**			**CPP-Strat**		**CPP-Beh**			**CPP-Strat**		**CPP-Beh**	
		Total	**Nutr.**	**Total**	**Nutr.**		**Total**	**Nutr.**	**Total**	**Nutr.**		**Total**	**Nutr.**	**Total**	**Nutr.**		**Total**	**Nutr.**	**Total**	**Nutr.**
	West	**0.08** *	0.07	**−0.13** *	**−0.20** *															
Fiber (g/d)																				
Interaction p-value		**0.01**	0.26	**0.00**	**0.02**		0.36	0.72	**0.00**	**0.00**		**0.03**	0.13	0.80	0.78		0.32	**0.03**	0.88	0.47
CPP effect estimates	Midwest	−0.28	−0.72	−0.04	−0.02	Rural	−0.83	0.26	**2.51** **	**2.87** **	Af. Am	**−1.03** *	−1.08	0.32	1.14	High	0.21	**0.52** *	0.59	0.82
	Northeast	0.44	−0.14	−0.19	−0.24	Suburban	0.06	−0.37	**−0.08** *	−0.12	Hispanic	**0.81** *	0.62	0.49	0.41	Low	−0.41	**−0.89** *	0.50	0.22
	South	**−0.97** *	−0.28	**1.61** **	**1.93** **	Urban	0.24	0.05	0.18	0.05	Other	−0.34	−0.11	0.78	0.70					
	West	**1.44** *	1.03	**−0.70** *	−0.67															

Bold indicates statistical significance at P< 0.05 using hierarchical models; All scores were standardized to be between 0 (lowest) and 1 (highest).

* P<0.05,

** P<0.01

Abbreviations: Af Am=African American; CPP=Community programs and policies; CPP-Strat=strategy index; CPP-Beh=behavior index; Nutr.= nutrition

1 Multi-level statistical models adjusted for clustering of children within schools and communities and child level variables: polynomial expansion of age with degrees as follows: 1 for fruit and vegetables; 2 for whole grains, fiber; 3 for sugar from sugar-sweetened beverages; 4 for total energy-dense foods of minimal nutritional value, gender, race, ethnicity, family income, maximum parental education and employment, seasonality of interview (based on sinusoidal curve over time);and community level variables: region, urbanicity, whether a high minority community (>30% African American or Hispanic), % African American, % Hispanic, % below poverty level, and % unemployed.

Table 3.

Summary of significance and direction of associations between CPPs and dietary intake by community characteristic[1]

Independent variables	CPP-Strat		CPP-Behav	
Dependent variables	**Healthy dietary intake**	**Unhealthy dietary intake**	**Healthy dietary intake**	**Unhealthy dietary intake**
Number of associations tested	6[2]	4[3]	6[2]	4[3]
Region				
Midwest	-	ns	ns	ns
Northeast	ns	---	ns	ns
South	---	+++	++++++	ns
West	+++	ns	---	ns
Urbanicity				
Rural	ns	ns	++++	-
Suburban	ns	ns	---	ns
Urban	ns	ns	-+	ns
Race/Ethnicity				
African American	---	ns	ns	ns
Hispanic	+++	ns	ns	ns
Income				
Low	--	-	ns	ns
Higher	++	-	ns	ns

Abbreviations: CPP-Strat=strategy index; CPP-Beh=behavior index

[1]One "+" for each significant positive association and one "-" for each significant negative association.

[2]Total and nutrition CPPs and 3 healthy foods (fruits/vegetables, whole grains, and fiber).

[3]Total and nutrition CPPs and 2 unhealthy foods (sugar from sugar-sweetened beverages and energy-dense foods of minimal nutritional value).