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Title

Associations of community programs and policies with children's dietary intakes: the Healthy Communities Study.

Permalink

<https://escholarship.org/uc/item/63f5c8r7>

Journal

Pediatric obesity, 13 Suppl 1(Suppl 1)

ISSN

2047-6302

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Publication Date

2018-10-01

DOI

10.1111/ijpo.12440

Peer reviewed



Published in final edited form as:

Pediatr Obes. 2018 October ; 13(Suppl 1): 14–26. doi:10.1111/ijpo.12440.

Associations of community programs and policies with children's dietary intakes: The Healthy Communities Study

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Abstract

Background.—The impact of community-based obesity prevention efforts on child nutrition has not been adequately studied.

Objective.—Examine relationships between number, type and intensity of community programs and policies (CPP) and child nutrition.

Methods.—An observational study of 5138 children (grades K-8) in 130 U.S. communities was conducted in 2013–2015. CPPs were identified by 10–14 key informant interviews per community. CPPs were characterized based on: count, intensity, number of different strategies used, and number of different behaviors targeted. Scores for the prior 6 years were calculated separately for CPPs that addressed primarily nutrition, primarily physical activity (PA), or total combined. Child intakes were calculated from a dietary screener and dietary behaviors were based on survey responses. Multi-level statistical models assessed associations between CPP indices and nutrition measures, adjusting for child and community-level covariates.

Results.—Implementing more types of strategies across all CPPs was related to lower intakes of total added sugar (when CPPs addressed primarily PA), sugar-sweetened beverages (for nutrition and PA CPPs), and energy-dense foods of minimal nutritional value (for total CPPs). Addressing more behaviors was related to higher intakes of fruit and vegetables (for nutrition and total CPPs),

and fiber (total CPPs). Higher count and intensity (PA and total CPPs) were related to more consumption of lower fat compared to higher fat milk. A higher count (PA CPPs) was related to fewer energy-dense foods and whole grains. No other relationships were significant at $p < 0.05$.

Conclusion.—Multiple characteristics of CPPs to prevent obesity appear important to improve children's diets.

Keywords

nutrition; community; program; policy; childhood; obesity

Introduction

Unprecedented increases in childhood obesity and associated health and economic costs¹ have led to numerous prevention trials, most of which have focused on single policies, programs, or sectors and have resulted in relatively modest improvements in child dietary behavior and/or weight.⁵ Because many factors influence weight and multi-component interventions have shown the most promise for child obesity prevention, more comprehensive community-based approaches are recommended.²⁻⁵ The relatively few community-based trials to date, however, have not identified which components result in improved child outcomes.⁵⁻¹¹

To inform future investment of limited resources, more needs to be known about which characteristics and combinations of community-based efforts addressing nutrition and physical activity (PA) are most impactful and about the collective impact of community efforts to prevent child obesity. Community efforts include programs (e.g., nutrition education in a youth organization), policies (e.g., requirements by a school district for weekly minutes of PE), and environmental changes (e.g., new sidewalks). The purpose of this study was to examine the associations between existing community programs and policies (CPPs) and nutrition measures in a large sample of children from diverse U.S. communities.

Methods

Study design.

As previously described,¹²⁻¹⁵ the NIH-funded Healthy Communities Study (HCS) was an observational study of children ($n=5138$) recruited from up to four public elementary and middle schools in 130 U.S. communities in 2013–2015. A community was defined by public high school catchment area. After stratifying by race/ethnicity, income, and region, a probability-based sample of 102 communities was selected. The random sample was supplemented by purposefully selecting 28 communities with known engagement in child obesity prevention efforts to ensure a sufficient number of communities with a relatively high level of CPPs. Children who were institutionalized or non-ambulatory, or whose families lived in the community for under 1 year were excluded. Parents provided written informed consent for child participation. 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.

CPP measures.

Data were collected on characteristics of CPPs using a structured interview guide administered in-person or by phone with 10–14 key informants per community. Informants were initially identified by contacting representatives from priority sectors (e.g., school principals, leads from health departments, hospitals, and parks and recreation); additional informants were identified using a snowball technique. Key informants were adults at their organization for at least 6 months and responded ‘moderate’ or ‘high’ to a question of whether they were highly aware, moderately aware, or had limited awareness of their organization’s programs and policies related to improving nutrition, increasing PA, and/or preventing obesity. Informants were first asked to list all efforts implemented by their organization, then probed on characteristics of each effort.^{14,16} Interviews were augmented by abstraction of documents (e.g., written policies, program reports) provided by informants. Any program, policy or other environment change related to nutrition, PA or obesity prevention among children ages 4–15 years that had occurred in the community during the 10-year study period was counted as a CPP. CPPs were coded by trained researchers using a codebook and scoring instructions. Each CPP was characterized by goal, reach, behavior change strategy, duration, and targeted behavior. Consistent with the study aim to identify characteristics of impactful CPPs, these dimensions were used to create multiple indices: count, intensity, number of different strategies utilized, and number of different behaviors targeted, as described elsewhere.^{14,16}

To derive CPP scores for each index over multiple years, yearly scores were summed and then standardized from 0 (lowest) to 1 (highest). Standardization enables a direct comparison of regression coefficients for each index, with the parameter estimate signifying the difference in the nutrition measure when comparing a community with the highest versus the lowest observed CPP score. The prior 1, 3, 6 and 10 year timeframes for CPPs were selected a priori. Because findings were relatively similar when using CPP data for the prior 1, 3, 6 and 10 years (see appendix), and because 6 years represents an intermediate length of time between 1 and 10 years, only the prior 6 year results are presented.

For each index and each nutrition measure, associations were examined for total CPPs, primarily nutrition CPPs (alone or in combination with PA), and primarily PA CPPs (alone or in combination with nutrition). Nutrition CPPs targeted at least one of 11 behaviors: fruit and vegetables; whole grain foods; breakfast; water; sugar-sweetened beverages; fast food; fat; energy dense foods of minimal nutritional value; total calories; breastfeeding/ infant health; any other diet behavior related to obesity prevention.¹⁵ PA CPPs targeted at least one of 13 behaviors: 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.¹⁷

The count index (CPP-Count) involved simply counting the number of distinct CPPs; characteristics that might distinguish more or less impactful CPPs were not considered. The intensity index (CPP-Int) involved quantifying three dimensions of each CPP: reach,

duration, and type of strategy utilized. Higher reach scores were assigned to CPPs that targeted a greater proportion of the community population. Higher duration scores were for CPPs that were ongoing rather than infrequent or one-time events. Higher strategy scores were for CPPs that changed access, barriers, or opportunities through policy or environmental changes, as compared to those that provided only information or enhanced skills. The strategy index (CPP-Strat) was constructed on the basis that combinations of strategies, such as education with policy or other supports, are more likely to achieve behavior change than use of a single type of strategy.^{3,5} This index differs from CPP-Int which used strategy type as one of three components in scoring *each* CPP; instead the CPP-Strat involved tallying the number of unique strategies addressed across *all* CPPs in a community from six types: providing information and enhancing skills; enhancing services and support; modifying access, opportunities, and barriers; changing consequences; modifying policy and systems; and other. Thus a community with one program using all six strategies would get the same CPP-Strat score as a community with multiple programs collectively using all six strategies. The behavior index (CPP-Behav) was based on the assumption that addressing a comprehensive set of behaviors influencing weight is better than focusing on only a few.^{3,5} The number of unique behaviors targeted by *all* CPPs was counted in each community from a maximum of the 11 nutrition and 13 PA behaviors enumerated above.

Nutrition measures.

The rationale, source, and scoring for each nutrition measure has been described previously.¹⁵ Briefly, measures were selected based on literature indicating a relationship with child obesity. Intakes were estimated for the past 30 days using the National Health and Nutrition Examination Survey (NHANES) Dietary Screener, developed by the National Cancer Institute.¹⁸ The respondent (parent/adult proxy, child, or combination) was determined by child age.¹⁹ Age- and gender-specific scoring algorithms¹⁸ were used to convert reported intake frequencies to estimated quantities of:

1. Sugar from sugar-sweetened beverages, from soda, sweetened coffee or tea, sports/energy drinks, fruit drinks (tsp/day);
2. Total added sugar, from sugar-sweetened beverages, cookies/cake/pie, donuts/sweet rolls, chocolate/candy, ice cream/frozen desserts (tsp/day);
3. Fruit and vegetables (excluding fried potatoes), from fruit, fruit juice, green leafy salad, other potatoes, beans, other vegetables, salsa, tomato sauce, vegetables on pizza (cup equivalents/d);
4. Whole grains, including hot/cold cereal, whole grain bread, brown rice/other cooked whole grains, popcorn (oz/day);
5. Fiber (g/day).
6. Frequency of intake (times/day) of energy-dense foods of minimal nutritional value, including cookies/cake/pie, donuts/sweet rolls, chocolate/candy, ice cream/frozen dessert, fried potatoes, and chips/crackers.

Child nutrition behaviors included the frequency of:

1. Eating breakfast (days/past week);
2. Eating while watching television at home (percent responding often or very often in past week);
3. Eating from a fast food restaurant (days/past week);
4. Having dinner with family (days/past week);
5. Consuming 1%, ½% or non-fat milk as opposed to higher fat milk (percent responding usually in past month).

Covariates.

Survey questions were asked of parents on child age and race/ethnicity, annual household income, and parental education and employment status. Child gender was recorded by research staff during recruitment. 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, as previously described.¹⁹ Community socio-demographic variables included: U.S. region, whether a minority population tract (30% or more African American or Hispanic), whether urban, rural or suburban community, proportion African American and Hispanic, and proportion below the federal poverty level and/or unemployed.

Statistical modeling.

To account for missing data from non-response, data underwent multiple imputation 20 times using chained equations (A Landgraf, unpublished). Linear mixed models were used to account for the complex design of the HCS; random-effect intercepts at the community-level were used to account for differences in the nutritional responses between communities. Models related CPP indices to child nutrition measures, adjusting for community and child-level covariates, and for correlation among children in the same school and community. Covariates were identified using least absolute shrinkage and selection operator techniques.²⁰ P-values <0.05 were considered statistically significant and none of the p-values were adjusted for multiple comparisons. 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

Child participants.

The 5138 children in the study were relatively evenly distributed by grade level (37.7% in grades K-2; 31.9% in grades 3–5; 30.5% in grades 6–9), and gender (Table 1). Almost half of children were Hispanic and one-fifth were African American. Slightly more than one quarter were from a household with an annual income below \$20,000. For almost half of the sample, the maximum parental education was high school or less. Almost three quarters had at least one parent employed full-time. Over 40% lived in southern states with about 20%

living in each of the remaining U.S. regions (midwest, northeast, and west). Dietary measures in the HCS sample were similar to national averages (Table 2).

Community programs and policies.

Of the 9459 total CPPs documented for the prior 6 years in the 130 communities, 2546 (27%) addressed nutrition only, 5433 (57%) addressed PA only, and 1479 (16%) addressed both PA and nutrition. Relative distributions were similar for the prior 1 year (Table 3). Because many CPPs simultaneously addressed both nutrition and PA, we examined CPPs in relation to dietary outcomes by goal: nutrition (including CPPs that addressed PA), PA (including CPPs that addressed nutrition), and total. A more detailed description of CPPs is provided elsewhere in this supplement.^{16, 21}

CPPs in relation to nutrition measures.

Results are presented for each CPP index using standardized scores for the prior 6 years after adjusting for covariates (Table 4). Higher CPP-Strat scores were related to lower intakes of: total added sugar (when CPPs addressed primarily PA, $\beta(\text{SE})=-1.32(0.64)$, $P=0.039$), sugar-sweetened beverages (for nutrition, $\beta(\text{SE})=-0.91(0.36)$ $P=0.011$, and for PA, $\beta(\text{SE})=-0.69(0.35)$, $P=0.050$), and energy-dense foods of minimal nutritional value (for total, $\beta(\text{SE})=-0.31(0.14)$, $P=0.032$). Higher CPP-Behav scores were related to higher intakes of fruit and vegetables (for nutrition, $\beta(\text{SE})=0.21(0.09)$, $P=0.015$, and for total, $\beta(\text{SE})=0.16(0.07)$, $P=0.013$), and fiber (for total, $\beta(\text{SE})=0.59(0.28)$, $P=0.032$). Higher CPP-Count and CPP-Int scores (for PA, $\beta(\text{SE})=0.16(0.05)$, $P=0.002$, and $\beta(\text{SE})=0.12(0.05)$, $P=0.017$, respectively, and for total, $\beta(\text{SE})=0.18(0.06)$, $P=0.001$, and $\beta(\text{SE})=0.13(0.05)$, $P=0.010$, respectively) were related to more consumption of lower fat compared to higher fat milk. A higher CPP-Count (for PA, $\beta(\text{SE})=-0.36(0.18)$, $P=0.047$, and $\beta(\text{SE})=-0.08(0.04)$, $P=0.046$) was also related to fewer energy-dense foods and whole grains, respectively. No relationships with CPPs for the prior 6 years were significant for the following eating behaviors: breakfast, fast food restaurant, dinner with family, and while watching television (data not shown).

In general similar relationships were observed between measures of CPPs for the prior 1, 3, 6 and 10 years with child nutrition. However, a relatively fewer number of findings were significant when CPPs were examined for the prior 1 ($n=5$) and 3 years ($n=7$) than when examined for the prior 6 ($n=13$) and 10 years ($n=13$) (appendix).

Discussion

While recent U.S. trends suggest that child energy intakes are declining,²² diet quality is improving,²³ and obesity is reaching a plateau,¹ much remains to be understood about what should be done to improve child nutrition for obesity prevention. To help inform community efforts, we examined CPPs and in multiple ways and examined multiple dietary factors potentially related to child obesity. Child dietary measures were significantly related to all four CPP indices. Higher scores on one or more indices in the prior 6 years were related to consumption of lower fat milk, lower intakes of total added sugar, sugar-sweetened beverages, and energy-dense foods of minimal nutritional value, and higher intakes of fruit

and vegetables, and fiber. Only one relationship was observed in a direction opposite to that expected: a higher count of PA CPPs was related to lower intakes of whole grains. No significant relationships were seen for eating: breakfast, from a fast food restaurant, dinner with family, or while watching television. Possible explanations are that fewer communities targeted these behaviors than targeted foods and beverages, or because fewer communities targeted parents compared to children as shown elsewhere in this supplement.^{16, 21} Alternatively, some behaviors may be harder to influence than others. For example, Cheadle *et al.* found that consumption of sugary beverages by children decreased after relatively modest community efforts, whereas little change was observed in fruit and vegetable intake after more intense community efforts.²⁴

We examined various temporal relationships as the optimal period required for achieving dietary behavior change is unclear and may differ by behavior. Failure of some nutrition interventions has often been attributed to inadequate duration.^{2,5} While a greater number of associations with nutrition measures were observed when CPPs were characterized over the prior 6 years (n=13) compared to the prior 1 year (n=5), more research is needed to better understand how long a CPP must be in place before a meaningful impact is achieved.

CPPs that focused primarily on PA were more often related to nutrition measures than CPPs focused primarily on nutrition. This may be partially because more CPPs addressed PA (73%) than nutrition (42%), and because a substantial proportion (one-sixth of total CPPs, 37% of CPPs in the nutrition subgroup and 21% of PA CPPs) addressed both nutrition and PA. A number of other studies have shown that healthy (and conversely unhealthy) dietary and PA behaviors cluster together in the same individuals and that influencing one behavior can have ripple effects on others.²⁵ It may also be that among communities, variation in child nutrition is related partly to unknown community characteristics other than CPPs for which we were unable to control. Further studies are needed to identify such community characteristics and better understand how they might directly or indirectly influence child nutrition.

Despite substantial community efforts (on average, 60 CPPs per community were reported in the year prior to child assessment), there is considerable room for improvement in child nutrition, findings which are consistent with other national studies. For example, in the HCS sample, total added sugar intake for 4 to 15 year olds averaged 19.0 tsp/day, which is comparable to the national average of 18.5 tsp/day using the Dietary Screener in 4 to 15 year olds (Table 2), and 19.1 tsp/day and 16% of total calories using 24-hour recalls in 2 to 19 year olds.²⁶ The 2015–2020 Dietary Guidelines for Americans recommend that total added sugar constitute less than 10% of daily calories.²⁷ A total added sugar intake reduction of 1–2 tsp/day, the effect size observed in this study, represents only one-quarter of the reduction needed by children to achieve the Dietary Guidelines recommendation. Likewise, the reported 2.5 cups/day of fruit and vegetables in the HCS sample, while consistent with national averages, is below recommended amounts which range from 2.5 to 5 cups/day for 4 to 15 year olds.²⁸

The magnitude of the differences in dietary measures seen between communities with the highest versus lowest scores on various indices are consistent with effect sizes observed in

intervention trials. As an example, the average difference in fruit and vegetable intake between communities that had the maximum CPP-Behav score (meaning they had programs and policies that collectively targeted all 11 dietary factors specified) compared to communities that targeted only one dietary factor was 0.21 cups/day. This amount is similar to the average increase achieved by intervention trials aimed at increasing child intakes of fruit and vegetables.²⁹

To our knowledge, this is the first U.S. study to characterize CPPs as they have collectively occurred over multiple years in relation to child nutrition. Previous studies have reported largely on single interventions, were primarily school-based, and had durations of less than one year.² One interpretation of the HCS results is that reducing child intakes of unhealthy items such as energy-dense sweets/snacks and sugar-sweetened beverages involves community efforts that provide information while simultaneously changing environments to support healthier choices. In contrast, efforts spanning multiple nutrition behaviors appear important for increasing consumption of fruit and vegetables. Implementing more CPPs with greater reach, duration and policy/environmental supports appears helpful for consumption lower fat instead of whole or 2% milk.

Our retrospective study, while not a randomized trial, covers a substantial time period. Additional strengths of the HCS include inclusion of relatively large numbers of children and communities, and a range of nutrition and CPP measures. Also, the HCS has limitations. Because of the observational design, causality cannot be inferred. To better understand “what works”, a variety of ways of characterizing CPPs and a variety of nutrition measures were examined and we did not adjust for multiple comparisons. The large number of comparisons may have resulted in detection of some significant findings by chance (type 1 error). With four indices, 11 dietary outcomes and three goals for CPPs, six significant findings would be expected by chance; we observed double that many (n=13). Although children and their parents were interviewed, all nutrition measures were based on self-report which are subject to recall error and reporting bias. Similarly, descriptions of CPPs relied upon self-report from a relatively small number of community informants who may have lacked information which was not captured in the related documents also reviewed. Finally, while the study included a diverse sample of communities and children, results may not be generalizable to others.

Study findings suggest that community efforts to improve children’s diets and PA are related to health-promoting dietary patterns. Using various ways of characterizing such efforts, CPPs are associated with many dietary behaviors that are important for obesity prevention. No single way of characterizing CPPs appeared to be superior in relation to better nutrition. This suggests that several features of CPPs are important, there is no “simple” solution, and coordination of community efforts to cover multiple strategies and behaviors may be needed. Future analyses of the HCS and additional studies with longitudinal designs will help to elucidate other features of CPPs required to prevent child obesity.

Acknowledgements

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health (NIH) or the U.S. government. No financial disclosures were reported by the authors

of this paper. LDR contributed to study design, provided overall study leadership, and drafted the manuscript; GWL contributed to study design, CPP and nutrition measures; LEA contributed to drafting the manuscript and interpretation of results; CML contributed to study design and quality control, CPP and nutrition measures, overall leadership in conducting the study, and interpretation of results; VCM contributed to CPP measures and quality control; DKW contributed to nutrition measures and interpretation of results; EAF contributed to study design, selection of communities, CPP measures, and interpretation of results; WJS contributed to study design, selection of communities, and statistical analyses; RDS contributed to quality control, nutrition measures, and interpretation of findings; AJL and JN performed statistical analyses; HLN and LCN contributed to study design and nutrition measures; KLW contributed to study design and nutrition measures, quality control oversight, and drafting the manuscript and the interpretation of results. All authors critically reviewed and approved the final manuscript.

The Healthy Communities Study was supported by the National Heart, Lung, and Blood Institute, in collaboration with the *Eunice Kennedy Shriver* National Institute of Child Health and Development, the National Institute of Diabetes and Digestive and Kidney Disorders, the National Cancer Institute, and the National Institutes of Health Office of Behavioral and Social Sciences Research; DHHS, under Contract No. HHSN268201000041C. This paper does not reflect the views of NIH.

The Battelle Memorial Institute's Institutional Review Board provided oversight for the study, operating under its Federal Wide Assurance No. 4696, on file with the NIH-HHS Office of Human Research Protection (OHRP). All data collection forms and protocols were approved by the U.S. Office of Management and Budget (OMB #0925-0649).

Appendix

Appendix Table 1.

Community program and policy (CPP) indices for the prior 1 year in relation to child nutrition measures.¹ (n=5138 children)

Index	CPP-Count ²			CPP-Inf ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total added sugar (tsp/day)												
Total CPPs	-1.17	0.91	0.196	-1.13	0.93	0.224	0.36	0.44	0.414	0.52	0.57	0.362
Nutrition CPPs	-0.13	0.77	0.861	-0.37	0.79	0.638	-0.21	0.58	0.718	0.24	0.85	0.774
Physical activity CPPs	-1.44	0.86	0.093	-1.27	0.81	0.116	-0.78	0.57	0.171	0.80	0.78	0.302
Sugar from sugar-sweetened beverages (tsp/day)												
Total CPPs	-0.38	0.49	0.445	-0.48	0.50	0.338	-0.01	0.24	0.967	0.11	0.31	0.717
Nutrition CPPs	0.14	0.41	0.734	-0.07	0.43	0.862	-0.61	0.31	0.053	-0.15	0.46	0.753
Physical activity CPPs	-0.52	0.47	0.273	-0.53	0.44	0.230	-0.43	0.31	0.164	0.33	0.42	0.426
Energy-dense foods of minimal nutritional value (times/day)												
Total CPPs	-0.33	0.20	0.100	-0.21	0.21	0.311	-0.02	0.10	0.867	0.17	0.13	0.178
Nutrition CPPs	-0.12	0.17	0.475	-0.09	0.18	0.629	-0.08	0.13	0.530	0.09	0.19	0.621
Physical activity CPPs	-0.36	0.19	0.064	-0.23	0.18	0.219	-0.17	0.13	0.191	0.26	0.17	0.131
Fruit and vegetables including legumes, excluding fried potatoes (cup/day)												
Total CPPs	0.06	0.10	0.571	0.09	0.10	0.398	0.00	0.05	0.979	0.12	0.06	0.053
Nutrition CPPs	0.04	0.09	0.651	0.07	0.09	0.431	0.01	0.07	0.937	0.15	0.10	0.110
Physical activity CPPs	0.05	0.10	0.594	0.07	0.09	0.422	0.01	0.06	0.843	0.13	0.09	0.145
Whole grains (oz/day)												
Total CPPs	-0.07	0.05	0.147	-0.07	0.05	0.138	-0.02	0.02	0.324	-0.00	0.03	0.982
Nutrition CPPs	-0.01	0.04	0.891	-0.02	0.04	0.613	0.00	0.03	0.911	-0.01	0.04	0.814
Physical activity CPPs	-0.07	0.05	0.119	-0.07	0.04	0.100	-0.02	0.03	0.470	0.00	0.04	0.953
Fiber (g/day)												
Total CPPs	-0.28	0.43	0.517	-0.18	0.44	0.690	0.00	0.21	0.991	0.42	0.27	0.119
Nutrition CPPs	-0.20	0.36	0.582	-0.10	0.37	0.787	0.18	0.28	0.514	0.47	0.40	0.246
Physical activity CPPs	-0.18	0.41	0.663	-0.11	0.39	0.769	-0.07	0.27	0.790	0.48	0.36	0.191
Regularly consume 1%, 1/2% or non-fat milk (%)												

Index	CPP-Count ²			CPP-Int ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total CPPs	0.17	0.06	0.004	0.14	0.06	0.020	0.02	0.03	0.485	0.05	0.04	0.188
Nutrition CPPs	0.07	0.05	0.178	0.06	0.05	0.228	0.01	0.04	0.876	0.07	0.06	0.197
Physical activity CPPs	0.15	0.06	0.007	0.11	0.05	0.034	0.01	0.04	0.851	0.05	0.05	0.355
Ate breakfast (days/week)												
Total CPPs	0.04	0.17	0.833	0.02	0.18	0.895	0.16	0.09	0.063	-0.01	0.11	0.928
Nutrition CPPs	-0.14	0.15	0.332	-0.10	0.15	0.505	0.09	0.12	0.455	0.00	0.16	0.996
Physical activity CPPs	0.16	0.17	0.328	0.14	0.16	0.383	0.24	0.11	0.028	-0.02	0.15	0.913

¹ Bold signifies statistical significance ($p < 0.05$) using linear mixed models. P-values < 0.05 were considered statistically significant and were not adjusted for multiple comparisons. All scores were standardized to be between 0 (lowest) and 1 (highest). Multi-level statistical models adjusted for clustering of children within schools and communities as well as for:

- Community level variables (weighted combination of census tract information (as community may include > 1 tract and/or parts of multiple tracts); U.S. region (midwest, northeast, south, west), minority classification (high African American, high Hispanic, or high other), urbanicity (urban, suburban, or rural), percent catchment area with children that are African American or Hispanic, percent catchment area with households living below poverty level, percent catchment with unemployed adults.
- Child level variables: age as polynomial with degrees as follows: 0 for regularly; 1 for fruit and vegetables; 2 for whole grains, fiber; 3 for sugar from sugar-sweetened beverages; 4 for total added sugar, energy-dense foods of minimal nutritional value), gender, race, ethnicity, family income, maximum parental education from biological mother/father, seasonality of interview (based on sinusoidal curve over time), maximum employment status of biological mother/father.

Number of CPPs for prior 1 year: 8838 total CPPs, 3740 nutrition which included 1365 that simultaneously addressed physical activity; 6463 physical activity which included 1365 that simultaneously addressed nutrition.

² Based on the number of distinct CPPs.

³ Based on scoring the reach, duration, and strategy of each CPP as described by Fawcett et al.¹⁴ and Collie-Akers et al.¹⁶

⁴ Based on the number of distinct strategies utilized by all CPPs within a community as described by Collie-Akers et al.¹⁶

⁵ Based on the number of distinct behaviors targeted by all CPPs within a community as described by Collie-Akers et al.¹⁶

Abbreviations: CPP-Behav, behavior index; CPP, community program and policy; CPP-Int, intensity index; CPP-Strat, strategy index.

Appendix Table 2.
Community program and policy (CPP) indices for the prior 3 years in relation to child nutrition measures.¹ (n=5138 children)

Index	CPP-Count ²			CPP-Inf ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total added sugar (tsp/day)												
Total CPPs	-1.37	0.90	0.128	-1.21	0.83	0.146	-0.13	0.48	0.779	0.34	0.60	0.568
Nutrition CPPs	-0.33	0.75	0.658	-0.60	0.80	0.450	-0.61	0.60	0.314	0.28	0.82	0.737
Physical activity CPPs	-1.54	0.84	0.067	-1.41	0.80	0.078	-0.93	0.57	0.104	0.35	0.78	0.655
Sugar from sugar-sweetened beverages (tsp/day)												
Total CPPs	-0.52	0.49	0.289	-0.57	0.45	0.212	-0.21	0.26	0.414	0.00	0.32	0.992
Nutrition CPPs	-0.01	0.41	0.974	-0.24	0.43	0.583	-0.73	0.32	0.024	-0.12	0.45	0.791
Physical activity CPPs	-0.62	0.46	0.180	-0.64	0.44	0.147	-0.54	0.31	0.081	0.09	0.42	0.834
Energy-dense foods of minimal nutritional value (times/day)												
Total CPPs	-0.36	0.20	0.074	-0.21	0.19	0.264	-0.12	0.11	0.258	0.15	0.13	0.276
Nutrition CPPs	-0.14	0.17	0.387	-0.12	0.18	0.514	-0.17	0.14	0.233	0.09	0.19	0.636
Physical activity CPPs	-0.37	0.19	0.053	-0.23	0.18	0.196	-0.21	0.13	0.110	0.18	0.17	0.306
Fruit and vegetables including legumes, excluding fried potatoes (cup/day)												
Total CPPs	0.04	0.10	0.662	0.07	0.09	0.459	0.02	0.05	0.713	0.14	0.07	0.031
Nutrition CPPs	0.03	0.08	0.763	0.06	0.09	0.486	-0.01	0.07	0.855	0.18	0.09	0.052
Physical activity CPPs	0.04	0.10	0.693	0.06	0.09	0.495	0.02	0.06	0.813	0.13	0.09	0.134
Whole grains (oz/day)												
Total CPPs	-0.08	0.05	0.098	-0.07	0.04	0.108	-0.02	0.02	0.368	0.00	0.03	0.948
Nutrition CPPs	-0.02	0.04	0.697	-0.03	0.04	0.479	0.00	0.03	0.973	-0.00	0.04	0.925
Physical activity CPPs	-0.08	0.04	0.090	-0.07	0.04	0.089	-0.02	0.03	0.598	0.00	0.04	0.972
Fiber (g/day)												

Index	CPP-Count ²			CPP-Int ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total CPPs	-0.31	0.43	0.475	-0.17	0.40	0.674	0.04	0.23	0.874	0.51	0.28	0.069
Nutrition CPPs	-0.22	0.36	0.537	-0.10	0.38	0.789	0.13	0.29	0.648	0.59	0.39	0.131
Physical activity CPPs	-0.20	0.41	0.615	-0.12	0.38	0.749	-0.04	0.27	0.873	0.49	0.37	0.181
Regularly consume 1%, 1/2% or non-fat milk (%)												
Total CPPs	0.17	0.06	0.003	0.13	0.05	0.017	0.03	0.03	0.432	0.06	0.04	0.160
Nutrition CPPs	0.07	0.05	0.145	0.06	0.05	0.221	-0.02	0.04	0.651	0.07	0.05	0.209
Physical activity CPPs	0.15	0.06	0.006	0.11	0.05	0.033	0.01	0.04	0.834	0.06	0.05	0.278
Ate breakfast (days/week)												
Total CPPs	-0.01	0.17	0.958	-0.02	0.16	0.924	0.16	0.09	0.080	-0.04	0.11	0.748
Nutrition CPPs	-0.18	0.14	0.195	-0.14	0.15	0.344	0.05	0.12	0.665	0.00	0.16	0.999
Physical activity CPPs	0.13	0.16	0.444	0.11	0.16	0.485	0.22	0.11	0.048	-0.06	0.15	0.674

¹ Bold signifies statistical significance (p<0.05) using linear mixed models. P-values <0.05 were considered statistically significant and were not adjusted for multiple comparisons. All scores were standardized to be between 0 (lowest) and 1 (highest). Multi-level statistical models adjusted for clustering of children within schools and communities as well as for:

- Community level variables (weighted combination of census tract information (as community may include >1 tract and/or parts of multiple tracts); U.S. region (midwest, northeast, south, west), minority classification (high African American, high Hispanic, or high other), urbanicity (urban, suburban, or rural), percent catchment area with children that are African American or Hispanic, percent catchment area with households living below poverty level, percent catchment with unemployed adults.
- Child level variables: age as polynomial with degrees as follows: 0 for regularly; 1 for fruit and vegetables; 2 for whole grains, fiber; 3 for sugar from sugar-sweetened beverages; 4 for total added sugar, energy-dense foods of minimal nutritional value), gender, race, ethnicity, family income, maximum parental education from biological mother/father, seasonality of interview (based on sinusoidal curve over time), maximum employment status of biological mother/father.

Number of CPPs for prior 3 years: 9170 total CPPs, 3894 nutrition which included 1426 that simultaneously addressed physical activity; 6702 physical activity which included 1426 that simultaneously addressed nutrition.

² Based on the number of distinct CPPs.

³ Based on scoring the reach, duration, and strategy of each CPP as described by Fawcett et al¹⁴ and Collie-Akers et al.¹⁶

⁴ Based on the number of distinct strategies utilized by all CPPs within a community as described by Collie-Akers et al. 16

⁵ Based on the number of distinct behaviors targeted by all CPPs within a community as described by Collie-Akers et al. 16

Abbreviations: CPP-Behav, behavior index; CPP, community program and policy; CPP-Int, intensity index; CPP-Strat, strategy index.

Appendix Table 3.

Community program and policy (CPP) indices for the prior 10 years in relation to child nutrition measures.¹ (n=5138 children)

Index	CPP-Count ²			CPP-Inf ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total added sugar (tsp/day)												
Total CPPs	-1.60	0.85	0.061	-1.48	0.79	0.061	-0.79	0.61	0.194	-0.21	0.61	0.724
Nutrition CPPs	-1.01	0.85	0.232	-1.47	0.93	0.113	-1.02	0.60	0.089	-0.10	0.66	0.878
Physical activity CPPs	-1.58	0.81	0.050	-1.53	0.79	0.053	-1.26	0.62	0.042	-0.33	0.69	0.630
Sugar from sugar-sweetened beverages (tsp/day)												
Total CPPs	-0.65	0.47	0.165	-0.72	0.43	0.095	-0.45	0.32	0.167	-0.31	0.33	0.347
Nutrition CPPs	-0.36	0.46	0.436	-0.69	0.50	0.168	-0.62	0.32	0.050	-0.19	0.36	0.595
Physical activity CPPs	-0.62	0.44	0.160	-0.69	0.43	0.111	-0.59	0.34	0.080	-0.38	0.37	0.311
Energy-dense foods of minimal nutritional value (times/day)												
Total CPPs	-0.37	0.19	0.050	-0.24	0.18	0.174	-0.22	0.14	0.108	0.05	0.14	0.715
Nutrition CPPs	-0.26	0.19	0.156	-0.27	0.21	0.199	-0.21	0.14	0.120	0.01	0.15	0.962
Physical activity CPPs	-0.35	0.18	0.055	-0.24	0.18	0.184	-0.25	0.14	0.068	0.07	0.16	0.657
Fruit and vegetables including legumes, excluding fried potatoes (cup/day)												
Total CPPs	0.03	0.10	0.749	0.06	0.09	0.490	0.05	0.07	0.455	0.16	0.07	0.023
Nutrition CPPs	0.02	0.09	0.824	0.08	0.10	0.434	0.01	0.07	0.911	0.16	0.07	0.033
Physical activity CPPs	0.02	0.09	0.838	0.04	0.09	0.633	0.04	0.07	0.560	0.12	0.08	0.112
Whole grains (oz/day)												
Total CPPs	-0.09	0.04	0.037	-0.08	0.04	0.058	-0.02	0.03	0.551	0.00	0.03	0.947
Nutrition CPPs	-0.03	0.04	0.497	-0.04	0.05	0.363	-0.02	0.03	0.560	0.01	0.03	0.868
Physical activity CPPs	-0.09	0.04	0.031	-0.08	0.04	0.044	-0.00	0.03	0.902	-0.01	0.04	0.776
Fiber (g/day)												

Index	CPP-Count ²			CPP-Int ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total CPPs	-0.28	0.41	0.499	-0.09	0.38	0.805	0.08	0.28	0.777	0.51	0.28	0.071
Nutrition CPPs	-0.25	0.40	0.532	-0.04	0.44	0.937	0.02	0.30	0.949	0.46	0.31	0.134
Physical activity CPPs	-0.22	0.39	0.577	-0.11	0.38	0.783	0.02	0.30	0.954	0.45	0.33	0.170
Regularly consume 1%, 1/2% or non-fat milk (%)												
Total CPPs	0.19	0.06	0.001	0.14	0.05	0.007	-0.03	0.04	0.468	0.08	0.04	0.044
Nutrition CPPs	0.11	0.06	0.056	0.09	0.06	0.127	-0.03	0.04	0.457	0.07	0.04	0.098
Physical activity CPPs	0.16	0.05	0.002	0.13	0.05	0.016	-0.01	0.04	0.741	0.08	0.05	0.081

¹ Bold signifies statistical significance (p<0.05) using linear mixed models. P-values <0.05 were considered statistically significant and were not adjusted for multiple comparisons. All scores were standardized to be between 0 (lowest) and 1 (highest). Multi-level statistical models adjusted for clustering of children within schools and communities as well as for:

- Community level variables (weighted combination of census tract information (as community may include >1 tract and/or parts of multiple tracts); U.S. region (midwest, northeast, south, west), minority classification (high African American, high Hispanic, or high other), urbanicity (urban, suburban, or rural), percent catchment area with children that are African American or Hispanic, percent catchment area with households living below poverty level, percent catchment with unemployed adults.

- Child level variables: age as polynomial with degrees as follows: 0 for regularly; 1 for fruit and vegetables; 2 for whole grains, fiber; 3 for sugar from sugar-sweetened beverages; 4 for total added sugar, energy-dense foods of minimal nutritional value), gender, race, ethnicity, family income, maximum parental education from biological mother/father, seasonality of interview (based on sinusoidal curve over time), maximum employment status of biological mother/father.

Number of CPPs for prior 10 years: 9623 total CPPs, 4084 nutrition which included 1507 that simultaneously addressed physical activity; 7046 physical activity which included 1507 that simultaneously addressed nutrition.

² Based on the number of distinct CPPs.

³ Based on scoring the reach, duration, and strategy of each CPP as described by Fawcett et al.¹⁴ and Collie-Akers et al.¹⁶

⁴ Based on the number of distinct strategies utilized by all CPPs within a community as described by Collie-Akers et al.¹⁶

⁵ Based on the number of distinct behaviors targeted by all CPPs within a community as described by Collie-Akers et al.¹⁶
Abbreviations: CPP-Behav, behavior index; CPP, community program and policy; CPP-Int, intensity index; CPP-Strat, strategy index.

Abbreviations:

(CPP-Behav)	behavior index
(CPPs)	community programs and policies
(CPP-Count)	count index
(HCS)	Healthy Communities Study
(CPP-Index)	intensity index
(PA)	physical activity
(CPP-Strat)	strategy index

References

1. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015–2016. NCHS data brief, no 288. Hyattsville, MD: National Center for Health Statistics, 2017.
2. World Health Organization. (2004). Global Strategy on Diet, Physical Activity, and Health. URL http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf.
3. Institute of Medicine. Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation. Washington DC: The National Academies Press, 2012.
4. Khan LK, Sobush K, Keener D, et al. Recommended community strategies and measurements to prevent obesity in the United States. MMWR. 2009; 58: 1–26.
5. Hoelscher DM, Kirk S, Ritchie L, Cunningham-Sabo L. Position of the Academy of Nutrition and Dietetics: interventions for the prevention and treatment of pediatric overweight and obesity. J Acad Nutr Diet. 2013; 113: 1375–1394. [PubMed: 24054714]
6. Mozaffarian D, Afshin A, Benowitz NL, et al. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. Circulation. 2012; 126: 1514–1563. [PubMed: 22907934]
7. Economos CD, Irish-Hauser S. Community interventions: a brief overview and their application to the obesity epidemic. J Law Med Eth 2007; 35: 131–137.
8. Bleich SN, Segal J, Wu Y, Wilson R, Wang Y. Systematic review of community-based childhood obesity prevention studies. Pediatrics. 2013; 132: e201–210. [PubMed: 23753099]
9. Brennan LK, Brownson RC, Orleans CT. Childhood obesity policy research and practice: evidence for policy and environmental strategies. Am J Prev Med. 2014; 46: e1–16. [PubMed: 24355679]
10. Taber DR, Chriqui JF, Perna FM, Powell LM, Chaloupka FJ. Weight status among adolescents in states that govern competitive food nutrition content. Pediatrics. 2012; 130: 437–444. [PubMed: 22891223]
11. Economos CD, Hyatt RR, Goldberg JP, et al. A community intervention reduces BMI z-score in children: Shape Up Somerville first year results. Obesity. 2007; 15: 1325–1336. [PubMed: 17495210]
12. Arteaga SS, Loria CM, Crawford PB, et al. The Healthy Communities Study: Its rationale, aims, and approach. Am J Prev Med 2015; 49: 615–623. [PubMed: 26384931]
13. John LV, Gregoriou M, Pate RR, et al. Operational implementation of the Healthy Communities Study: How communities shape children’s health. Am J Prev Med 2015; 49: 631–635. [PubMed: 26384933]
14. Fawcett SB, Collie-Akers VL, Schultz JA, Kelley M. Measuring community programs and policies in the Healthy Communities Study. Am J Prev Med 2015; 49: 636–641. [PubMed: 26384934]

15. Ritchie LD, Wakimoto P, Woodward-Lopez G, et al. The Healthy Communities Study nutrition assessments: Child diet and the school nutrition environment. *Am J Prev Med* 2015; 49: 647–652. [PubMed: 26384936]
- 16*. Collie-Akers VL, Schultz JA, Fawcett SB, et al. Measuring intensity of community programs and policies to prevent childhood obesity in a diverse sample of U.S. communities: The Healthy Communities Study. *Pediatr Obes* 2018; XX: xxx–xxx. Article also submitted for this supplement
17. Pate RR, McIver KL, Colabianchi N, Troiano RP, Reis JP, Carroll DD, Fulton JE. Physical Activity Measures in the Healthy Communities Study. *Am J Prev Med*. 2015; 49: 653–659. [PubMed: 26384937]
18. National Cancer Institute. (2016). Dietary screener questionnaire in the NHANES 2009–10. URL <http://appliedresearch.cancer.gov/nhanes/dietscreen/>.
19. Strauss WJ, Sroka CJ, Frongillo EA, et al. Statistical design features of the Healthy Communities Study. *Am J Prev Med* 2015; 49: 624–630. [PubMed: 26384932]
20. Tibshirani R Regression shrinkage and selection via the lasso. *J Royal Stat Soc. Series B (methodological)* 1996; 58: 267–288.
21. Collie-Akers V, Schultz JA, Fawcett SB, et al. The prevalence of community programs and policies to prevent childhood obesity in a diverse sample of U.S. communities: The Healthy Communities Study. *Pediatr Obes* 2018; XX: xxx–xxx.* Article also submitted for this supplement
22. Ervin RB, Ogden CL. Trends in energy and macronutrients in children and adolescents from 1999–2000 through 2009–2010. *NCHS Data Brief*. 2013; 113: 1–8.
23. Wilson MM, Reedy J, Krebs-Smith SM. American diet quality: where it is, where it is heading, and what it could be? *J Acad Nutr Diet*. 2016; 116: 302–310. [PubMed: 26612769]
24. Cheadle A, Atiedu A, Rauzon S, et al. A Community-Level Initiative to Prevent Obesity: Results From Kaiser Permanente’s Healthy Eating Active Living Zones Initiative in California. *Am J Prev Med*. 2018; 54: S150–S159. [PubMed: 29680115]
25. Wilson DK. Behavior matters: the relevance, impact, and reach of behavioral medicine. *Ann Behav Med* 2015; 49: 40–48. [PubMed: 25559044]
26. Ervin RB, Kit BK, Carroll MD, Ogden CL. Consumption of added sugar among U.S. children and adolescents, 2005–2008. *NCHS Data Brief*. 2012; 87: 1–8.
27. Department of Health US and Human Services and US Department of Agriculture. *2015 – 2020 Dietary Guidelines for Americans*. 8th Edition. December 2015 URL <http://health.gov/dietaryguidelines/2015/guidelines/>.
28. Kim SA, Moore LV, Galuska D, et al. Vital signs: fruit and vegetable intake among children - United States, 2003–2010. *MMWR Morb Mortal Wkly Rep*. 2014; 63: 671–676. [PubMed: 25102415]
29. Evans CE, Christian MS, Cleghorn CL, Greenwood DC, Cade JE. Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 y. *Am J Clin Nutr*. 2012; 96: 889–901. [PubMed: 22952187]

Summary**What is already known about this subject**

- Multi-component and multi-sector community interventions are recommended to prevent child obesity.
- Little is known about whether community programs and policies implemented in the U.S. are improving child nutrition; a better understanding of these efforts and their relationship to child nutrition can help inform community efforts.

What this study adds

- We conducted an observational study collecting dietary data from over 5000 children ages 4–15 years and retrospective data on community programs and policies in a diverse sample of 130 communities across the U.S.
- Different features of community policies and programs were related to better child nutrition – there is likely no ‘single’ or ‘simple’ solution.
- Policy and food environments that support children’s healthy food choices in conjunction with delivering information and enhancing skills are associated with better diets.
- It is important to target changes in multiple dietary behaviors – not only increasing healthy foods and beverages, but also limiting less healthy ones.

Table 1.

Characteristics of children and their communities in the Healthy Communities Study. (n=5138 children, 130 communities)

Child-level characteristics	
Age, year (Mean ± SD)	9.3 ± 2.7
Female (%)	50.9
Hispanic (%)	44.8
Race (%)	20.1
Black Only	70.3
White Only	4.7
Multiple	4.8
Other	
Annual household income (%)	27.0
<\$20,000	24.3
\$20–35,000	12.6
\$35–50,000	10.7
\$50–75,000	7.8
\$75–100,000	17.6
\$>100,000	
Maximum parental education (%)¹	22.7
Less than high school	20.0
High school diploma or equivalent	25.0
Some college or associate degree	15.4
Bachelor degree	16.9
Graduate degree	
Maximum parental employment (%)²	72.9
Full-time	10.1
Part-time	6.1
Unemployed	10.9
Other	
Community-level characteristics	
Region of U.S. (%)	19.3
Midwest	15.4
Northeast	41.6
South	23.8
West	
Minority tract (%)³	20.6
African American minority tract	39.6
Hispanic minority tract	39.6
Not in minority tract	
Urbanicity (%)⁴	22.6
Rural	39.5
Suburban	37.8
Urban	
Sociodemographics (Mean ± SD)⁵	19.7 ± 23.4
African American	34.7 ± 29.6
Hispanic	20.6 ± 10.6
Below poverty level	8.8 ± 3.4
Unemployed	

¹Maximum for biological parents; graduate includes masters, professional, doctorate degree.

²Maximum employment status ranked as follows: full-time, part-time, unemployed (including temporary layoff or leave of absence), other (including retired, disabled, keeping house, student).

³Minority tracts defined as having at least 30% of the community population being African American or Hispanic.

⁴Urban 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.¹⁹

⁵Socio-demographic variables for the community catchment areas were calculated using estimates from the 2009–2013 5-year American Community Survey (ACS). The ACS variables were area-weighted based on the percent of each census tract that fell within the community catchment area

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Table 2.

Dietary intakes and behaviors¹ of children in the Healthy Communities Study (HCS; n=5138 children) compared to nationally representative values.

Nutrition measure	HCS sample	Nationally representative sample
Total added sugar, tsp/day (Mean ± SD)	19.0 ± 7.8	18.5 ± 0.2 ⁵
Sugar from sugar-sweetened beverages, tsp/day (Mean ± SD)	7.0 ± 4.8	7.0 ± 0.1 ⁵
Energy-dense foods of minimal nutritional value, times/day (Mean ± SD)	2.0 ± 1.8	1.3 ± 0.0 ^{5,6}
Fruit and vegetables including legumes, excluding fried potatoes, cup equivalent/day (Mean ± SD)	2.5 ± 0.9	2.1 ± 0.0 ⁵
Whole grains, oz/day (Mean ± SD)	0.7 ± 0.4	0.7 ± 0.0 ⁵
Fiber, g/day (Mean ± SD)	15.5 ± 3.9	14.1 ± 0.1 ⁵
Usually consumed 1%, ½% or non-fat milk (%) ²	26.8	30.9 ⁵
Ate breakfast, days/week ³ (Mean ± SD)	6.2 ± 1.8	4.4 ± 0.1 ⁷
Ate from fast food restaurant, days/week ³ (Mean ± SD)	1.0 ± 1.2	1.7 ± 0.1 ⁷
Ate dinner with family, days/week ³ (Mean ± SD)	5.0 ± 2.4	5.1 ± 0.1 ⁷
Ate while watching television often or very often (%) ⁴	39.2	39.5 ⁷

¹Intakes for total added sugar, sugar from sugar-sweetened beverages, energy dense foods of minimal nutritional value, fruit and vegetables, whole grains and fiber were quantified using the NHANES Dietary Screener; all other behaviors were assessed using survey questions.

²Reported usual consumption in past 30 days with answer options of: whole or regular, 2% or reduced-fat, 1%, ½% or low-fat milk, fat-free, skim or non-fat, soy, other, refused, don't know.

³Frequency reported in past week.

⁴HCS sample reported how often in past week television on while eating at home with answer options of: never, rarely, sometimes, often, very often, refused, don't know. Nationally representative sample reported how often television on while eating with answer options of 'most of the time' and 'always'.

⁵From NHANES 2009–2010 data on 4–15 year olds, n=2246 for total added sugar, n=2253 for sugar sweetened beverages, n= 2236 for energy-dense foods, n=2243 for fruits and vegetables, n=2249 for whole grains, n=2234 for fiber, n=2146 for milk. (Centers for Disease Control and Prevention. National Center for Health Statistics. NHANES Data. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2009–2010. www.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2009. Accessed 1/12/18).

⁶The NHANES DSQ does not include a question on potato chips/corn chips/crackers that was included in the HCS sample.

⁷From NYPANS 2010 data on 14–15 year olds, n=3574 for breakfast, n=3525 for fast food, n=3239 for dinner with family, n=3495 for eating while watching television (Centers for Disease Control and Prevention. 2010 National Youth Physical Activity and Nutrition Study. www.cdc.gov/healthyouth/data/yrbs/nypans.htm. Accessed 1/12/18).

Abbreviations: NHANES, National Health and Nutrition Examination Survey; NYPANS, National Youth Physical Activity and Nutrition Survey.

Table 3. Community program and policy (CPP) indices for the prior 1 year and prior 9 years in the Healthy Communities Study.¹ (n=130 communities)

Index	CPP-Count ²		CPP-Int ³		CPP-Strat ⁴		CPP-Behav ⁵	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Past 1 year								
Total (n=8838 CPPs)	68.0	22.1	34.9	11.5	4.9	0.4	22.4	1.6
Nutrition (n=3740 CPPs)	28.8	11.8	15.8	6.3	4.7	0.5	10.1	1.0
Physical Activity (n=6463 CPPs)	49.7	17.4	24.0	8.3	4.7	0.5	12.3	1.1
Past 6 years								
Total (n=9459 CPPs)	332.3	111.4	168.1	57.3	28.5	2.2	130.6	11.0
Nutrition (n=4026 CPPs)	132.8	57.5	72.0	31.2	26.8	3.0	59.1	6.7
Physical Activity (n=6912 CPPs)	251.1	90.2	119.8	42.4	27.3	3.2	71.4	7.2

Numbers of physical activity and nutrition CPPs do not add to the number of total CPPs because some addressed both physical activity and nutrition.

¹To derive CPP scores over multiple years, yearly scores were summed; prior to multi-level modeling, scores were standardized to be between 0 (lowest) and 1 (highest). Numbers shown in table are not standardized.

²Based on the number of distinct CPPs.

³Based on scoring the reach, duration, and strategy of CPPs as described by Fawcett *et al.*¹⁴ and Collie-Akers *et al.*¹⁶

⁴Based on the number of distinct strategies utilized by all CPPs within a community as described by Collie-Akers *et al.*¹⁶

⁵Based on the number of distinct behaviors targeted by all CPPs within a community as described by Collie-Akers *et al.*¹⁶

Abbreviations: CPP-Behav, behavior index; CPP, community program and policy; CPP-Int, intensity index; CPP-Strat, strategy index.

Table 4. Community program and policy (CPP) indices for the prior 6 years in relation to child nutrition measures¹ (n=5138 children) 13

Index	CPP-Count ²			CPP-Int ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Total added sugar (tsp/day)												
Total CPPs	-1.50	0.85	0.080	-1.38	0.79	0.080	-0.91	0.64	0.155	0.11	0.59	0.854
Nutrition CPPs	-0.72	0.80	0.373	-1.13	0.87	0.197	-1.26	0.69	0.068	0.21	0.76	0.781
Physical activity CPPs	-1.53	0.80	0.056	-1.46	0.78	0.060	-1.32	0.64	0.039	-0.08	0.75	0.918
Sugar from sugar-sweetened beverages (tsp/day)												
Total CPPs	-0.62	0.47	0.182	-0.69	0.43	0.110	-0.57	0.34	0.094	-0.19	0.32	0.548
Nutrition CPPs	-0.24	0.43	0.578	-0.54	0.47	0.256	-0.91	0.36	0.011	-0.13	0.41	0.747
Physical activity CPPs	-0.64	0.44	0.147	-0.69	0.42	0.103	-0.69	0.35	0.050	-0.27	0.40	0.500
Energy-dense foods of minimal nutritional value (times/day)												
Total CPPs	-0.37	0.19	0.051	-0.23	0.18	0.188	-0.31	0.14	0.032	0.15	0.13	0.264
Nutrition CPPs	-0.21	0.18	0.234	-0.21	0.19	0.291	-0.29	0.16	0.070	0.10	0.17	0.566
Physical activity CPPs	-0.36	0.18	0.047	-0.24	0.18	0.176	-0.28	0.15	0.054	0.15	0.17	0.354
Fruit and vegetables including legumes, excluding fried potatoes (cup/day)												
Total CPPs	0.03	0.10	0.762	0.06	0.09	0.511	0.01	0.07	0.948	0.16	0.07	0.013
Nutrition CPPs	0.02	0.09	0.796	0.07	0.10	0.451	-0.04	0.08	0.649	0.21	0.09	0.015
Physical activity CPPs	0.02	0.09	0.834	0.04	0.09	0.624	0.01	0.07	0.920	0.12	0.08	0.142
Whole grains (oz/day)												
Total CPPs	-0.09	0.04	0.052	-0.07	0.04	0.073	-0.04	0.03	0.262	0.01	0.03	0.758
Nutrition CPPs	-0.03	0.04	0.548	-0.04	0.05	0.405	-0.03	0.04	0.454	0.01	0.04	0.845
Physical activity CPPs	-0.08	0.04	0.046	-0.08	0.04	0.054	-0.02	0.03	0.613	0.00	0.04	0.985
Fiber (g/day)												
Total CPPs	-0.33	0.41	0.416	-0.16	0.38	0.673	-0.07	0.30	0.832	0.59	0.28	0.032
Nutrition CPPs	-0.23	0.38	0.534	-0.06	0.41	0.880	-0.06	0.33	0.850	0.69	0.36	0.053
Physical activity CPPs	-0.26	0.39	0.499	-0.16	0.37	0.664	-0.06	0.30	0.838	0.47	0.35	0.185

Index	CPP-Count ²			CPP-Int ³			CPP-Strat ⁴			CPP-Behav ⁵		
	β	SE	P	β	SE	P	β	SE	P	β	SE	P
Regularly consume 1%, 1/2% or non-fat milk (%)												
Total CPPs	0.18	0.06	0.001	0.13	0.05	0.010	0.01	0.04	0.806	0.07	0.04	0.054
Nutrition CPPs	0.09	0.05	0.100	0.08	0.06	0.191	-0.06	0.05	0.217	0.08	0.05	0.093
Physical activity CPPs	0.16	0.05	0.002	0.12	0.05	0.017	0.01	0.04	0.859	0.07	0.05	0.144

¹ Bold signifies statistical significance ($p < 0.05$) using linear mixed models. P-values < 0.05 were considered statistically significant and were not adjusted for multiple comparisons. All scores were standardized to be between 0 (lowest) and 1 (highest). Multi-level statistical models adjusted for clustering of children within schools and communities as well as for:

- Community level variables (weighted combination of census tract information (as community may include > 1 tract and/or parts of multiple tracts); U.S. region (midwest, northeast, south, west), minority classification (high African American, high Hispanic, or high other), urbanicity (urban, suburban, or rural), percent catchment area with children that are African American or Hispanic, percent catchment area with households living below poverty level, percent catchment with unemployed adults.
- Child level variables: age as polynomial with degrees as follows: 0 for regularly; 1 for fruit and vegetables; 2 for whole grains, fiber; 3 for sugar from sugar-sweetened beverages; 4 for total added sugar, energy-dense foods of minimal nutritional value), gender, race, ethnicity, family income, maximum parental education from biological mother/father, seasonality of interview (based on sinusoidal curve over time), maximum employment status of biological mother/father.

Number of CPPs for prior 6 years: 9459 total CPPs, 4026 nutrition which included 1479 that simultaneously addressed physical activity; 6912 physical activity which included 1479 that simultaneously addressed nutrition.

² Based on the number of distinct CPPs.

³ Based on scoring the reach, duration, and strategy of each CPP as described by Fawcett et al¹⁴ and Collie-Akers et al.¹⁶

⁴ Based on the number of distinct strategies utilized by all CPPs within a community as described by Collie-Akers et al.¹⁶

⁵ Based on the number of distinct behaviors targeted by all CPPs within a community as described by Collie-Akers et al.¹⁶

Abbreviations: CPP-Behav, behavior index; CPP, community program and policy; CPP-Int, intensity index; CPP-Strat, strategy index.