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The association between community-level economic hardship and childhood obesity prevalence in Los Angeles

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What is already known about this subject

- Neighbourhood social, economic and environmental factors are associated with childhood obesity.
- Childhood obesity disproportionately impacts those living in low-income neighbourhoods.

What this study adds

- Childhood obesity prevalence is strongly associated with community-level social and economic conditions as measured using a composite Economic Hardship Index.
- Childhood obesity prevalence among communities in the highest hardship quartile was more than double the prevalence among communities in the lowest hardship quartile (26.9 vs. 12.5%).
- The relationship between economic hardship and obesity differs by race/ethnicity.

Summary

Objective: The association between community-level economic hardship and childhood obesity prevalence was examined in Los Angeles County, one of the largest and most racially and ethnically diverse regions in the United States.

Methods: Data from the 2008–2009 California Department of Education's Physical Fitness Testing Program were analyzed to assess obesity prevalence among 5th, 7th and 9th grade students attending public schools (n = 298 485). Community-level socioeconomic conditions were compared using a census-tract-based Economic Hardship (EH) index. Mixed-effects modelling was used to examine the association between obesity prevalence and gender, grade, race/ethnicity and EH.

Results: Higher community-level EH was associated with higher childhood obesity prevalence ($P < 0.001$). The obesity prevalence among communities in the highest EH quartile (26.9%) was more than double the obesity prevalence among communities in the lowest EH quartile (12.5%). The slope of the association between EH and childhood obesity differed by racial/ethnic group. The slope was higher for non-Hispanic White students, Hispanics, and non-Hispanic Asians, and lower for non-Hispanic Black students. Racial/ethnic disparities were observed across the socioeconomic spectrum.

Conclusions: Findings suggest that efforts to improve community socioeconomic conditions could reduce childhood obesity prevalence. Prevention efforts should target communities with high economic hardship and also focus on providing culturally relevant interventions that address disparities in obesity prevalence across communities.

Keywords: Childhood obesity, community, disparities, economic hardship.

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Introduction

Current data show that nearly 17% of children and adolescents in the United States are obese, increasing their risk for type 2 diabetes, cardiovascular disease and associated conditions extending into adulthood (1). Multiple studies suggest that underlying social and economic conditions are inextricably linked to the recent rise in childhood obesity and emphasize the importance of neighbourhood environments (2–6). Such studies have differed in their approach to studying associations among socioeconomic status indicators and obesity.

One approach has been to use social experiment studies to examine changes in obesity in individuals moving from one neighbourhood to another. These have shown that changing neighbourhood environments, rather than the act of moving itself, can reduce the prevalence of obesity and diabetes (7). Ludwig *et al*. gave families in major U.S. cities housing vouchers to move from high-poverty to low-poverty neighbourhoods. These subjects were more likely to have lower body mass indices and fewer cases of extreme obesity compared to controls that received traditional monetary vouchers or no vouchers. Another study that examined the association between poverty and obesity in King County, WA, found that limited economic resources shift dietary choices towards energy dense, highly palatable diets that provide maximum calories for the lowest cost (8). Both limited financial resources and limited environmental access reduce a family's ability to obtain nutrient-dense foods and correlate with higher levels of obesity (9).

The impact of economic and environmental hardships on childhood obesity is further compounded by racial and ethnic disparities (1,10), with one study finding that race and socioeconomic status account for up to 24% of the variability in childhood obesity rates among communities (11). Larger-scale analyses using nationally representative samples in the United States and Canada have also found significant associations among race, low socioeconomic status and obesity (12–17). One study found that adolescents attending schools with higher median incomes had lower body mass indices, suggesting that targeting lower-income schools may be a critical channel to impact obesity in youth (13). Another study showed that race/ethnicity interacts with community poverty to influence the prevalence of obesity (14).

The association between socioeconomic status and obesity is not new. Researchers have been calling for policymakers to develop a framework for obesity prevention that accounts for the association among obesity and economic, social, and environmental indicators (18–20). The current study adds to previous research by examining the association between childhood obesity and community-level economic hardship across the full socioeconomic spectrum (high to low), using a comprehensive measure rather than a single socioeconomic status indicator (e.g. income, education). The objective of this study is to further examine the magnitude of the relationship between the social and economic environment and childhood obesity in Los Angeles County, a region characterized by tremendous racial and ethnic diversity coupled with large, persistent health and socioeconomic disparities.

Methods

Data sources

Data from the California Department of Education's Physical Fitness Testing Program (PFTP) for the 2008–2009 academic years were used to calculate obesity prevalence. The state-mandated PFTP is administered annually in spring to all 5th, 7th and 9th grade students attending public schools in California. Standardized testing is conducted using a tool called the FITNESSGRAM, which was developed by the Cooper Institute to measure student aerobic capacity, body composition and muscular strength, endurance, and flexibility (21,22). PFTP data for 2008–2009 included approximately 93% of all 5th, 7th and 9th grade students enrolled in Los Angeles County public schools. To calculate the Economic Hardship Index, we used data from the American Community Survey (ACS) 2005–2009 5-year estimates (23).

Study variables

Body mass index (BMI) was calculated based on measured heights and weights recorded for public school children enrolled in grades 5, 7 and 9 during mandatory school-based physical fitness testing. Childhood obesity was defined as having a BMI for age at or above the 95th percentile according to gender- and age-specific growth charts developed by the U.S. Centers for Disease Control and Prevention (24). Records with missing values, or height-for-age, weight-for-age, or BMI values that were identified as biologically implausible based on World Health Organization's recommended exclusion ranges (1.4% of the records) were excluded from the analysis (25).

Other variables examined included gender (male, female), grade level (5th, 7th, 9th) and race/ethnicity. Four racial/ethnic groups were included in the analy-

sis: non-Hispanic (NH) White students, Hispanics, NH Black students, and NH Asians. Students with missing race/ethnicity information (4.0% of records), or who were identified as 'Pacific Islander' or 'Other race' (0.06% of records), were not included in the current analysis due to the small number of students in these groups. The percentage of obese students for each gender, grade and race/ethnicity was calculated for students attending schools physically located within the defined cities and communities.

The Economic Hardship (EH) index, developed by the Nelson A. Rockefeller Institute of Government, was used to compare social and economic conditions among cities and communities (26–28). The EH index is a relative composite index of six indicators. These include (i) crowded housing (percentage occupied by housing units with more than 1 person per room); (ii) poverty (percentage of persons living below the federal poverty level); (iii) unemployment (percentage of persons over the age of 16 years who are unemployed); (iv) education (percentage of persons over the age of 25 years without a high school education; (v) dependency (percentage of the population under 18 or over 64 years of age); and (vi) income (per capita income), which operate at the community level, as opposed to individual or family level indicators. It has the advantage of being comprised of data available from the U.S. Census Bureau at the census tract level. Scores on the index range from 1 to 100, with a higher score representing a greater level of economic hardship or burden. Additional methodological details regarding the index are available elsewhere (26–28). While there are currently no published analyses that have examined the EH index in relation to health outcomes, it includes important social indicators, providing a more complete, multidimensional measure of neighbourhood socioeconomic conditions than provided by individual measures such as income or employment alone.

Geographic definitions

Geocoding of public schools located within the County of Los Angeles was completed based on a March 2008 listing of public schools, which was downloaded from the California Department of Education's web site. Geocoded schools were assigned to census tracts, which were aggregated to city and unincorporated community boundaries. City boundaries were defined according to U.S. Census 2000 Incorporated Places, and communities were defined using 2000 Census Designated Place boundaries; because of its large size, the City of Los Angeles was further broken down into community planning areas (CPAs) using boundaries obtained from the Los Angeles City Planning Department. A total of 27 cities and communities with populations of less than 10 000 were excluded from the analysis because the ACS data for these smaller communities had large coefficients of variation. This resulted in the exclusion of 4% of the student records. Two additional communities lacked schools reporting any PFTP data. A total of 135 cities, communities and CPAs, hereafter termed communities, were included.

Statistical analysis

The prevalence of childhood obesity was determined for each gender, grade, racial/ethnic group and community. We performed mixed-effects modelling to examine the relationship between childhood obesity prevalence and EH at the community level. The initial model included percentage of obese as the dependent variable; gender, grade and race/ethnicity as fixed effects; and EH as a fixed covariate. Community was included in the model as a random effect (intercept). Including community as a random effect in the model resulted in a smaller Bayesian information criterion, indicating an improved model. Testing for interactions demonstrated a significant interaction between EH and race/ethnicity ($P < 0.001$), but no significant interaction between EH and gender ($P = 0.502$) or EH and grade ($P = 0.421$). Because the relationship between EH and obesity was of primary interest in this analysis, separate models were subsequently run for each racial/ethnic group. Tukey's honestly significant difference was used for post hoc pairwise comparisons. All descriptive, univariate and regression analyses were performed in JMP version 9.0.1 (SAS Institute, Cary, NC, USA). A significance level of $\alpha = 0.05$ was used.

Results

Records from a total of 298 485 students attending public schools in the 135 defined communities were included in the analysis. Of these students, 49.0% were female, 68.8% were Hispanic, 14.2% were NH White, 7.6% were NH Black, and 9.4% were NH Asian. Childhood obesity prevalence varied by gender, grade, race/ethnicity and community (Table 1 and Supporting Information Table S1). Hispanic children attending schools within the defined communities had the highest childhood obesity prevalence (26.9%), followed by Black students (20.7%), while NH Asians had the lowest (10.1%). Obesity prevalence was higher among boys, decreased with increasing grade level, and increased with increasing EH (Table 1). There was a strong

Table 1 Prevalence of childhood obesity by gender, grade, race/ethnicity and level of economic hardship among Los Angeles County communities, 2009

	Percentage of obese 2009 (%)	No. of students tested
Overall	22.5	298485
Gender		
Female	19.7	146381
Male	25.5	152104
Grade		
5	27.1	91443
7	21.9	100404
9	19.5	106638
Race/Ethnicity		
NH White	11.3	42254
Hispanic	26.9	205331
NH Black	20.7	22708
NH Asian	10.1	28192
Economic hardship quartile		
1st	12.5	37557
2nd	18.5	71141
3rd	23.9	95536
4th	26.9	94251

NH, non-Hispanic.

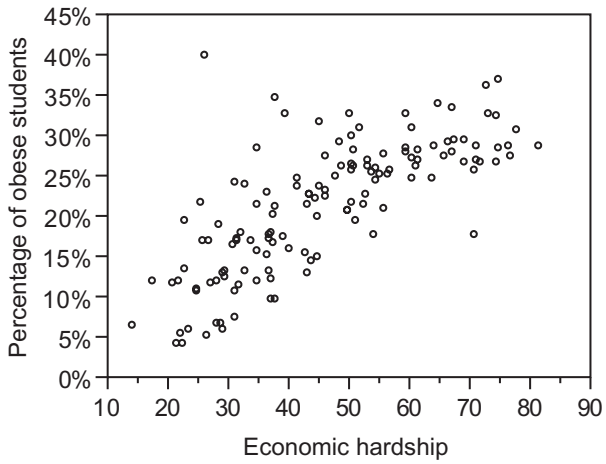

Figure 1 Percentage of obese 5th, 7th and 9th grade students by economic hardship for 135 cities and communities in Los Angeles County, 2009.

correlation between prevalence of childhood obesity and economic hardship across the 135 defined communities ($\rho = 0.74$, $P < 0.001$; Fig. 1). The prevalence of obesity among the communities ranged from 4.2 to 40.0% (Supporting Information Table S1). The community with the lowest EH had an obesity prevalence of 6.6%, while the obesity prevalence in the community with the highest EH was more than four times higher (28.8%). The prevalence of obesity among all communities in the lowest EH quartile was 12.5%, compared to an obesity prevalence of 26.9% among all communities in the highest EH quartile.

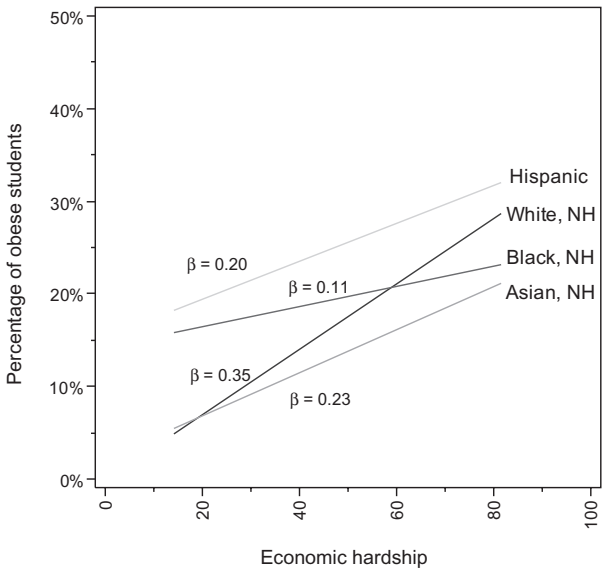

Figure 2 Interaction plot of obesity and economic hardship by race/ethnicity, Los Angeles county, 2009. NH, non-Hispanic.

Results of the initial mixed-effects model showed that the slope of the relationship between childhood obesity and EH differed by racial/ethnic group ($P < 0.001$). The slope was steepest among NH White students and NH Asians, and flattest among NH Black students (Fig. 2). Results of the race/ethnicity specific models showed obesity prevalence to be higher for boys than girls among NH White students, Hispanics, and NH Asians ($P < 0.001$). The reverse was seen among NH Black students, where girls demonstrated a higher obesity prevalence than boys ($P = 0.004$) (Table 2). Among NH White students, higher EH was significantly associated with higher prevalence of obesity ($P < 0.001$), but obesity did not differ significantly by grade level ($P = 0.053$). Among Hispanics, higher EH was significantly associated with higher obesity prevalence ($P < 0.001$), and higher grade level was significantly associated with decreasing obesity ($P < 0.001$). Among NH Black students, higher EH was significantly associated with higher obesity prevalence ($P = 0.011$), and the obesity prevalence was lower in grades 7 and 9 compared to grade 5, but no significant difference was found between grades 7 and 9. Among NH Asians, higher EH was also significantly associated with higher prevalence of obesity ($P < 0.001$), and higher grade level was significantly associated with

Table 2 Adjusted mean obesity prevalence (SE) by gender, ethnicity and grade level*

	Overall	Female	Male	Grade 5	Grade 7	Grade 9
NH White	13.2	11.3 (0.65)	15.6 (0.64)	14.4 (0.74)	13.5 (0.73)	12.4 (0.71)
Hispanic	25.4	21.6 (0.39)	28.9 (0.39)	29.1 (0.45)	24.9 (0.46)	21.7 (0.48)
NH Black	19.0	21.2 (0.77)	18.4 (0.76)	23.8 (1.17)	19.0 (0.84)	16.6 (0.77)
NH Asian	11.1	7.8 (0.61)	15.1 (0.58)	14.4 (0.78)	11.5 (0.70)	8.5 (0.66)

*Among 135 cities and communities in Los Angeles County, 2009.
NH, non-Hispanic; SE, standard error.

decreasing obesity ($P < 0.001$). The intra-class correlation coefficient (ICC) varied among the race/ethnicity specific models and was largest for the model examining childhood obesity among NH White students (0.31), indicating that for this group the variance between communities accounted for approximately 31% of the total variance. The ICC was smaller for the NH Asian (0.15), Hispanic (0.11), and NH Black (0.11) subgroups.

Discussion

The current study sought to extend our understanding of the association between community-level economic hardship and childhood obesity by examining the full spectrum of EH across 135 defined communities in Los Angeles County. The analysis showed a strong association between the prevalence of childhood obesity and the level of EH within communities, with a striking fourfold difference in childhood obesity prevalence between the communities with the highest and lowest levels of EH. We also found that the variance between communities accounted for a large proportion of the variance in childhood obesity, highlighting the importance of addressing community-level factors. However, the proportion varied by racial/ethnic group.

Consistent with previous studies, marked racial/ethnic disparities in obesity prevalence were observed (5,11). Hispanic children had the highest childhood obesity prevalence overall at 26.9%, followed by NH Black students (20.7%). Unique to this study, however, was the finding that the slope of the association between childhood obesity and EH differed by racial/ethnic group. The association between EH and childhood obesity prevalence was most pronounced among NH White students and NH Asians, with lesser impact observed among NH Black students. This finding may reflect unique factors in African–American populations that cross socioeconomic lines, including environmental factors such as cumulative stress from chronic exposure to unsafe neighbourhoods and racial discrimination (29), differential food and beverage marketing across racial/ethnic groups (30), or socio-cultural norms. Culture and beliefs can strongly influence social norms related to diet and physical activity. For example, Black adolescents have been found to be less likely to participate in organized sports and to have greater declines in physical activity with increasing age (31). Additionally, studies have shown that Black adults who are overweight or obese are more likely to consider their weights to be in the healthy or normal range compared to those in other racial/ethnic groups (32). The differential association between economic hardship and obesity prevalence found across racial and ethnic groups, as well as the residual racial/ethnic disparities in obesity prevalence observed across the socioeconomic spectrum and across communities, highlights the additional need for obesity prevention efforts that are tailored to disproportionately impacted populations, particularly Black and Hispanic children.

Several limitations of the current study include the measurement tools. Specifically, the EH index was not developed in relation to health, but it includes important social determinants and provides a more complete overview of neighbourhood socioeconomic conditions than any individual measure. In addition, while the current study used a robust measure of neighbourhood socioeconomic conditions, it did not have data on individual family socioeconomic status, which is likely to be independently related to childhood obesity risk. Also, the study only included students attending public schools and did not have data on where the students live in relation to where they go to school, which could explain a lesser impact of economic hardship on obesity prevalence if students living in poor neighbourhoods attended school in more affluent neighbourhoods. However, the Los Angeles County Unified School District, which accounts for over 40% of students in Los Angeles County, maintains strict boundary lines for assigning students in a given community to a specific public school, which would minimize such impacts (33). Additionally, while the PFTP testing is performed by staff that are trained in administering the testing, including how to measure height and weight, information was not available on who conducted the testing at each school. The testing is most com-

monly done by physical education teachers, but other teachers perform the testing also, and data were not available to assess inter-rater reliability. Finally, although the PFTP is a mandatory program, there is still potential bias from non-participation among students due to absence, medical excuse or disability, which may be more common among overweight, obese or underweight students. However, student participation in fitness testing over the past several years has consistently been well over 90%.

The strengths and novelty of the current study include its scope, both in population size and socioeconomic range, its use of a composite EH index, and the finding that the relationship between childhood obesity and EH differs by racial/ethnic group. In terms of scope, the study population included 93% of all 5th, 7th and 9th grade public school students (nearly 300 000 students) in the most populous county in the nation, and included a spectrum of communities ranging from those experiencing the greatest economic burden to those experiencing the least. Furthermore, because of this wide scope and full socioeconomic range, these results can be extended to other large urban regions with highly diverse racial and ethnic populations.

The current study was strengthened by use of a composite measure of EH, taking into account crowded housing, poverty, unemployment, education, dependency and income, which provided a more complete picture of how community-level social and economic conditions may relate to obesity prevalence than income measures alone. Specifically, factors contributing to economic hardship are varied, and a single indicator cannot sufficiently capture such complexities. Previous studies have used income alone as a metric of economic hardship, which misses potential intervention targets. The six indicators comprising the EH index have each been linked directly or indirectly with childhood obesity; employing a metric that captures the multidimensional characteristics of economic hardship provides an evidence base for broad-spectrum policy recommendations (34). Furthermore, because the EH index is a relative index, results can be compared across communities, emphasizing that neighbourhood conditions matter, and can guide policymakers to target cities/populations with the highest composite EH indices (30).

While the six indicators were not analyzed separately, the composite EH index offers a platform on which to base policy recommendations. Specifically, cities with the highest EH indices should be primary targets for social, environmental and economic change. The Institute of Medicine's latest Childhood Obesity Prevention Policies emphasize five key areas: physical activity and reduced sedentary time, healthful eating, marketing and screen time, sleep, and growth monitoring (35). Once a population is identified, further analyses can be conducted to identify more specific environmental and infrastructure-based policy needs, such as those related to employment, housing, education and parental support.

In conclusion, the current study further emphasizes the need to focus public health efforts on addressing the underlying environmental, social and economic determinants of childhood obesity. Policymakers should prioritize communities facing the highest levels of economic hardship and implement policies that impact social and environmental conditions. Prevention efforts should also focus on tailoring interventions for racial/ethnic groups that are most disproportionately affected. Finally, additional research is needed to examine the relationship between underlying socio-cultural factors, environmental factors and risk of obesity, which may help further inform childhood obesity prevention efforts.

Conflict of interest statement

The study authors declare no conflicts of interest.

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Table S1. Prevalence of childhood obesity and level of economic hardship among 135 cities and communities in Los Angeles County, 2009.