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Understanding drivers of micro-level disparities in childhood body mass index, overweight, and obesity within low-income, minority communities

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A B S T R A C T

The focus of childhood obesity disparities has been mainly on macro-level disparities, such as, between lower versus higher socioeconomic groups. But, less is known about *micro*-level disparities, that is disparities *within* minority and low-income populations. The present study examines individual and family level predictors of micro-level obesity disparities. We analyze data on 497 parent–child dyads living in public housing communities in Watts, Los Angeles. Cross-sectional multivariable linear and logistic regression models were estimated to examine whether individual and family level factors predict children's BMI z-scores, overweight, and obesity in the sample overall and separately by child's gender and age group. Child characteristics of our study sample included mean age 10.9 years, 74.3% Hispanic, 25.7% Non-Hispanic Black, 53.1% female, 47.5% with household income below $10,000, 53.3% with overweight or obesity, and 34.6% with obesity. Parental BMI was the strongest and most consistent predictor of child zBMI, overweight, and obesity, even after controlling for parent's diet and activity behaviors and home environment. The parenting practice of limiting children's screentime was also protective of unhealthy BMI in younger children and females. Home environment, parental diet and activity behaviors, and parenting practices related to food and bedtime routines were not significant predictors. Overall, our findings show that there is considerable heterogeneity in child BMI, overweight, and obesity even within low-income communities with similar socioeconomic and built environments in their neighborhoods. Parental factors play an important role in explaining micro-level disparities and should be an integral part of obesity prevention strategies in low-income minority communities.

1. Introduction

Substantial racial-ethnic and socioeconomic disparities in childhood obesity are well documented. Hispanic and non-Hispanic Black children between ages 2–18 years in the U.S. were 60% and 50% more likely, respectively, to present with obesity compared to non-Hispanic White (hereafter, white) children.(Fryar et al., 2018) Likewise, childhood obesity rate is 1.25 times higher among children in families where the head of household has high school degree or less, relative to children in families where the head of household has at least a college degree. (Ogden et al., Feb 2018).

A large literature has studied the role of social-ecological risk factors at multiple levels ranging from the individual-level (e.g. sex, age) to the family (e.g. socioeconomic status), interpersonal (social environment), neighborhood/school (e.g. school polices and environments, built environment, crime), and societal levels (e.g. state or federal policies) in influencing childhood obesity.(Ohri-Vachaspati et al., Aug 2015) However, disentangling the role of each of these layers is challenging because many of them are correlated. For example, lower socioeconomic status and racial-ethnic minority families tend to live in communities that have fewer resources and opportunities for healthy lifestyles.(Lovasi et al., Nov 2009) Consequently, it is difficult to isolate the independent influence of family level factors from those of neighborhood level contributors. Furthermore, much of this literature has focused on understanding macro-level disparities, i.e. what factors explain differences between minority versus non-minority groups, or between higher versus lower socioeconomic groups. For example, differences in neighborhood food and physical activity environments are often identified as important factors contributing to macro-level disparities in childhood obesity.(Guerrero et al., Mar 2016; Rossen and Talih, Oct 2014) While children in minority and low-income subpopulations have higher obesity risk "on average" than children in white and higher income subpopulations, less is known about *micro*-level disparities, such as disparities *within* minority and low-income subpopulations.(Salvo et al., Oct 2019) In other words, what factors explain why some low-income minority children are more likely to present obesity than others?

The present study provides important insights into this question by examining what individual and family level factors explain variation in childhood body mass index (BMI) and obesity among families that have similar exposure to neighborhood and societal level risk. We study this

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question in an urban public housing community where children and their families live in clustered housing, creating equal spatial access to neighborhood opportunities and amenities. The families are almost all members of racial-ethnic minority groups (Hispanic and non-Hispanic Black) and are socioeconomically similar. This creates the opportunity to examine factors that explain micro-level disparities within this community. Specifically, using data on child-parent dyads, we examine the extent to which family level factors including parent's BMI, parent's lifestyle behaviors (i.e., diet and physical activity), home environment, families' perceived barriers to healthy lifestyles, and parenting practices explain differences in child BMI and obesity within low-income, minority communities.

2. Methods

2.1. Data and sample

We use data from the Watts Neighborhood Health Study,(Datar et al., 2022) a cohort study designed to evaluate the impacts of a public housing redevelopment on obesity and related health behaviors and outcomes of adult and child residents. The study recruited households from three public housing sites in Watts, Los Angeles CA. These included the redevelopment site (Jordan Downs) and two control sites (Nickerson Gardens and Imperial Courts). All households at Jordan Downs and a subsample of households at the control sites were recruited between May 2018 and December 2019 during two waves of data collection. During Wave 1, one adult and all children ages 2 years and older in the household who spoke English or Spanish were eligible to participate in the study. Those recruited in 2018 participated in two waves of baseline data collection (Waves 1 and 2), whereas additional family members from participating households who were recruited after May 2019 participated in only one baseline wave (Wave 2). All adults and children ages 9 years and older were surveyed and measured for height and weight. Children under 9 years were only measured for height and weight. Additional details about recruitment and the larger study's protocol are provided elsewhere.(Datar et al., 2022) The study was approved by the University of Southern California's Institutional Review Board.

A total of 674 children from 328 households participated in the baseline measurement data collection and had BMI data. One child had a BMI z-score of −4.72, which we considered unreliable, and 19 (2.8%) did not have a participating adult from the same household in Wave 1 when data on most family level factors were collected; both groups were excluded from the analysis. Because questions about parenting practices were only asked for parents with a survey-eligible child, 154 (23.5%) children were excluded from the analysis. Three cases had partially missing data and were also excluded, resulting in an analysis sample of 497 child-parent dyads. To understand the difference between our analytic sample and the excluded child sample due to non-response to the parenting questions or partially missing data, we compared the BMI and demographic differences on the child and parent samples using independent sample *t*-test for continuous variables and Pearson chi-square test for categorical variables (Appendix Table A1).

2.2. Outcome measures

Child Body Mass Index, Overweight and Obesity: Trained study staff measured children's height and weight using a standardized protocol. Height was measured using a stadiometer (Charder HM200P Portstad Portable Stadiometer, Charder), rounded to the nearest 0.1 cm. Weight was measured using a Tanita UM-081 digital scale, recorded to the nearest 0.1 kg. Measurements were taken at least twice, and a third measurement was taken if the two differed by a pre-determined amount (>0.5 cm for height, >0.2 kg for weight). The average of the two closest measurements was used as the final measure. BMI was calculated and transformed into age- and sex-specific z-scores (zBMI) according to the U.S. growth charts using the *zanthro* command in STATA. We also constructed indicators for overweight or obesity (zBMI>=1.036) and obesity (zBMI>=1.645), which correspond to the 85th and 95th percentiles on the BMI growth charts for age and sex, respectively.

2.3. Explanatory variables

Child and family sociodemographic characteristics: Child's age in years, race/ethnicity (Hispanic, non-Hispanic Black or African American, Other), and gender (female) were obtained from the child survey or during height and weight measurements, and household income ($9,999 or less, $10,000– $19,999, and $20,000 or more) was obtained from the parent survey. We also included an indicator for whether the family lived in Jordan Downs, to control for unobserved confounders that vary across public housing sites could be correlated with outcomes.

Home environment: Several aspects of the home environment relevant for diet and activity behaviors were assessed via the parent survey. Family mealtimes and eating home cooked meals have been previously shown to be protective of obesity.(Dallacker et al., May 2018; Tumin and Anderson, Jun 2017) To assess frequency of family mealtimes and cooking meals at home from scratch, parents were asked: "In a typical week, on how many days do you eat the evening meal with at least some of your family?" and "In a typical week, on how many evenings does your family have a dinner that was prepared at home from scratch?" We created binary indicator variables for whether these activities took place with high frequency (five or more evenings per week). In addition, the home food environment has also been linked with obesity in the literature.(Shier et al., Jun 2016) To assess the home food environment, parents were asked to rate the following statement on a 5-pt scale ranging from "strongly disagree' to "strongly agree": *Most of the food in my house is healthy*. A response of "strongly disagree" or "disagree" was used to construct an indicator variable for unhealthy food environment. To assess whether the home was conducive for cooking meals and exercising, parents were asked how much they agree or disagree with the following statements: (a) "*my kitchen has the right space and airing to prepare meals for my family*", and (b) "*if I want to, my house has enough space inside to exercise like with a yoga mat, treadmill/stationary bike or jump rope*". A response of "strongly agree" or "agree" was used to construct two indicators for whether the home had adequate space for cooking meals and exercising.

Barriers to healthy lifestyles: Perceived barriers to eating healthy and exercising have been posited in health behaviors models as important influencers of health behaviors.(Glanz et al., 2008) To assess such barriers, parents were provided a list of potential barriers to exercising and eating healthy and were asked how often they were barriers for them (never, rarely, sometimes, often, very often or always). We created two binary indicators for whether safety and lack of opportunities in the neighborhood were important barriers (=1 if it was often, very often or always a barrier for them, and 0 otherwise). We also created similar indicators for whether cost of healthy meals and lack of access to fresh fruits and vegetables were barriers for them.

Parenting practices: Parenting practices related to children's screen-time, bedtime, and junk food intake have been previously shown to be strongly predictive of child obesity.(Anderson and Whitaker, Mar 2010; Appelhans et al., 2014) To assess such practices, parents were asked three Yes/No questions about the limits they have for child activities – (1) "*Do you have any firm limits or agreements with your child about how much screen time is allowed on any devices, such as TV, computer, videogame, or smart phone*?", (2) "*Do you have any rules about bedtime for your child*?", and (3) *Do you have any firm limits or agreements with your child about how many sugary drinks, salty snacks or sweets s/he can eat?*" We created indicator variables (Yes = 1/No = 0) for each of the three parenting practices.

Parent diet and activity behaviors: Parents' diet and activity behaviors can be important for children's weight status because they not only proxy for other unmeasured aspects of the home environment but are

likely to influence children's health behaviors via behavior modeling. (Pearson et al., Feb 2009; Coto et al., 2019) Parent's diet was assessed at baseline via two interviewer-administered 24-hour dietary recalls conducted using the National Cancer Institute's ASA24® tool. The tool guides respondents through multiple steps of recalls including meal-based list, gap review, detailed pass, forgotten foods, and a final review. The recall data was used to create the Healthy Eating Index (HEI) (Krebs-Smith et al., 2018), a measure (0–100) of diet quality to assess how well food intakes aligns with key recommendation so the Dietary guidelines for Americans. The HEI was rescaled to 10 points for ease of interpretation. In sensitivity analysis, we used an alternate measure of parent diet based on a single item measure that asked parents, "In general, how healthy is your diet? Would you say it is Excellent, Very good, Good, Fair, or Poor?". The responses were dichotomized to 1 (good or higher) and 0 (fair or poor). This alternate measure was found to be more predictive of parents' BMI and obesity compared to the HEI. (Liu et al., Jun 2022).

Parent's physical activity was assessed using a short recall of leisure time physical activity. Parents reported days per week and minutes per day of moderate and vigorous activity outside of work for the past week, similar to the National Health and Nutrition Examination Survey. Adults also reported time spent watching TV and playing video games. Time spent per week on these three types of activities were used as separate predictors in the analysis, allowing a more nuanced model specification. In sensitivity analyses, we used an alternate measure of physical activity based on a single item self-report measure of physical activity (days past week of >=20 min of physical activity) that was more predictive of obesity in this sample than the short-recall measure and even accelerometry-based measures.(Liu et al., Jun 2022).

Parent BMI: Finally, we also include parent BMI as an explanatory variable because it captures the influence of genetics, home environment, and behavior modeling, and has been shown to be an important predictor for children's weight status.(Lee et al., 2019; Morello et al., Dec 2012) Parent's height and weight measurements were taken by trained study staff at the same time as the child's measurements using similar protocols. BMI was computed as the ratio of the measured weight [kg] to height [m]-squared.

2.4. Statistical analysis

Multivariable linear and logistic regression models were estimated to predict child's BMI z-score and overweight and obesity outcomes, respectively, using individual and family level predictors including child and family socio-demographic characteristics, home environment, perceived barriers to healthy lifestyles, parenting practices related to screentime, bedtime, and junk food consumption, parent's diet and physical activity behaviors, and parent's BMI. A stepwise build of the full regression model is provided in Appendix Table A2-A4. Following suggestions by Norton and colleagues(Norton et al., Apr 2019), we report marginal difference in probabilities attributable to change in risk factors for the logistic regression estimates (hereafter, marginal effects or ME), instead of odds ratios.

All models were estimated on the full sample and on the subsamples of male, female, children younger than 11 years, and 11 years or older, to examine whether predictors of zBMI overweight and obesity varied by child's gender and age. To account for the potential dependency in outcomes when multiple children lived in the same household, the standard errors were clustered at the household level. We used the 5% level as the threshold for statistical significance. All analyses were conducted using Stata 16 (StataCorp, College Station, TX).

Table 1
Sample descriptive statistics.

Variable	Mean (Std. Dev.) or N (%)	
Outcomes		
Child BMI z-score	0.96	(1.2)
Child Overweight or obese	265	(53.3)
Child Obese	172	(34.6)
Explanatory Variables		
Child's age in years	10.95	(3.9)
Child's Gender		
Male	233	(46.9)
Female	264	(53.1)
Child's race-ethnicity		
Hispanic	369	(74.3)
Non-Hispanic Black or other	128	(25.8)
Annual household income		
Less than $10,000	236	(47.5)
$10,000 - $19,999	144	(29.0)
$20,000 or more	117	(23.5)
Parent's education		
Less than high school	251	(50.5)
High school	163	(32.8)
More than high school	83	(16.7)
Lives in Jordan Downs		
No	154	(31.0)
Yes	343	(69.0)
Unhealthy home food environment		
No	165	(33.2)
Yes	332	(66.8)
Kitchen space adequate for cooking		
No	114	(22.9)
Yes	383	(77.1)
Home has space for indoor exercise		
No	224	(45.1)
Yes	273	(54.9)
Family eats dinner together 5 or more times per week		
No	123	(24.8)
Yes	374	(75.2)
Dinners prepared from scratch 5 or more times per week		
No	125	(25.1)
Yes	372	(74.9)
Barriers to healthy lifestyle		
Cost of food is a barrier		
No	355	(71.4)
Yes	142	(28.6)
Lack of access to fresh fruits/veggies is a barrier		
No	418	(84.1)
Yes	79	(15.9)
Lack of physical activity opportunities is a barrier		
No	311	(62.6)
Yes	186	(37.4)
Neighborhood safety is a barrier		
No	284	(57.1)
Yes	213	(42.9)
Parenting practices		
Screentime limits		
No	156	(31.4)
Yes	341	(68.6)
Bedtime rules		
No	83	(16.7)
Yes	414	(83.3)
Junk food limits		
No	128	(25.7)
Yes	369	(74.3)
Parent diet: HEI score, rescaled by 10	5.19	(1.3)
Parent physical activity: Vigorous (mins/week)	6.64	(14.3)
Parent physical activity: Moderate (mins/week)	18.64	(23.3)
Parent physical activity: Sedentary (mins/week)	22.70	(24.0)
Parent BMI	32.54	(7.6)

Notes: N = 497.

3. Results

Table 1 shows the descriptive statistics of the analysis variables for our sample. The mean age of the sample was 10.95 years (SD = 3.94), 74.3% were Hispanic and 53.1% were females. Just under half (47.5%) of the children lived in a household with annual income of $9,999 or less, and 51% had a parent with less than a high school education. With respect to the outcomes, 53.3% presented with overweight or obese, with 34.6% presenting obesity.

Regression results for child's zBMI, overweight or obesity, and

obesity are reported in Tables 2-4, respectively. Parent's BMI was the strongest and most consistent predictor of all three outcomes in the full sample as well as the subsamples by child's gender and age group. For example, parent BMI was strongly predictive of zBMI in the full sample (b = 0.042, 95% CI: 0.027,0.057, p < 0.01), among boys (b = 0.034, 95% CI: 0.009,0.060, p < 0.01), females (b = 0.047, 95% CI: 0.029,0.065, p < 0.01), children younger than 11 years (b = 0.030, 95% CI: 0.010,0.050, p < 0.01) and in older children (b = 0.048, 95% CI: 0.029,0.067, p < 0.01).

Findings for the other predictors varied by outcome and population subsample. For zBMI, the parenting practice of setting limits on children's screentime was the only significant predictor in the full sample (ME = -0.336, 95% CI: −0.612, 0.060). In the subgroup analyses, screentime limits was a significant predictor in females (ME = -0.426, 95% CI: −0.771,-0.081) but not in males (ME = -0.235, 95% CI: −0.601, 0.130). It was also a significant predictor only in older children (ME = -0.432, 95% CI: −0.768,-0.096), but the association was just slightly smaller in younger children (ME = -0.376, 95% CI: −0.759, 0.008). Other significant predictors were parents' moderate physical activity, which was associated with zBMI in younger children but not older children, although the association was counterintuitive. Finally, having food costs as a barrier to healthy eating was associated with a higher zBMI among older children (ME = 0.434, 95% CI: 0.060, 0.808) but not younger children.

For overweight or obesity as the outcome, setting screentime limits was significantly protective in the full sample (ME = -0.134, 95% CI:

Table 2
Child and Family Level Predictors of Child zBMI.

	All	Males	Females	Ages 2–10 yrs	Ages 11–17 yrs
Explanatory Variables	b (95% CI)	b (95% CI)	b (95% CI)	b (95% CI)	b (95% CI)
Parent BMI	0.042***	0.034***	0.047***	0.030***	0.048***
	(0.027–0.057)	(0.009–0.060)	(0.029–0.065)	(0.010–0.050)	(0.029–0.067)
Parent diet: HEI score	−0.021	0.064	−0.097	−0.030	0.010
	(−0.115–0.073)	(−0.073–0.201)	(−0.216–0.021)	(−0.157–0.097)	(−0.097–0.116)
Parent PA: vigorous (mins/week)	−0.003	−0.007	−0.001	−0.004	−0.001
	(−0.012–0.007)	(−0.022–0.009)	(−0.010–0.008)	(−0.016–0.009)	(−0.012–0.010)
Parent PA: moderate (mins/week)	0.004*	0.008*	0.001	0.008**	0.002
	(−0.000–0.009)	(−0.000–0.015)	(−0.004–0.007)	(0.001–0.014)	(−0.003–0.008)
Parent PA: sedentary (mins/week)	−0.001	−0.003	0.000	0.002	−0.004
	(−0.006–0.004)	(−0.010–0.005)	(−0.005–0.006)	(−0.004–0.009)	(−0.010–0.002)
Parenting practice: Screentime limits	−0.336**	−0.235	−0.426**	−0.376*	−0.432**
	(−0.612 - −0.060)	(−0.601–0.130)	(−0.771 - −0.081)	(−0.759–0.008)	(−0.768 - −0.096)
Parenting practice: Bedtime rules	0.225	0.299	0.207	0.050	0.355
	(−0.140–0.590)	(−0.227–0.825)	(−0.273–0.687)	(−0.454–0.554)	(−0.114–0.824)
Parenting practice: Junk food limits	0.186	0.107	0.283	0.228	0.110
	(−0.137–0.509)	(−0.335–0.549)	(−0.109–0.674)	(−0.166–0.622)	(−0.323–0.543)
Unhealthy home food environment	0.094	−0.175	0.278	0.183	0.056
	(−0.195–0.382)	(−0.560–0.209)	(−0.073–0.629)	(−0.169–0.535)	(−0.302–0.414)
Kitchen space adequate for cooking	−0.009	0.021	−0.125	0.014	0.090
	(−0.303–0.284)	(−0.370–0.413)	(−0.488–0.237)	(−0.320–0.349)	(−0.321–0.502)
Home has space for indoor exercise	0.047	0.077	−0.003	0.046	0.111
	(−0.217–0.312)	(−0.265–0.419)	(−0.337–0.332)	(−0.317–0.409)	(−0.214–0.435)
Cost of food is a barrier	0.158	0.014	0.321*	−0.230	0.434**
	(−0.152–0.468)	(−0.498–0.526)	(−0.011–0.654)	(−0.648–0.189)	(0.060–0.808)
Lack of access to fresh fruits/veggies is a barrier	0.056	0.207	0.003	0.293	−0.044
	(−0.351–0.464)	(−0.231–0.646)	(−0.582–0.588)	(−0.148–0.733)	(−0.596–0.508)
Lack of opportunities for PA is a barrier	−0.163	−0.094	−0.177	−0.253	−0.109
	(−0.459–0.133)	(−0.513–0.324)	(−0.542–0.187)	(−0.665–0.159)	(−0.471–0.253)
Concern about neighborhood safety is a barrier	0.096	0.156	0.002	0.342*	−0.100
	(−0.165–0.356)	(−0.237–0.548)	(−0.320–0.325)	(−0.024–0.708)	(−0.445–0.245)
Family dinners ≥ 5 nights/week	−0.043	0.045	−0.180	−0.181	0.024
	(−0.311–0.225)	(−0.281–0.371)	(−0.550–0.191)	(−0.625–0.264)	(−0.325–0.373)
Dinners made from scratch ≥ 5 nights/week	−0.021	−0.046	0.044	−0.153	0.115
	(−0.312–0.270)	(−0.418–0.327)	(−0.326–0.415)	(−0.564–0.259)	(−0.273–0.503)
Child's ethnicity is Hispanic	0.101	0.179	0.092	0.325*	−0.010
	(−0.151–0.352)	(−0.220–0.578)	(−0.245–0.429)	(−0.037–0.688)	(−0.349–0.329)
Child's age in years	−0.002	0.012	−0.013	−0.001	−0.067**
	(−0.032–0.029)	(−0.034–0.058)	(−0.053–0.028)	(−0.074–0.073)	(−0.132 - −0.001)
Child is female	0.118			0.261*	0.048
	(−0.085–0.321)			(−0.041–0.562)	(−0.227–0.322)
Household income $10,000 - $19,999	−0.108	−0.261	0.110	−0.001	−0.193
	(−0.397–0.181)	(−0.644–0.123)	(−0.259–0.479)	(−0.394–0.391)	(−0.552–0.165)
Household income ≥$20,000	0.044	0.090	0.009	0.339*	−0.259
	(−0.273–0.361)	(−0.400–0.581)	(−0.365–0.383)	(−0.052–0.730)	(−0.667–0.149)
Parent education: high school only	−0.079	−0.276	0.086	−0.245	0.025
	(−0.352–0.194)	(−0.671–0.120)	(−0.269–0.442)	(−0.610–0.120)	(−0.322–0.373)
Parent education: more than high school	−0.129	−0.341	0.013	−0.016	−0.161
	(−0.483–0.226)	(−0.878–0.197)	(−0.386–0.412)	(−0.522–0.490)	(−0.567–0.245)
Family lives in Jordan downs	−0.205*	−0.303	−0.122	−0.124	−0.229
	(−0.448–0.039)	(−0.676–0.069)	(−0.428–0.183)	(−0.466–0.219)	(−0.561–0.103)
Constant	−0.405	−0.588	−0.099	−0.225	0.318
	(−1.229–0.419)	(−1.800–0.623)	(−1.178–0.980)	(−1.528–1.078)	(−1.170–1.807)
Observations	497	233	264	219	278
R-squared	0.139	0.164	0.182	0.177	0.226

Notes: Estimates are from multivariable linear regression models where standard errors are clustered at the household level. Abbreviations: PA = Physical Activity; HEI = Healthy Eating Index. *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 3
Child and Family Level Predictors of Child Overweight or Obesity.

	All	Males	Females	Ages 2–10 yrs	Ages 11–17 yrs
Explanatory Variables	ME (95% CI)	ME (95% CI)	ME (95% CI)	ME (95% CI)	ME (95% CI)
Parent BMI	0.013***	0.014***	0.012***	0.010***	0.015***
	(0.007–0.019)	(0.004–0.023)	(0.004–0.020)	(0.003–0.018)	(0.007–0.023)
Parent diet: HEI score	−0.005	0.028	−0.042	−0.005	0.002
	(−0.046–0.036)	(−0.029–0.086)	(−0.096–0.012)	(−0.061–0.052)	(−0.047–0.051)
Parent PA: vigorous (mins/week)	−0.001	−0.000	−0.002	−0.001	−0.001
	(−0.005–0.002)	(−0.005–0.005)	(−0.006–0.001)	(−0.006–0.003)	(−0.005–0.003)
Parent PA: moderate (mins/week)	0.001	0.003*	−0.000	0.003	0.000
	(−0.001–0.003)	(−0.000–0.005)	(−0.003–0.003)	(−0.001–0.006)	(−0.002–0.002)
Parent PA: sedentary (mins/week)	−0.000	0.001	−0.000	0.001	−0.001
	(−0.002–0.002)	(−0.002–0.004)	(−0.003–0.002)	(−0.002–0.004)	(−0.003–0.002)
Parenting practice: Screentime limits	−0.134**	−0.118	−0.156**	−0.179***	−0.139**
	(−0.240 - −0.028)	(−0.271–0.036)	(−0.297 - −0.014)	(−0.316 - −0.043)	(−0.273 - −0.004)
Parenting practice: Bedtime rules	0.072	0.114	0.033	−0.031	0.126
	(−0.074–0.218)	(−0.085–0.312)	(−0.156–0.221)	(−0.223–0.161)	(−0.052–0.305)
Parenting practice: Junk food limits	0.042	0.045	0.046	0.078	0.004
	(−0.088–0.172)	(−0.132–0.223)	(−0.111–0.202)	(−0.084–0.241)	(−0.165–0.173)
Unhealthy home food environment	0.058	0.005	0.104	0.090	0.044
	(−0.057–0.173)	(−0.161–0.172)	(−0.038–0.245)	(−0.065–0.246)	(−0.101–0.189)
Kitchen space adequate for cooking	−0.053	−0.051	−0.090	−0.063	−0.024
	(−0.160–0.054)	(−0.213–0.111)	(−0.238–0.058)	(−0.222–0.096)	(−0.177–0.128)
Home has space for indoor exercise	0.073	0.071	0.082	0.067	0.105
	(−0.039–0.184)	(−0.078–0.220)	(−0.063–0.227)	(−0.081–0.215)	(−0.027–0.238)
Cost of food is a barrier	0.086	0.021	0.160**	−0.059	0.186**
	(−0.034–0.206)	(−0.175–0.217)	(0.021–0.299)	(−0.214–0.096)	(0.039–0.334)
Lack of access to fresh fruits/veggies is a barrier	0.021	−0.039	0.089	0.017	0.045
	(−0.116–0.157)	(−0.215–0.138)	(−0.107–0.285)	(−0.162–0.197)	(−0.120–0.210)
Lack of opportunities for PA is a barrier	−0.083	−0.014	−0.121	−0.068	−0.076
	(−0.206–0.040)	(−0.193–0.165)	(−0.278–0.036)	(−0.240–0.104)	(−0.226–0.075)
Concern about neighborhood safety is a barrier	0.056	0.061	0.033	0.130*	−0.002
	(−0.052–0.164)	(−0.089–0.211)	(−0.114–0.180)	(−0.020–0.280)	(−0.141–0.136)
Family dinners ≥ 5 nights/week	−0.032	−0.043	−0.027	−0.100	−0.003
	(−0.145–0.080)	(−0.187–0.101)	(−0.181–0.127)	(−0.266–0.066)	(−0.148–0.143)
Dinners made from scratch ≥ 5 nights/week	0.004	−0.013	−0.002	−0.030	0.057
	(−0.119–0.126)	(−0.177–0.152)	(−0.168–0.164)	(−0.191–0.131)	(−0.095–0.208)
Child's ethnicity is Hispanic	0.048	0.066	0.036	0.148**	0.001
	(−0.059–0.155)	(−0.097–0.230)	(−0.109–0.180)	(0.002–0.294)	(−0.159–0.160)
Child's age in years	0.003	0.009	−0.002	0.017	−0.018
	(−0.008–0.015)	(−0.006–0.024)	(−0.017–0.014)	(−0.012–0.046)	(−0.045–0.008)
Child is female	0.046			0.103	0.010
	(−0.041–0.132)			(−0.027–0.232)	(−0.099–0.118)
Household income $10,000 - $19,999	−0.083	−0.160**	0.011	−0.120	−0.065
	(−0.200–0.034)	(−0.311 - −0.009)	(−0.138–0.160)	(−0.282–0.043)	(−0.206–0.075)
Household income ≥$20,000	0.013	0.040	−0.021	0.098	−0.092
	(−0.112–0.137)	(−0.140–0.220)	(−0.185–0.143)	(−0.058–0.254)	(−0.264–0.080)
Parent education: high school only	−0.027	−0.039	−0.020	−0.046	−0.015
	(−0.135–0.082)	(−0.190–0.112)	(−0.169–0.128)	(−0.184–0.091)	(−0.159–0.130)
Parent education: more than high school	−0.071	−0.143	−0.037	−0.030	−0.074
	(−0.233–0.091)	(−0.363–0.078)	(−0.233–0.160)	(−0.249–0.189)	(−0.266–0.117)
Family lives in Jordan downs	−0.061	−0.113	0.013	−0.094	−0.024
	(−0.162–0.041)	(−0.254–0.028)	(−0.123–0.150)	(−0.235–0.048)	(−0.162–0.114)
Observations	497	233	264	219	278

Notes: Estimates are marginal effects from multivariable logistic regression models where standard errors are clustered at the household level. Abbreviations: ME: Marginal Effects; PA = Physical Activity; HEI = Healthy Eating Index. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

−0.240,-0.028) with no other predictors having a significant association. In the subgroup analyses, setting screentime limits was a significant predictor among females (ME = -0.156, 95% CI: −0.297,-0.014), young children (ME = -0.179, 95% CI: −0.316,-0.043) and older children (ME = -0.139, 95% CI: −0.273,-0.004), but not among boys (ME = -0.118, 95% CI: −0.271,0.036). Having food cost as a barrier to healthy eating was a significant predictor for both female (ME = 0.160, 95% CI: 0.021, 0.299) and older children (ME = 0.186, 95% CI: 0.039, 0.334) but not in male or younger children.

For obesity, the predictors were fewer and less strongly predictive. None of the predictors were significant in the full sample. In the subgroup analyses, setting screentime limits was only protective among younger children (ME = -0.195, 95% CI: −0.353,-0.037) but was not significant for the remaining subgroups.

Sensitivity analyses using alternate measures of parents' diet and activity behaviors yielded similar results and are reported in Appendix Table A5-A7.

4. Discussion

This study examined what individual and family level factors explained variation in childhood zBMI, overweight, and obesity among children living in an urban public housing community. By focusing on public housing communities our study was, in effect, able to control for access to neighborhood opportunities and amenities since public housing resident live in clustered housing and as a result have similar exposure to neighborhood environments. Our sample is almost entirely minority (Hispanic and non-Hispanic Black) and low-income, yet there is considerable variation in child zBMI, overweight, and obesity prevalence, which suggests there are other factors beyond neighborhood environments that may explain this variability even *within* this at-risk population. Using data on child-parent dyads, we examined the extent to

Table 4
Child and Family Level Predictors of Child Obesity.

	All	Male	Female	Ages 2–10 yrs	Ages 11–17 yrs
Explanatory Variables	ME (95% CI)	ME (95% CI)	ME (95% CI)	ME (95% CI)	ME (95% CI)
Parent BMI	0.013***	0.011**	0.014***	0.012***	0.014***
	(0.008–0.018)	(0.003–0.019)	(0.007–0.020)	(0.006–0.019)	(0.006–0.021)
Parent diet: HEI score	0.004	0.017	−0.006	−0.007	0.015
	(−0.035–0.042)	(−0.039–0.073)	(−0.055–0.043)	(−0.055–0.042)	(−0.037–0.068)
Parent PA: vigorous (mins/week)	−0.000	0.001	−0.001	0.001	−0.001
	(−0.003–0.002)	(−0.003–0.005)	(−0.004–0.003)	(−0.002–0.005)	(−0.005–0.003)
Parent PA: moderate (mins/week)	0.001	0.003**	0.000	0.003**	0.001
	(−0.000–0.003)	(0.000–0.005)	(−0.002–0.003)	(0.000–0.005)	(−0.002–0.003)
Parent PA: sedentary (mins/week)	−0.001	−0.001	−0.002	−0.001	−0.002
	(−0.003–0.000)	(−0.004–0.002)	(−0.004–0.001)	(−0.004–0.001)	(−0.004–0.001)
Parenting practice: Screentime limits	−0.078	−0.068	−0.080	−0.195**	−0.056
	(−0.183–0.027)	(−0.217–0.081)	(−0.211–0.051)	(−0.353 - −0.037)	(−0.192–0.080)
Parenting practice: Bedtime rules	0.050	0.035	0.058	0.078	0.030
	(−0.074–0.175)	(−0.195–0.264)	(−0.113–0.230)	(−0.106–0.263)	(−0.145–0.204)
Parenting practice: Junk food limits	0.020	0.080	−0.008	−0.011	0.025
	(−0.097–0.137)	(−0.118–0.277)	(−0.149–0.134)	(−0.169–0.146)	(−0.149–0.198)
Unhealthy home food environment	0.057	0.003	0.083	0.123	0.016
	(−0.045–0.159)	(−0.148–0.154)	(−0.052–0.219)	(−0.026–0.271)	(−0.119–0.152)
Kitchen space adequate for cooking	−0.022	−0.014	−0.062	−0.053	0.030
	(−0.131–0.087)	(−0.166–0.138)	(−0.206–0.083)	(−0.194–0.089)	(−0.132–0.191)
Home has space for indoor exercise	0.017	−0.002	0.035	0.005	0.029
	(−0.081–0.114)	(−0.142–0.139)	(−0.097–0.168)	(−0.126–0.136)	(−0.108–0.167)
Cost of food is a barrier	0.062	0.067	0.091	−0.047	0.137*
	(−0.054–0.177)	(−0.115–0.249)	(−0.036–0.218)	(−0.191–0.097)	(−0.018–0.291)
Lack of access to fresh fruits/veggies is a barrier	0.050	0.006	0.112	0.034	0.063
	(−0.079–0.179)	(−0.172–0.184)	(−0.048–0.272)	(−0.138–0.206)	(−0.122–0.247)
Lack of opportunities for PA is a barrier	−0.039	−0.037	−0.028	−0.021	−0.029
	(−0.146–0.068)	(−0.188–0.113)	(−0.175–0.118)	(−0.160–0.117)	(−0.175–0.117)
Concern about neighborhood safety is a barrier	0.048	0.048	0.010	0.130*	−0.022
	(−0.053–0.149)	(−0.091–0.187)	(−0.122–0.143)	(−0.001–0.262)	(−0.162–0.118)
Family dinners ≥ 5 nights/week	0.008	0.021	−0.017	0.026	0.000
	(−0.105–0.120)	(−0.120–0.162)	(−0.169–0.134)	(−0.161–0.213)	(−0.145–0.146)
Dinners made from scratch ≥ 5 nights/week	−0.043	−0.083	−0.009	−0.008	−0.052
	(−0.157–0.070)	(−0.231–0.065)	(−0.159–0.141)	(−0.161–0.144)	(−0.204–0.101)
Child's ethnicity is Hispanic	0.047	0.200***	−0.052	0.186***	−0.035
	(−0.049–0.143)	(0.048–0.352)	(−0.176–0.072)	(0.048–0.324)	(−0.183–0.113)
Child's age in years	0.005	0.006	0.005	0.015	−0.016
	(−0.006–0.015)	(−0.009–0.021)	(−0.010–0.020)	(−0.012–0.041)	(−0.043–0.010)
Child is female	0.020			0.058	0.002
	(−0.063–0.102)			(−0.061–0.178)	(−0.103–0.107)
Household income $10,000 - $19,999	−0.049	−0.081	0.002	−0.010	−0.076
	(−0.156–0.058)	(−0.233–0.071)	(−0.133–0.138)	(−0.157–0.137)	(−0.219–0.068)
Household income ≥$20,000	0.066	0.053	0.067	0.131*	0.013
	(−0.057–0.189)	(−0.111–0.217)	(−0.094–0.228)	(−0.017–0.278)	(−0.170–0.196)
Parent education: high school only	−0.055	−0.087	−0.042	−0.042	−0.060
	(−0.161–0.051)	(−0.237–0.063)	(−0.176–0.092)	(−0.182–0.098)	(−0.204–0.085)
Parent education: more than high school	−0.098*	−0.093	−0.128	0.011	−0.163**
	(−0.212–0.016)	(−0.294–0.107)	(−0.289–0.032)	(−0.178–0.201)	(−0.321 - −0.005)
Family lives in Jordan downs	−0.048	−0.089	−0.008	−0.076	−0.016
	(−0.145–0.050)	(−0.233–0.054)	(−0.136–0.121)	(−0.216–0.063)	(−0.164–0.131)
Observations	497	233	264	219	278

Notes: Estimates are marginal effects from multivariable logistic regression models where standard errors are clustered at the household level. Abbreviations: ME: Marginal Effects; PA = Physical Activity; HEI = Healthy Eating Index. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

which family level factors including parent's BMI, parent's lifestyle behaviors, home environment, families' perceived barriers to healthy lifestyles, and parenting practices explained differences in child zBMI, overweight, and obesity in this community.

Our study points to some important predictors of micro-level disparities in child BMI, overweight, and obesity. First, parental BMI was the strongest and most consistent predictor of zBMI, overweight, and obesity, suggesting strong intergenerational transmission in unhealthy weight. Parental BMI has been shown to be an important predictor of child obesity in prior studies.(Lee et al., 2019; Morello et al., Dec 2012) This correlation was observed even after controlling for parent's diet and activity behaviors and home environment, although these measures were based on self-reports. Another possibility is that genetics may play a role in this intergenerational transmission. While we did not assess this directly in our study, a growing body of research finds that BMI is highly heritable(Elks et al., 2012) Second, the parenting practice of limiting children's screentime was protective of higher zBMI, overweight, and obesity in some children, particularly younger children and girls. Children's overall screentime(Fang et al., Sep 2019) and parental monitoring of children's screentime (Anderson and Whitaker, Mar 2010; Haines et al., 2013; Tiberio et al., May 2014) have been linked with child overweight and obesity in different populations. Most recently, Appelhans et al(Appelhans et al., 2014) compared the home environment of normal weight and overweight or obese children in low-income families and found that parental monitoring of children's screentime was an important explanatory factor. Parental monitoring of children's screentime typically reduces with children's age(Nikken et al., Sep 2007), which may explain why we observe a protective effect of limiting screentime on obesity among young children but not in children older than 11 years. Regarding gender differences in the protective effect of screentime limits, we are not aware of any existing studies on this question. We speculate that these differences could be due to multiple

factors. Prior research suggests that boys tend to have higher screentime than girls,(Nagata et al., 2022) potentially making screentime limits less effective in boys. Another possibility is that there may be cultural reasons for gender-differentiated parenting(Updegraff et al., 2014) that might lead to differential enforcement of, or compliance with, screentime limits in boys versus girls. A third possible explanation may be that reduced screentime may be replaced by different activities for boys versus girls, such as sleep duration,(Franco et al., 2020) which is independently protective of obesity.(Mitchell et al., May 2013) Third, food costs being a barrier to healthy eating was another important predictor of higher zBMI and overweight or obesity in older children, suggesting that adolescents' diets may be more sensitive to food costs compared to younger children who are more likely to be eligible for nutrition support programs (e.g. WIC).

The lack of any significant predictive power in measures of home environment, parental diet and activity behaviors, and other parenting practices related to food and bedtime routines, is somewhat surprising given their theoretical importance and empirical support in the prior literature. One potential explanation is that these factors might be better predictors of child obesity when studying macro-disparities, i.e. *across* socioeconomic groups or *between* white and non-white racial-ethnic groups. But, given our focus on micro-level disparities and the relative homogeneity in socioeconomic background and neighborhood environments, perhaps the limited role for these factors is to be expected. Another possible reason may be that these factors have similar effects on parents and children, and by controlling for the parent's BMI, they no longer show distinct predictive utility on the child's BMI or obesity status.

Our study findings should be interpreted in light of limitations, which include a cross-sectional design that does not allow for causal inference and potential lack of generalizability to other contexts outside public housing communities in Watts. Self-reported data on several predictor variables is also a limitation because of the possibility of systematic reporting bias.

Overall, our results show that there is considerable heterogeneity in child BMI, overweight, and obesity even within low-income communities with similar socioeconomic and built environments in their neighborhoods. Moreover, parental factors play an important role in explaining micro-level disparities. The public health implications of these findings are that parents should be an integral part of strategies for obesity prevention in low-income communities. In future work, we will examine what factors explain micro-disparities in parents' BMI and obesity, and whether predictors of these disparities among children and parents evolve as families are differentially impacted by redevelopment-induced changes in the housing and built environments.

CRediT authorship contribution statement

Ashlesha Datar: Conceptualization, Methodology, Formal analysis, Writing – original draft, Funding acquisition. **Victoria Shier:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **Ying Liu:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

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