Journal of Developmental Origins of Health and Disease (2012), **3**(6), 433–441.

doi:10.1017/S2040174412000384

ORIGINAL ARTICLE

Maternal experiences of racial discrimination and child weight status in the first 3 years of life

B. Dixon[1], S. L. Rifas-Shiman[1], T. James-Todd[2], K. Ertel[3], N. Krieger[3], K. P. Kleinman[1], J. W. Rich-Edwards[2], M. W. Gillman[1,4] and E. M. Taveras[1,5]*

[1]*Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, MA, USA*
[2]*Connors Center for Women's Health and Gender Biology, Brigham and Women's Hospital, Boston, MA, USA*
[3]*Department of Society, Human Development, and Health, Harvard School of Public Health, Boston, MA, USA*
[4]*Department of Nutrition, Harvard School of Public Health, Boston, MA, USA*
[5]*Division of General Pediatrics, Children's Hospital Boston, Boston, MA, USA*

Among US racial/ethnic minority women, we examined associations between maternal experiences of racial discrimination and child growth in the first 3 years of life. We analyzed data from Project Viva, a pre-birth cohort study. We restricted analyses to 539 mother–infant pairs; 294 were Black, 127 Hispanic, 110 Asian and 8 from additional racial/ethnic groups. During pregnancy, mothers completed the Experiences of Discrimination survey that measured lifetime experiences of racial discrimination in diverse domains. We categorized responses as 0, 1–2 or ⩾3 domains. Main outcomes were birth weight for gestational age *z*-score; weight for age (WFA) *z*-score at 6 months of age; and at 3 years of age, body mass index (BMI) *z*-score. In multivariable analyses, we adjusted for maternal race/ethnicity, nativity, education, age, pre-pregnancy BMI, household income and child sex and age. Among this cohort of mostly (58.2%) US-born and economically non-impoverished mothers, 33% reported 0 domains of discrimination, 33% reported discrimination in 1–2 domains and 35% reported discrimination in ⩾3 domains. Compared with children whose mothers reported no discrimination, those whose mothers reported ⩾3 domains had lower birth weight for gestational age *z*-score (β −0.25; 95% CI: −0.45, −0.04), lower 6 month WFA *z*-score (β −0.34; 95% CI: −0.65, −0.03) and lower 3-year BMI *z*-score (β −0.33; 95% CI: −0.66, 0.00). In conclusion, we found that among this cohort of US racial/ethnic minority women, mothers' report of experiencing lifetime discrimination in ⩾ 3 domains was associated with lower fetal growth, weight at 6 months and 3-year BMI among their offspring.

Received 23 September 2011; Revised 8 May 2012; Accepted 14 May 2012; First published online 7 June 2012

Keywords: child growth, discrimination, infancy, racism

Introduction

As early as 3 years of age, children manifest cardio-metabolic profiles that are linked to heart disease later in life.[1] Weight, adiposity and rate of change in these anthropometric parameters, beginning *in utero* and continuing through early childhood, are associated with such adverse cardio-metabolic outcomes, including hypertension, hyperinsulinemia and insulin resistance, in later childhood and adulthood.[2–4] Prenatal determinants, including maternal smoking, gestational weight gain and gestational diabetes are associated with child growth and adiposity, which, in turn, may affect chronic disease risk.[5–7]

Substantial racial/ethnic disparities exist in adverse cardio-metabolic outcomes.[2] We recently reported racial and ethnic differences in early life risk factors for childhood adiposity, suggesting that contributors to disparities in cardio-metabolic outcomes may emerge as early as the prenatal period.[8] These findings are consistent with the postulated cycle of health inequalities by Gravlee,[9] in which maternal health directly affects fetal health, which subsequently affects the health of the offspring during infancy and childhood.

To explain observed racial/ethnic disparities in cardio-metabolic outcomes, one set of hypotheses posits that maternal psychosocial and societal stressors in the prenatal period, prevalent in racial/ethnic minority populations, may lead to maternal inflammatory, vascular or neuroendocrine processes that could influence child growth and adiposity.[10–14] Alternatively, maternal behavioral or coping responses in the face of chronic stress, could also influence child growth.[15] Also, acute or chronic stress could lead to unhealthy maternal emotion regulation and insecure attachment with their children, which can increase risk for childhood obesity.[16] Maternal lifetime experience of racial discrimination is one example of a chronic stressor that may have adverse effects on child outcomes. For example, some[17,18] but not all studies[19,20] have found that racial discrimination experienced by mothers *during pregnancy* is associated with preterm and/or low birth weight deliveries. Although studies in adults have shown that experience of racial discrimination is associated with hypertension and several other adverse adult cardio-metabolic outcomes,[21] no existing studies

*Address for correspondence: Dr E. M. Taveras, Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, 133 Brookline Avenue, 6th floor, Boston, MA 02215, USA. (Email elsie_taveras@harvardpilgrim.org)

have examined associations of maternal experiences of racism with child growth outcomes beyond birth. In addition, most but not all[22,23] existing studies of racial discrimination and birth outcomes are limited to racial discrimination during pregnancy rather than lifetime experience.

The purpose of this study was to examine associations of maternal lifetime experiences of racial discrimination with child growth and adiposity-related outcomes in the first 3 years of life in a prospective pre-birth cohort study.

Methods

Subjects/study design

The subjects for this study were participants in Project Viva, a prospective cohort study of gestational factors, pregnancy outcomes and offspring health.[24] Between April 1999 and July 2002 we recruited women who were attending their initial prenatal visit at eight obstetrical offices of a multi-specialty group practice in eastern Massachusetts. Further details of recruitment and retention procedures are available elsewhere.[24]

Of the 2128 women who delivered a live infant, 2104 self-identified their race/ethnicity. Of the 704 racial/ethnic minority women, 539 had non-missing data on self-reported, lifetime experiences of racism: 294 were Black, 127 Hispanic, 110 Asian and 8 were of other race/ethnicities. These 539 women and their infants constituted the analytic dataset. Project Viva included singleton pregnancies only. Socioeconomic position of these 539 participants was slightly higher than the 165 participants of color excluded from this analysis, for example 64.6% *v.* 55.7% had annual household incomes of ⩾$40,000/year, 48.6% *v.* 30.1% were college graduates and 58.2% *v.* 50.6% were US born. Of the 539 participants included in the analysis cohort, we measured body mass index (BMI) among 299 children aged 3 years.

After obtaining informed consent, we performed in-person study visits with the mother at the end of the first and second trimesters of pregnancy, and with the mother and child in the first few days after delivery and at 6 months and 3 years after birth. Human subjects committees of Harvard Pilgrim Health Care, Brigham and Women's Hospital and Beth Israel Deaconess Medical Center approved the study protocols.

Measurements

Main exposure

In Project Viva's Early Pregnancy Questionnaire, mothers self-reported racism experiences using an adapted and expanded version of the validated 'Experiences of Discrimination' (EOD) measure developed by Krieger[25] and Krieger *et al.*[26] Participants completing the EOD measure responded to the prompt 'I have experienced unfair or bad treatment because of my race or ethnicity.' Responses included yes or no answers in each of eight different situational domains during their lifetimes: at school, getting hired or getting a job, at work, getting housing, getting medical care, getting service in a store or restaurant, on the street or in a public setting and from the police or in the courts. We summed 'yes' responses to produce a personal racism exposure score (range 0–8). We categorized responses as 0, 1–2 or 3 or more self-reported domains of lifetime experiences of racism to account for potential non-linear associations.[26] The assumption was made that the total number of settings in which women reported racial discrimination was an indicator of their overall exposure to racial discrimination. The survey further assessed the time period of when the women experienced the discrimination (before the age of 18 years, from the age of 18 years until pregnancy and during pregnancy). However, we did not include those additional measures in this study.

Outcome measures

At each in-person visit, we measured child length or height using a length board or calibrated stadiometer, and weight using an electronic scale; at 3 years, we also measured subscapular (SS) and triceps skinfold thicknesses (TR). Outcome at birth was birth weight for gestational age *z*-score ('fetal growth'),[27] determined using US national reference data.[27] Outcome at 6 months was age- and sex-specific weight for age (WFA) *z*-score. Outcomes at 3 years included age- and sex-specific BMI *z*-score,[28] and the sum (SS + TR – overall adiposity) and ratio (SS : TR – central adiposity) of SS and TR. Research assistants performing all measurements followed standardized techniques.[29]

Study covariates

Using a combination of self-administered questionnaires and interviews, we collected information about maternal age, education, parity, household income and nativity (US born, moved to the United States before the age of 17 years, moved to the United States after the age of 17 years). Research assistants asked mothers the question, 'Which of the following best describes your race or ethnicity?' Mothers had a choice of one or more of the following racial/ethnic groups: Hispanic or Latina, white or Caucasian, black or African American, Asian or Pacific Islander, American Indian or Alaskan Native and other (please specify). For the participants who chose 'other' race/ethnicity, we compared the specified responses to the US census definitions[30] for the other five race and ethnicities and reclassified them where appropriate. If a participant chose more than one racial/ethnic group, we used a hierarchy: black, Hispanic, Asian, American Indian, other, white. Mothers reported their pre-pregnancy weight and height from which we calculated their pre-pregnancy BMI. We categorized gestational weight gain as inadequate, adequate or excessive for pre-pregnancy BMI categories using the 2009 Institute of Medicine guidelines.[31] We assessed maternal depressive symptoms with the Edinburgh Postnatal Depression Scale in mid-pregnancy and at 6 months after birth.[32] Finally, we assessed smoking at mid-pregnancy and categorized responses as former, never or current smoker.

Statistical analysis

Our main exposure of interest was self-reported domains of lifetime experiences of racism categorized as 0, 1–2 or 3 or more domains. We first examined the bivariate associations between racism score categories with other covariates and our main outcomes. We then used multiple linear regression models to assess the independent associations between racism and our main outcomes.

In multivariate models, we included only those covariates that were of *a priori* interest or confounded associations of racism with child adiposity. Model 1 was adjusted for maternal age and race/ethnicity, and child sex and age at outcome. Model 2 was also adjusted for maternal nativity, education and pre-pregnancy BMI; household income; and (for WFA *z*-score at 6 months) birth weight for gestational age *z*-score. In addition, because we were interested in fat distribution after controlling for overall body size, we further adjusted all SS : TR models for child's BMI *z*-score. As adjustment for parity, gestational weight gain, maternal smoking, antenatal or postpartum depression did not materially affect the associations between racism and child growth and adiposity outcomes, we did not include them in our final models. We report regression estimates (β) and 95% confidence intervals for the main predictor. Because racial discrimination may vary by racial/ethnic group, we performed analyses separately by mothers' self-identified racial and ethnic groups and included cross-product interaction terms to test for multiplicative interaction. We present results for each racial/ethnic group separately and combined. We conducted all analyses using SAS, version 9.2 (Cary, North Carolina, USA).

In secondary analyses, we used Imputation and Variance Estimation (IVEware) software to examine potential bias due to missing data on self-reported domains of racism ($n = 165$).[33] We imputed 20 values for each missing observation to create 20 'completed' datasets. After imputation, we combined multivariable modeling estimates using Proc MI ANALYZE in SAS version 9.2.[34]

Results

Table 1 shows that ~33% (176 of 539) of participants reported 0 domains of lifetime experiences of racial discrimination, 33% (176 of 539) reported 1–2 domains of experiences and 35% (187 of 539) reported 3 or more domains of experiences (Table 1). Black participants reported more domains of racial discrimination than participants from other racial/ethnic groups. Participants most frequently reported experiences of racial discrimination when getting service at a store or restaurant, on the street or in public settings and at school or work (Table 1).

Compared with mothers who reported no EOD, mothers who reported 1–2 or 3 or more domains of experiences of racial discrimination showed some differences in sociodemographic and other characteristics. Participants born in the United States reported more EOD than participants who moved to the United States later in life (Table 2). Higher maternal pre-pregnancy BMI was associated with more experiences of racial discrimination. Maternal education and income had U-shaped associations with reported experiences of racism: mothers with higher educational attainment or income were more likely to report 0 and to report ⩾3 lifetime domains of discrimination than women with lower education or income (Table 2).

Bivariate relations of reported racial discrimination and anthropometric outcomes of the children are presented in Table 3. In these unadjusted analyses, we observed a trend in lower birth weight for gestational age *z*-score with more experiences of racial discrimination.

In multivariate analyses adjusted for maternal age and race/ethnicity, child age at outcome and child sex, racism scores ⩾3 were associated with smaller fetal growth and smaller

Table 1. *Distribution of self-reported domains of lifetime experiences of racism, overall and by race/ethnicity, among 539 racial/ethnic minority women from Project Viva, a pre-birth cohort study in Massachusetts*

Situational domains in which participants reported ever experiencing racial discrimination	Overall $n = 539$	%	Black $n = 294$	%	Hispanic $n = 127$	%	Asian $n = 110$	%	Additional racial/ethnic groups $n = 8$	%
At school	185	34	116	39	30	24	35	32	4	50
Getting hired or getting a job	92	17	71	24	12	9	8	7	1	13
At work	156	29	106	36	26	2	21	19	3	38
Getting housing	59	11	46	16	10	8	3	3	0	0
Getting medical care	29	5	19	7	5	4	5	5	0	0
Getting service in a store or restaurant	246	46	173	59	43	34	27	25	3	38
On the street or in a public setting	199	37	130	44	35	28	31	28	3	38
From the police or in the courts	97	18	70	24	19	15	6	5	2	25
Racism score, 3-level category										
0	176	32.7	65	22.1	54	42.6	54	49.1	3	37.5
1–2	176	32.7	95	32.3	44	34.6	35	31.8	2	25.0
3+	187	34.6	134	45.6	29	22.8	21	19.1	3	37.5

https://doi.org/10.1017/S2040174412000384 Published online by Cambridge University Press

Table 2. *Characteristics of participants, overall and by racism exposure, among 539 racial/ethnic minority women from Project Viva, a pre-birth cohort study in Massachusetts*

Characteristic	Overall ($n = 539$)	Number of self-reported domains of experiences of racism			P-value[b]
		0 ($n = 176$)	1–2 ($n = 176$)	3+ ($n = 187$)	
	Mean (S.D.)				
Maternal age (years)	30.0 (5.8)	30.0 (5.7)	29.2 (5.9)	30.6 (5.9)	0.09
Pre-pregnancy BMI (kg/m$^{2)}$	25.9 (6.3)	24.6 (6.1)	26.3 (5.9)	26.9 (6.6)	0.001
Breastfeeding duration (months)	5.3 (4.4)	5.2 (4.3)	5.3 (4.4)	5.3 (4.4)	0.98
	n (column %)				
Nativity					<0.001
US born	309 (58.2)	73 (42.2)	113 (64.9)	123 (66.9)	
Moved to United States ⩽17 years of age	120 (22.6)	37 (21.4)	40 (23.0)	43 (23.4)	
Moved to United States >17 years of age	102 (19.2)	63 (36.4)	21 (12.1)	18 (9.8)	
Gestational weight gain category[a]					0.22
Adequate/inadequate	252 (47.2)	89 (50.9)	73 (42.0)	90 (48.7)	
Excessive	282 (52.8)	86 (49.1)	101 (58.1)	95 (51.4)	
Parity					0.50
1	245 (45.5)	86 (48.9)	82 (46.6)	77 (41.2)	
2	185 (34.3)	56 (31.8)	56 (31.8)	73 (39.0)	
3+	109 (20.2)	34 (19.3)	38 (21.6)	37 (19.8)	
College graduate					0.04
No	277 (51.4)	82 (46.6)	104 (59.1)	91 (48.7)	
Yes	262 (48.6)	94 (53.4)	72 (40.9)	96 (51.3)	
Household income					0.06
< $40,000/year	168 (35.4)	45 (30.0)	66 (42.6)	57 (33.7)	
⩾$40,000/year	306 (64.6)	105 (70.0)	89 (57.4)	112 (66.3)	
Sex of child (%)					0.56
Female	260 (48.2)	83 (47.2)	81 (46.0)	96 (51.3)	
Male	279 (51.8)	93 (52.8)	95 (54.0)	91 (48.7)	
Depression					
Mid-pregnancy	47 (12.9)	14 (11.9)	13 (11.9)	20 (14.6)	0.76
6 months postpartum	35 (11.5)	7 (7.1)	13 (13.5)	15 (13.6)	0.26

[a] Categories of weight gain based on the 2009 recommendations of the Institute of Medicine.[31]
[b] Chi-square P-value for categorical characteristics and global P-value from linear regression for continuous characteristics.

child size at 6 months and 3 years (Model 1, Table 4). Further adjustment for maternal nativity, education, pre-pregnancy BMI, household income and birth weight for gestational age z-score substantially strengthened the observed relationships (Model 2, Table 4). In fully adjusted model, compared with children whose mothers reported 0 experiences, those whose mothers reported ⩾3 domains of EOD had lower birth weight for gestational age z-score (β −0.25; 95% CI: −0.45, −0.04), lower 6 month WFA z-score (β −0.34; 95% CI: −0.65, −0.03) and lower 3-year BMI z-score (β −0.33; 95% CI: −0.66, 0.00). Although children whose mothers reported ⩾3 domains of discrimination appeared to have lower SS + TR (β −0.65; 95% CI: −2.21, 0.91), the confidence intervals were wide and included 0. Maternal experience of racism was not associated with the ratio of SS to TR at the age of 3 years (Table 4). Children of mothers reporting 1–2 domains of discrimination generally had intermediate body size, suggesting a dose-response association (Table 4).

Table 4 also shows results stratified by racial/ethnic group. Overall, the effect estimates were similar in direction across groups, but we did observe some differences in the magnitudes of effect across groups for birth weight for gestational age z-score. Among Hispanic participants the association of racism with fetal growth ($\beta = -0.70$; 95% CI: −1.13, −0.26 for >3 *v.* 0 lifetime domains) appeared to be stronger than among Asian ($\beta = -0.21$; 95% CI: −0.70, 0.27) or Black ($\beta = -0.05$; 95% CI: −0.34, 0.23) participants (P-value for interaction = 0.01). We did not observe effect modification by race/ethnicity for the other outcomes.

https://doi.org/10.1017/S2040174412000384 Published online by Cambridge University Press

Table 3. *Distribution of outcome variables at birth, 6 months and 3 years, overall and by racism score, among 539 racial/ethnic minority women from Project Viva, a pre-birth cohort study in Massachusetts*[a]

Child anthropometrics	*n*	Overall mean (S.D.)	Number of self-reported domains of experiences of racism		
			0 ($n = 176$)	1–2 ($n = 176$)	3+ ($n = 187$)
			Mean (S.D.)		
Birth					
Birth weight for gestational age *z*-score	539	−0.08 (0.95)	−0.01 (0.93)	−0.06 (0.97)	−0.14 (0.95)
6 months					
Weight for age *z*-score	270	0.30 (0.99)	0.22 (0.92)	0.46 (1.08)	0.25 (0.98)
3 years					
BMI *z*-score	299	0.45 (1.1)	0.46 (1.0)	0.52 (1.2)	0.39 (1.2)
Sum of SS + TR (mm)	284	16.3 (4.9)	16.5 (4.1)	16.7 (5.5)	15.9 (5.0)
SS : TR ratio	284	0.68 (0.16)	0.68 (0.18)	0.70 (0.15)	0.67 (0.15)

SS, subscapular; TR, triceps skinfold thickness.
[a] Data includes losses to follow-up.

In secondary analyses using multiple imputations, we observed similar but somewhat attenuated associations compared to our primary 'complete case' analysis. Examples included effect estimates of −0.21 (95% CI: −0.40, −0.01) in imputed *v.* −0.25 (95% CI: −0.45, −0.04) in complete case analysis for birth weight for gestational age, −0.27 (95% CI: −0.60, −0.07) *v.* −0.34 (95% CI: −0.65, −0.03) for 6-month WFA *z*-score, and −0.32 (95% CI: −0.65, 0.02) *v.* −0.33 (95% CI: −0.66, 0.00) for 3-year BMI *z*-score, for >3 *v.* 0 lifetime domains of discrimination using Model 2.

Discussion

Although previous studies have found that maternal experiences of chronic stressors are associated with adverse child outcomes including preterm birth, low birth weight and adverse growth patterns among their offspring,[17,18,35] to our knowledge, this is the first study to examine the association of maternal experiences of racial discrimination with child growth and adiposity outcomes. Over two-thirds of racial/ethnic minority women participating in Project Viva reported 1 or more domains of experiences of racial discrimination in their lifetimes. Mothers' reports of lifetime experiences in more domains of racial discrimination was associated with lower measures of fetal growth, 6-month WFA and 3-year BMI among their offspring, after adjustment for relevant confounders. Maternal experiences of racial discrimination did not appear to be associated with 3-year ratio of SS to TR, a measure of central adiposity.

Of note, we observed a U-shaped relationship in that mothers with a higher educational attainment reported more experiences of racial discrimination. There are several possible explanations for this observation. First, mothers with higher educational attainment may spend more time in settings (i.e. school or work) in which they are exposed to discrimination. Second, the EOD measure is dependent on the mothers' perception of their experiences. Thus, more highly educated women may be more aware of the institutionalized racism experienced in the workplace or school. Finally, the higher socioeconomic status itself may be coupled with the mothers' perception of racial or ethnic isolation. These explanations, however, are speculative and further studies are needed to better understand the relationship between racial discrimination and socioeconomic status.

Few studies have examined the influence of maternal stressors on the long-term growth and adiposity of her offspring.[35,36] Our findings that maternal racial discrimination was associated with smaller body size is consistent with an analysis from the same cohort by Ertel *et al.*,[36] who reported that maternal antenatal depression was associated with lower child BMI at 3 years of age. However, Ertel *et al.* also found an association of depression with elevated central adiposity, which we did not find in relation to racism in the current study. Family or domestic violence is another stressor that may affect long-term growth and adiposity outcomes of the offspring. Boynton-Jarrett *et al.*[35] found that maternal experiences of intimate partner violence were associated with elevated offspring obesity risk at the age of 5 years, in contrast to our results showing lower BMI. Unlike our study, the study by Boynton-Jarret *et al.* did not examine associations of intimate partner violence and child growth outcomes under the age of 5 years and included a predominantly low-income population.

Given the paucity of studies examining racism and child growth or adiposity we can only speculate on potential pathways by which maternal experiences of racial discrimination could influence child growth and adiposity, drawing from other literature on stress and adverse child outcomes. For example, some studies have suggested that physiological changes resulting from chronic stressors over a lifetime can cumulatively result in 'weathering' of the physiologic stress response such as activation

https://doi.org/10.1017/S2040174412000384 Published online by Cambridge University Press

Table 4. *Multivariable adjusted[a] associations between maternal lifetime experiences of racism (0, 1–2 and 3+ domains) and child weight-related outcomes at birth, 6 months and 3 years, overall and according to race/ethnicity, among 539 racial/ethnic minority women from Project Viva, a pre-birth cohort study in Massachusetts*

		Effect estimate (95% confidence interval)			
Anthropometric outcomes	*n*	Overall (*n* = 539)	Black (*n* = 294)	Hispanic (*n* = 127)	Asian (*n* = 110)
Birth weight for gestational age *z*-score					
Model 1	539				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.04 (−0.24, 0.15)	0.00 (−0.29, 0.28)	−0.04 (−0.41, 0.34)	−0.07 (−0.46, 0.33)
3+ racism domains		−0.18 (−0.38, 0.01)	0.00 (−0.27, 0.27)	−0.52 (−0.95,−0.10)	−0.18 (−0.66, 0.30)
Model 2	531				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.11 (−0.31, 0.09)	−0.01 (−0.31, 0.28)	−0.25 (−0.63, 0.14)	−0.11 (−0.51, 0.30)
3+ racism domains			−0.05 (−0.34, 0.23)	−0.70 (−1.13,−0.26)	−0.21 (−0.70, 0.27)
Weight for age *z*-score at 6 months					
Model 1	270				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		0.19 (−0.12, 0.49)	0.49 (−0.06, 1.04)	0.44 (−0.08, 0.96)	−0.21 (−0.74, 0.32)
3+ racism domains		−0.14 (−0.46, 0.17)	0.13 (−0.37, 0.63)	0.12 (−0.45, 0.68)	−0.49 (−1.17, 0.19)
Model 2	269				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.02 (−0.32, 0.28)	0.22 (−0.35, 0.78)	0.20 (−0.32, 0.73)	−0.39 (−0.94, 0.16)
3+ racism domains		−0.34 (−0.65,−0.03)	−0.18 (−0.71, 0.36)	0.01 (−0.58, 0.60)	−0.55 (−1.25, 0.15)
BMI *z*-score at 3 years					
Model 1	299				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.01 (−0.34, 0.33)	−0.22 (−0.79, 0.35)	0.13 (−0.55, 0.81)	0.07 (−0.46, 0.61)
3+ racism domains		−0.22 (−0.56, 0.13)	−0.27 (−0.81, 0.27)	−0.19 (−0.93, 0.56)	−0.51 (−1.16, 0.15)
Model 2	296				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.14 (−0.46, 0.17)	−0.31 (−0.85, 0.24)	0.00 (−0.63, 0.63)	−0.04 (−0.60, 0.52)
3+ racism domains		−0.33 (−0.66, 0.00)	−0.34 (−0.87, 0.19)	−0.27 (−0.98, 0.45)	−0.56 (−1.23, 0.10)
Sum of SS + TR at 3 years (mm)					
Model 1	284				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		0.07 (−1.41, 1.55)	−2.15 (−4.71, 0.41)	2.18 (−1.10, 5.45)	0.76 (−1.34, 2.86)
3+ racism domains		−0.81 (−2.35, 0.73)	−2.27 (−4.71, 0.16)	0.64 (−2.93, 4.20)	−0.95 (−3.52, 1.62)
Model 2	281				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		−0.04 (−1.53, 1.45)	−2.02 (−4.58, 0.54)	1.34 (−2.13, 4.82)	0.76 (−1.46, 2.99)
3+ racism domains		−0.65 (−2.21, 0.91)	−1.80 (−4.26, 0.67)	0.03 (−3.84, 3.90)	−1.32 (−3.98, 1.33)
SS : TR ratio at 3 years					
Model 1	283				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		0.94 (−3.92, 5.80)	1.77 (−6.22, 9.76)	7.44 (−2.68,17.56)	−0.64 (−9.56, 8.27)
3+ racism domains		−1.21 (−6.26, 3.84)	0.84 (−6.79, 8.48)	1.01 (−9.94,11.96)	−5.48 (−16.7, 5.71)
Model 2	280				
0 racism domains		0.0 (ref)	0.0 (ref)	0.0 (ref)	0.0 (ref)
1–2 racism domains		2.11 (−2.87, 7.10)	2.78 (−5.54,11.10)	8.14 (−1.81,18.09)	4.44 (−4.99,13.86)
3+ racism domains		0.35 (−4.91, 5.61)	2.49 (−5.57,10.54)	1.54 (−9.55,12.63)	−2.09 (−13.7, 9.55)

BMI, body mass index; SS, subscapular; TR, triceps skinfold thickness.

[a] Model 1 was adjusted for maternal age and race/ethnicity, child age at outcome and child sex. Multivariate Model 2 was adjusted for all variables in Model 1 plus maternal nativity (US born, moved to United States before the age of 17 years, moved to United States after the age of 17 years), education and pre-pregnancy BMI; household income; and (for weight for age *z*-score at 6 months) birth weight for gestational age *z*-score. All SS : TR models are additionally adjusted for BMI *z*-score at 3 years of age.

https://doi.org/10.1017/S2040174412000384 Published online by Cambridge University Press

of the mothers' hypothalamic–pituitary–adrenocortical axis, or permanently alter immune and vascular function, thus affecting maternal health and possibly child growth.[37] Other potential pathways are more speculative. For example, racism's effects on child growth could involve its influence on antenatal depression. In another study in Project Viva, antenatal depression is related to lower BMI at the age of 3 years.[36,38] However, adjustment for maternal depression did not attenuate our observed relationships and was not associated with maternal experiences of racism. It is also possible that mothers who have experienced more racial discrimination are at higher risk of psychosocial stress; severe psychosocial stress even in the absence of depression may cause poor infant feeding practices that lead to slower weight gain in infancy.[39–41] Another possibility is that mothers with more reported experiences of racial discrimination may have adverse coping behaviors that can be sensed and internalized by their child,[42] although no studies have related coping behaviors or the child's response to weight gain.[16] Furthermore, it is possible that mothers with more reported experiences of racial discrimination may have difficulty with emotion regulation that can impact their attachment with their child. Insecure child attachment has been shown to increase risk for childhood obesity.[16]

The long-term implications of our findings await further cohort follow-up and similar analyses in other cohorts. Lower fetal growth is associated with increased rates of cardiovascular disease in adult life,[43–47] but it is not clear whether this phenomenon results from racial discrimination or other determinants of reduced fetal growth. Further, the highest risk is among children born small who gain excess weight in childhood; we did not observe this phenotype in relation to racial discrimination. In this era of epidemic obesity, most would consider lower WFA at 6 months and lower BMI at 3 years to be favorable outcomes.[48,49] However, as WFA and BMI are determined both by adipose and lean muscle tissue, future work is needed to determine which component is associated with maternal stressors. Although the reductions in 6-month and 3-year weight status were not severe in this relatively well-off cohort, it is possible that a similar magnitude of racism's effect in a more disadvantaged population could lead to enough weight faltering to have chronic adverse effects.[50]

As with any study, it is important to consider limitations and strengths. First, although our measure of self-reported experiences of racial discrimination examined lifetime experiences in different situations, we did not ask respondents to enumerate specific events or to indicate their level of severity or the frequency with which they occurred, suggesting that our results offer a conservative assessment of the association between racial discrimination and the specified outcomes. Second, the educational and income levels of our study population were relatively high. Our results may not be generalizable to racial/ethnic minority women with fewer socioeconomic resources. Third, our relatively limited sample size makes it difficult to detect any interaction effects by race/ethnicity. Fourth, in any observational study it is possible that unmeasured characteristics or inadequately measured characteristics might explain the observed associations between exposure and outcome. Nevertheless, we were able to control for important recognized demographic, socio-economic and weight-related confounders. An additional strength of our study was the multiple imputation approach, which strengthened our inferences insofar as they show that the results based on the observed data are not unduly biased by missing data.

In conclusion, our findings suggest that maternal lifetime experience of racial discrimination is associated with lower weight status in the first 3 years of life. Although further studies are needed to examine the long-term associations between maternal psychosocial stressors and child growth, adiposity and metabolic sequelae, as well as biological and psychosocial mechanisms for such associations, our study suggests that maternal experiences of racial discrimination may leave an imprint on offspring health.

Acknowledgments

This study was supported by a grant from the National Institute on Minority Health and Health Disparities (MD 003963). The authors would like to thank the participants of Project Viva.

References

1. Skinner AC, Steiner MJ, Henderson FW, Perrin EM. Multiple markers of inflammation and weight status: cross-sectional analyses throughout childhood. *Pediatrics*. 2010; 125, e801–e809.
2. Kurian AK, Cardarelli KM. Racial and ethnic differences in cardiovascular disease risk factors: a systematic review. *Ethn Dis*. 2007; 17, 143–152.
3. Gillman MW, Rifas-Shiman SL, Kleinman K, *et al*. Developmental origins of childhood overweight: potential public health impact. *Obesity*. 2008; 16, 1651–1656.
4. Kuh D, Ben-Shlomo Y. *A Life Course Approach to Chronic Disease Epidemiology: Tracing the Origins of Ill-health From Early to Adult life*, 2nd edn, 2004. Oxford University Press: London.
5. Oken E, Levitan EB, Gillman MW. Maternal smoking during pregnancy and child overweight: systematic review and meta-analysis. *Int J Obes (Lond)*. 2008; 32, 201–210.
6. Oken E, Taveras EM, Kleinman KP, Rich-Edwards JW, Gillman MW. Gestational weight gain and child adiposity at age 3 years. *Am J Obstet Gynecol*. 2007; 196, 322, e321–e328.
7. Wright CS, Rifas-Shiman SL, Rich-Edwards JW, *et al*. Intrauterine exposure to gestational diabetes, child adiposity, and blood pressure. *Am J Hypertens*. 2009; 22, 215–220.
8. Taveras EM, Gillman MW, Kleinman K, Rich-Edwards JW, Rifas-Shiman SL. Racial/ethnic differences in early-life risk factors for childhood obesity. *Pediatrics*. 2010; 125, 686–695.
9. Gravlee CC. How race becomes biology: embodiment of social inequality. *Am J Phys Anthropol*. 2009; 139, 47–57.
10. Dallman MF, Akana SF, Pecoraro NC, *et al*. Glucocorticoids, the etiology of obesity and the metabolic syndrome. *Curr Alzheimer Res*. 2007; 4, 199–204.

11. Dallman MF, Pecoraro NC, La Fleur SE, *et al*. Glucocorticoids, chronic stress, and obesity. *Prog Brain Res*. 2006; 153, 75–105.
12. la Fleur SE, Akana SF, Manalo SL, Dallman MF. Interaction between corticosterone and insulin in obesity: regulation of lard intake and fat stores. *Endocrinology*. 2004; 145, 2174–2185.
13. Tataranni PA, Larson DE, Snitker S, *et al*. Effects of glucocorticoids on energy metabolism and food intake in humans. *Am J Physiol*. 1996; 271, E317–E325.
14. Kramer MR, Hogue CR. What causes racial disparities in very preterm birth? A biosocial perspective. *Epidemiol Rev*. 2009; 31, 84–98.
15. Warne JP. Shaping the stress response: interplay of palatable food choices, glucocorticoids, insulin and abdominal obesity. *Mol Cell Endocrinol*. 2009; 300, 137–146.
16. Anderson SE, Whitaker RC. Attachment security and obesity in US preschool-aged children. *Arch Pediatr Adolesc Med*. 2011; 165, 235–242.
17. Collins Jr JW, David RJ, Symons R, *et al*. Low-income African-American mothers' perception of exposure to racial discrimination and infant birth weight. *Epidemiology*. 2000; 11, 337–339.
18. Mustillo S, Krieger N, Gunderson EP, *et al*. Self-reported experiences of racial discrimination and Black-White differences in preterm and low-birthweight deliveries: the CARDIA Study. *Am J Public Health*. 2004; 94, 2125–2131.
19. Rosenberg L, Palmer JR, Wise LA, Horton NJ, Corwin MJ. Perceptions of racial discrimination and the risk of preterm birth. *Epidemiology*. 2002; 13, 646–652.
20. Murrell NL. Stress, self-esteem, and racism: relationships with low birth weight and preterm delivery in African American women. *J Natl Black Nurses Assoc*. 1996; 8, 45–53.
21. Brondolo E, Rieppi R, Kelly KP, Gerin W. Perceived racism and blood pressure: a review of the literature and conceptual and methodological critique. *Ann Behav Med*. 2003; 25, 55–65.
22. Dominguez TP, Dunkel-Schetter C, Glynn LM, Hobel C, Sandman CA. Racial differences in birth outcomes: the role of general, pregnancy, and racism stress. *Health Psychol*. 2008; 27, 194–203.
23. Dominguez TP, Strong EF, Krieger N, Gillman MW, Rich-Edwards JW. Differences in the self-reported racism experiences of US-born and foreign-born Black pregnant women. *Soc Sci Med*. 2009; 69, 258–265.
24. Gillman MW, Rich-Edwards JW, Rifas-Shiman SL, *et al*. Maternal age and other predictors of newborn blood pressure. *J Pediatr*. 2004; 144, 240–245.
25. Krieger N. Racial and gender discrimination: risk factors for high blood pressure? *Soc Sci Med*. 1990; 30, 1273–1281.
26. Krieger N, Smith K, Naishadham D, Hartman C, Barbeau EM. Experiences of discrimination: validity and reliability of a self-report measure for population health research on racism and health. *Soc Sci Med*. 2005; 61, 1576–1596.
27. Oken E, Kleinman KP, Rich-Edwards JW, Gillman MW. A nearly continuous measure of birth weight for gestational age using a United States national reference. *BMC Pediatr*. 2003; 3, 6.
28. National Center for Health Statistics. CDC Growth Charts, United States, 2000. Retrieved 6 January 2012 from http://www.cdc.gov/growthcharts/
29. Shorr IJ. *How to Weigh and Measure Children*, 1986. U.N.: New York.
30. U.S. Census Bureau, Population Division. Racial and Ethnic Classifications Used in Census 2000 and Beyond, 2000. Retrieved February 8, 2011, from http://www.census.gov/population/www/socdemo/race/racefactcb.html
31. Committee to Reexamine IOM Pregnancy Weight Guidelines. *Weight Gain During Pregnancy: Reexamining the Guidelines*, 2009. Institute of Medicine, National Research Council, The National Academies Press: Washington, DC.
32. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *Br J Psychiatr*. 1987; 150, 782–786.
33. Raghunathan TE, Solenberger PW, Van Hoewyk J. *IVEware: Imputation and Variance Estimation Software User Guide*, 2002. Survey Research Center, Institute for Social Research, Ann Arbor, Michigan; ftp://ftp.isr.umich.edu/pub/src/smp/ive/ive_user.pdf
34. Horton NJ, Kleinman KP. Much ado about nothing: a comparison of missing data methods and software to fit incomplete data regression models. *Am Stat*. 2007; 61, 79–90.
35. Boynton-Jarrett R, Fargnoli J, Suglia SF, Zuckerman B, Wright RJ. Association between maternal intimate partner violence and incident obesity in preschool-aged children: results from the Fragile Families and Child Well-being Study. *Arch Pediatr Adolesc Med*. 2010; 164, 540–546.
36. Ertel KA, Koenen KC, Rich-Edwards JW, Gillman MW. Antenatal and postpartum depressive symptoms are differentially associated with early childhood weight and adiposity. *Paediatr Perinat Epidemiol*. 2010; 24, 179–189.
37. Kramer MR, Hogue CJ, Dunlop AL, Menon R. Preconceptional stress and racial disparities in preterm birth: an overview. *Acta Obstet Gynecol Scand*. 2011; 90, 1307–1316.
38. Ertel KA, Koenen KC, Rich-Edwards JW, Gillman MW. Maternal depressive symptoms not associated with reduced height in young children in a US prospective cohort study. *PLoS One*. 2010; 5, e13656.
39. Farrow C, Blissett J. Maternal cognitions, psychopathologic symptoms, and infant temperament as predictors of early infant feeding problems: a longitudinal study. *Int J Eat Disord*. 2006; 39, 128–134.
40. Farrow CV, Blissett JM. Is maternal psychopathology related to obesigenic feeding practices at 1 year? *Obes Res*. 2005; 13, 1999–2005.
41. Wright CM, Parkinson KN, Drewett RF. The influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive): data from a prospective birth cohort. *Arch Dis Child*. 2006; 91, 312–317.
42. Ong AD, Fuller-Rowell T, Burrow AL. Racial discrimination and the stress process. *J Pers Soc Psychol*. 2009; 96, 1259–1271.
43. Barker DJP, Winter PD, Osmond C, Margetts B, Simmonds SJ. Weight in infancy and death from ischaemic heart disease. *Lancet*. 1989; 2, 577–580.
44. Eriksson J, Forsen T, Tuomilehto J, Osmond C, Barker D. Fetal and childhood growth and hypertension in adult life. *Hypertension*. 2000; 36, 790–794.

45. Osmond C, Barker DJP, Winter PD, Fall CHD, Simmonds SJ. Early growth and death from cardiovascular disease in women. *BMJ*. 1993; 307, 1519–1524.
46. Frankel S, Elwood P, Sweetnam P, Yarnell J, Davey Smith G. Birthweight, body-mass index in middle age, and incident coronary heart disease. *Lancet*. 1996; 348, 1478–1480.
47. Rich-Edwards JW, Stampfer MJ, Manson JE, *et al*. Birthweight and the risk of cardiovascular disease in adult women. *BMJ*. 1997; 315, 396–400.
48. Baird J, Fisher D, Lucas P, *et al*. Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ*. 2005; 331, 929.
49. Monteiro PO, Victora CG. Rapid growth in infancy and childhood and obesity in later life – a systematic review. *Obes Rev*. 2005; 6, 143–154.
50. Emond AM, Blair PS, Emmett PM, Drewett RF. Weight faltering in infancy and IQ levels at 8 years in the Avon Longitudinal Study of Parents and Children. *Pediatrics*. 2007; 120, e1051–e1058.