

## Original Article

## Childhood maltreatment and the risk of pre-pregnancy obesity and excessive gestational weight gain

Jill C. Diesel\*, Lisa M. Bodnar\*<sup>†‡</sup>, Nancy L. Day\*<sup>§</sup> and Cynthia A. Larkby\*<sup>§</sup>

\*Department of Epidemiology, University of Pittsburgh Graduate School of Public Health, Pittsburgh, Pennsylvania, USA, <sup>†</sup>Department of Obstetrics, Gynecology, and Reproductive Sciences, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA, <sup>‡</sup>Magee-Womens Research Institute, Pittsburgh, Pennsylvania, USA, and <sup>§</sup>Department of Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA

## Abstract

The objective of this study was to estimate whether maternal history of childhood maltreatment was associated with pre-pregnancy obesity or excessive gestational weight gain. Pregnant women ( $n = 472$ ) reported pre-pregnancy weight and height and gestational weight gain and were followed up to 16 years post-partum when they reported maltreatment on the Childhood Trauma Questionnaire (CTQ). CTQ score ranged from no maltreatment (25) to severe maltreatment (125). Prenatal mental health modified the association between CTQ score and maternal weight ( $P < 0.15$ ), and thus stratified models are presented. After adjusting for race, prenatal tobacco, marijuana and alcohol use, a one standard deviation (1 SD) increase in CTQ score was associated with a 45% increase in the risk of pre-pregnancy obesity among the 141 women with elevated anxiety ( $\geq 75$ th percentile on the State Trait Anxiety Inventory) [relative risk, RR (95% confidence interval, CI): 1.45 (1.12, 1.88)], but was not associated among less anxious ( $< 75$ th percentile) women [RR (95% CI): 1.10 (0.81, 1.51)]. Risk of excessive gestational weight gain was higher [adjusted RR (95% CI): 1.21 (1.07, 1.37)] with every 1 SD increase in CTQ score for anxious women. No association was observed for less anxious women [adjusted RR (95% CI): 0.89 (0.78, 1.02)]. Prenatal depression similarly modified the association between maltreatment and weight gain. Factors such as psychological status and traumatic experiences in early childhood may contribute to pre-pregnancy obesity and excessive gestational weight gain.

**Keywords:** pregnancy, obesity, gestational weight gain, child abuse/neglect, child maltreatment, anxiety.

Correspondence: Dr Cynthia A. Larkby, Department of Psychiatry, University of Pittsburgh School of Medicine, 3811 O'Hara Street, Pittsburgh, PA 15213, USA. E-mail: larkby@pitt.edu

## Introduction

Pre-pregnancy obesity occurs in one out of five women (Chu *et al.* 2009) and increases the risk of numerous adverse maternal and infant health outcomes, including pre-eclampsia, gestational diabetes and childhood obesity (Catalano 2007). Excessive gestational weight gain (GWG), defined as weight gain greater than the 2009 Institute of Medicine (IOM) recommendations, is also common, affecting at least 40% of all pregnancies (IOM 2009). High preg-

nancy weight gain is associated with poor perinatal outcomes and exacerbates many of the adverse effects of maternal obesity (IOM 2009). Identifying preconception determinants of obesity and excessive GWG is a public health priority (IOM 2009).

Childhood maltreatment may be a factor predisposing to maternal obesity and excessive GWG. An association between maltreatment in childhood and later weight may be explained by underlying neuroendocrine or behavioural mechanisms promoting stress and weight gain (Noll *et al.* 2007; Sanci

*et al.* 2008). Childhood maltreatment appears to be common. Data have suggested that 15–28% of the population experiences physical abuse in childhood, that 26% experience emotional abuse, 5–12% experience sexual abuse and that physical or supervision neglect is experienced by 12–14% and 21–42%, respectively (Hussey *et al.* 2006; MMWR 2010). However, prevalence rates are highly sensitive to timing of maltreatment, case ascertainment and case definition. In adults, a history of maltreatment in childhood is associated with obesity (Williamson *et al.* 2002; Aaron & Hughes 2007; Mamun *et al.* 2007; Noll *et al.* 2007; Boynton-Jarrett *et al.* 2012; Richardson *et al.* 2013). Nevertheless, there are few data on the association between childhood maltreatment and pregnancy-related weight (Hollingsworth *et al.* 2012), and the two previous studies did not distinguish childhood maltreatment from current violence (Stevens-Simon & McAnarney 1994; Johnson *et al.* 2002). The associations between maltreatment and later obesity that have been reported in the literature may vary depending upon whether the maltreatment occurred during childhood or during an adult relationship.

Our objective was to estimate the association between history of childhood maltreatment, the risk of pre-pregnancy obesity and excessive GWG. We hypothesised that abuse/neglect in childhood would be associated with subsequent pre-pregnancy obesity and excessive GWG.

## Materials and methods

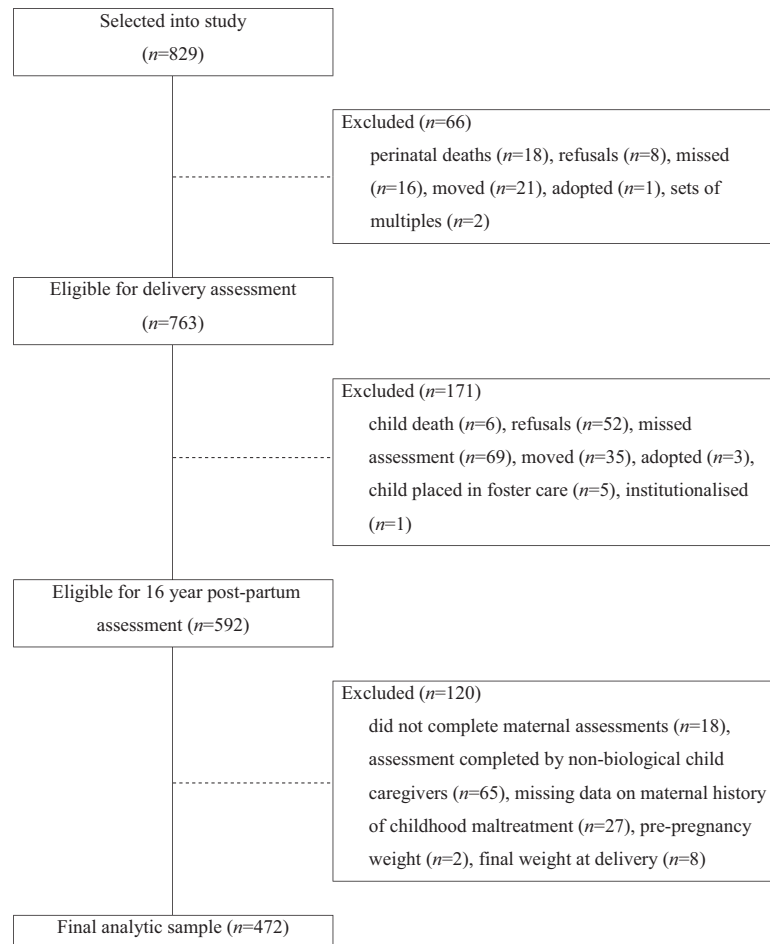
We conducted a retrospective analysis of data obtained from the Maternal Health Practices and

Child Development (MHPCD) cohort study. The original study was designed to evaluate the long-term effects of prenatal substance use on child development (Day *et al.* 2002). From 1982 to 1985, pregnant women were recruited from a prenatal clinic at Magee-Womens Hospital in Pittsburgh, PA, USA, that served predominantly low-income women. Women  $\geq 18$  years old in the fourth or fifth prenatal month were approached for the initial screening interview. A total of 1360 women agreed to participate (85% response rate). The study sample was selected based upon first trimester substance use. All women who reported drinking three or more drinks per week in the first trimester of pregnancy and a random sample of those reporting less than this amount were selected for the alcohol cohort. Similarly, all women who reported using two or more marijuana joints per month in the first trimester of pregnancy and a random sample of those reporting less than this amount were selected for the marijuana cohort. The two cohorts were selected in parallel and with replacement, so that women could be in either or both cohorts (47% overlap). The combined cohort included 829 women and was used for this analysis.

Women were interviewed at a mean of 18.9 weeks gestation (SD 3.1) regarding first trimester socio-demographic characteristics and health behaviours. At delivery (mean 39.1, SD 2.1 weeks), women reported information including their total GWG. A total of 763 women had live, singleton births and were available for the delivery assessment (Fig. 1). All mother–infant pairs assessed at delivery were eligible for follow-up evaluations that occurred throughout the post-natal period. Women's history of childhood

### Key messages

- Pre-pregnancy body mass index (BMI) and gestational weight gain are clinically relevant markers of nutrition during pregnancy and are associated with obstetric outcomes.
- Childhood maltreatment has been linked to adulthood obesity, but it is unclear whether maltreatment affects weight during pregnancy.
- Psychological factors that predict maternal weight or weight gain have been understudied.
- Childhood maltreatment was associated with the risk of pre-pregnancy obesity and excessive weight gain among pregnant women with elevated anxiety, but not among less anxious women.
- It may be of clinical value to address the psychosocial and nutritional needs of pregnant women.



**Fig. 1.** Flow diagram of the sample selection.

maltreatment was ascertained at the 16-year post-partum visit. A total of 472 women comprised the total analytic sample. Further details of the core study design and methodology are available (Day *et al.* 2002). The Institutional Review Boards of Magee-Womens Hospital and University of Pittsburgh approved the study, and written informed consent was obtained at each study phase. The University of Pittsburgh Institutional Review Board approved this secondary analysis as exempt research.

### Measurement

Childhood victimisation was assessed at 16 years post-partum using the revised Childhood Trauma Questionnaire (CTQ) (Bernstein & Fink 1998). The

CTQ is a reliable and validated instrument composed of 25 items that assess five types of abuse/neglect: physical, sexual and emotional abuse, and physical and emotional neglect (5 items per sub-scale). Likert-style responses rate the frequency with which each item occurred (1 = *never true* to 5 = *very often true*). Responses for each sub-scale are summed to estimate severity (possible range: 5 = none to 25 = severe). In order to evaluate whether maltreatment varied by pregnancy weight characteristics, we used cut-points to define moderate/severe abuse/neglect for each subtype of abuse (physical  $\geq 10$ ; emotional  $\geq 13$ ; sexual  $\geq 8$ ) and neglect (physical  $\geq 10$ ; emotional  $\geq 15$ ) (Bernstein & Fink 1998). These cut-points were selected to balance sensitivity and specificity for maltreatment severity (Bernstein & Fink 1998). To

address multicollinearity due to co-occurring maltreatment subtypes, we used the total child maltreatment score in our analyses (Nicolson *et al.* 2010). Responses to all 25 items are summed for a total score (possible range: 25 = none to 125 = severe). Total CTQ score was positively skewed with a majority of the CTQ scores concentrated in the lower tail of the distribution (skewness: 1.38,  $P < 0.001$ ). We analysed the continuous CTQ score in 1 SD increases (equivalent to 17.96 units on the CTQ). Childhood maltreatment was defined as an elevated CTQ score in the upper 50th percentile of the distribution ( $\geq 37$ ). While no suggested cut-points exist for the total CTQ score, we chose the 50th percentile in order to maximise the sensitivity of our measure while balancing the sample size needed to power our analyses (Scher *et al.* 2001). Recall of childhood maltreatment during adulthood may be more accurate than recollection of the events during childhood (Widom & Shepard 1996; Widom & Morris 1997; Fergusson *et al.* 2000).

We studied two dichotomous outcomes: pre-pregnancy obesity and excessive GWG. Pre-pregnancy obesity was defined as body mass index (BMI) [ $\text{weight (kg)}/\text{height(m)}^2$ ]  $\geq 30.0 \text{ kg m}^{-2}$ , based upon self-reported pre-pregnancy weight and height at enrolment. Women reported at delivery the amount of weight gained during pregnancy. We defined excessive GWG as a weight gain greater than the 2009 Institute of Medicine gestational weight gain guidelines (IOM 2009) given the gestational age at delivery as described previously (Bodnar *et al.* 2010).

### Covariates

The Center for Epidemiologic Studies-Depression Scale (CES-D) is a 20-item self-report measure of depression symptomology validated for use in the general population (Radloff 1977). Responses to each item are on 4-point scale ranging from 0 to 3, with a total score ranging from 0 to 60, with higher scores indicating higher depression symptoms. The anxiety scale of the State Trait Personality Inventory (STPI) is a 10-item self-report questionnaire used to measure transitory and dispositional anxiety in adults (Spielberger 1979). Item responses are rated on a 4-point scale where higher scores indicate higher

anxiety. The STPI anxiety scale is correlated with the State-Trait Anxiety Inventory (Spielberger *et al.* 1983).

Covariates reported at enrolment were analysed according to the following classifications: current maternal age in years (continuous); race (black; white); marital status (married; unmarried); employment status (working or going to school; neither working nor going to school); monthly household income [ $< \$400$ ;  $\geq \$400$  (approximately  $< \$979$ ;  $\geq \$979$  in 2014 (US Bureau of Labor Statistics 2014)]; education (less than high school; graduated high school; some college); parity (nulliparous; parous); smoking status in the first trimester of pregnancy (none;  $>0$  to  $<0.5$  pack day $^{-1}$ ;  $0.5$  to  $<1$  pack day $^{-1}$ ;  $\geq 1$  packs day $^{-1}$ ); alcohol use in the first trimester of pregnancy (none;  $>0$  to  $<1$  drink day $^{-1}$ ;  $\geq 1$  drinks day $^{-1}$ ); marijuana use in the first trimester of pregnancy (none;  $>0$  to  $<1$  joints day $^{-1}$ ;  $\geq 1$  joints day $^{-1}$ ); other illicit drug use in the first trimester of pregnancy (yes; no); first trimester depression ( $\geq 75$ th percentile on the CES-D); first trimester trait anxiety ( $\geq 75$ th percentile on the STPI); first trimester social support ( $< 25$ th percentile of a factor score measuring social support;  $\geq 25$ th percentile).

### Statistical analysis

Distributions of maternal characteristics at  $< 20$  weeks gestation were tested across levels of CTQ scores and pre-pregnancy BMI using Pearson's chi-square tests. Geometric means and 95% confidence intervals (95% CI) were calculated for skewed variables and were tested using the Kruskal-Wallis equality of populations test. Multivariable modified Poisson's regression models were used to test the independent association between a history of childhood maltreatment and the risk of pre-pregnancy obesity as well as excessive GWG (Zou 2004). The Poisson models were modified by including a robust variance estimator, which curtails the overestimated variance known to occur. We studied each association using the continuous total child maltreatment score as well as a dichotomised maltreatment score. Theory-based causal diagrams (Greenland *et al.* 1999) were built using investigators' *a priori* knowledge of causal relationships described

in the literature to select potential confounders at the first prenatal visit. Potential confounders included maternal age, race, education, income, cigarette smoking, marijuana use, alcohol use, depression, anxiety, hostility and social support; pre-pregnancy BMI was additionally included in the excessive GWG model.

Effect modification by pre-pregnancy BMI, prenatal substance use and prenatal mental health status were tested using likelihood ratio tests, and due to limited power, we used an alpha level of 0.15. Only pre-pregnancy BMI (in the excessive GWG model) and race met our definition of confounding (exclusion from the model changed the main-effect risk ratio by  $\geq 10\%$ ); further adjustment did not result in meaningful differences.

Due to oversampling for prenatal substance use in this cohort, we additionally adjusted for cigarette smoking, marijuana use and alcohol use in all reported models. We presented estimates for the primary effect only because estimates for secondary risk factors (confounders and effect modifiers) in the same model may be misleading (Westreich & Greenland 2013). The sensitivity of our results was tested by excluding women with heavy prenatal alcohol ( $\geq 1$  drinks day<sup>-1</sup> in the first trimester) or marijuana use ( $\geq 1$  joints day<sup>-1</sup> in the first trimester) as well as by applying inverse probability sample weights (Hernan *et al.* 2004) to reweight the sample to the clinic population from which this cohort was selected (Vanderwerker *et al.* 2003).

Stata software, version 11 (StataCorp, College Station, TX, USA), was used for analysis.

## Results

Overall, the sample was young [mean 23.0 (SD 3.9) years], unmarried, with high school education, unemployed, low income and tended to use substances in the first trimester of pregnancy (Table 1). The sample included a number of non-users, with 27% abstaining from both alcohol and marijuana in the first trimester; substance use declined over the course of pregnancy (data not shown). The sample was 46% white and 54% African American. Ten per cent of women were obese before becoming pregnant, and 46% gained

excessive weight during pregnancy. Half of women (53%) were classified as having a history of childhood maltreatment ( $\geq 50$ th percentile of CTQ score). White race, low income, cigarette smoking and elevated anxiety and depression were associated with elevated CTQ scores. Women who were parous, smoked heavily, had excessive weight gain and elevated depression in early pregnancy were more likely to be obese. Non-smokers tended to gain above the IOM guidelines.

The final analytic sample had a higher proportion of African American women ( $P < 0.05$ ) compared with the enrolled study sample, but there were no differences in pre-pregnancy BMI, adequacy of pregnancy weight gain, childhood maltreatment scores, substance use, anxiety or depression.

In unadjusted analyses, total CTQ score was marginally higher among obese than non-obese women, but the difference did not reach statistical significance ( $P = 0.06$ ). When we examined subtypes of childhood maltreatment, women reporting moderate/severe physical abuse in childhood were more often obese before pregnancy, but there were no other differences in maternal weight by subtype of abuse (emotional; sexual) or neglect (physical; emotional) (data not shown). After adjustment for race, tobacco, alcohol and marijuana use, each 1 SD increase in CTQ score was associated with a 31% increase in the risk of pre-pregnancy obesity (Table 2). Women with an elevated CTQ score had a twofold increase in the risk of pre-pregnancy obesity after confounder adjustment. Prenatal anxiety modified the association between history of child maltreatment and pre-pregnancy BMI ( $P = 0.13$ ). The risk of obesity was higher among women with a history of both maltreatment and elevated prenatal anxiety, but not among less anxious women with a history of maltreatment. Every 1 SD increase in CTQ score was associated with a 45% increase in the adjusted risk of obesity (95% CI: 1.12, 1.88) among women with elevated anxiety. There was no association between continuous CTQ score and the adjusted risk of obesity for less anxious women. The pairwise correlation between maternal depression and trait anxiety was high ( $r = 0.72$ ;  $P < 0.01$ ) and there was overlap between elevated depression and elevated anxiety.

**Table 1.** Maternal characteristics at <20 weeks, by total childhood maltreatment score, pre-pregnancy obesity and excessive gestational weight gain

	CTQ score		Pregravid BMI (kg m <sup>-2</sup> )		Gestational weight gain	
	Not elevated (<50th percentile)	Elevated (≥50th percentile)	Not obese (<30.0)	Obese (≥30.0)	Not excessive (≤IOM)	Excessive (>IOM)
Maternal race/ethnicity, <i>n</i> (%) <sup>*</sup>						
White	147 (57.2)	110 (42.8)	227 (88.3)	30 (11.7)	139 (54.1)	118 (45.9)
Black	75 (34.9)	140 (65.1)	196 (91.2)	19 (8.8)	127 (59.1)	88 (40.9)
Education, <i>n</i> (%)						
<High school	50 (41.7)	70 (58.3)	110 (91.7)	10 (8.3)	71 (59.2)	49 (40.8)
High school graduate	141 (48.8)	148 (51.2)	261 (90.3)	28 (9.7)	165 (57.1)	124 (42.9)
>High school	31 (49.2)	32 (50.8)	52 (82.5)	11 (17.5)	30 (47.6)	33 (52.4)
Marital status, <i>n</i> (%)						
Unmarried	148 (47.1)	166 (52.9)	284 (90.5)	30 (9.6)	182 (58.0)	132 (42.0)
Married	74 (46.8)	84 (53.2)	139 (88.0)	19 (12.0)	84 (53.2)	74 (46.8)
Parity, <i>n</i> (%) <sup>†</sup>						
Nulliparous	99 (47.1)	111 (52.9)	195 (92.9)	15 (7.1)	114 (54.3)	96 (45.7)
Parous	123 (47.0)	139 (53.1)	228 (87.0)	34 (13.0)	152 (58.0)	110 (42.0)
Employment/school, <i>n</i> (%)						
In school and/or working	63 (50.0)	63 (50.0)	113 (89.7)	13 (10.3)	61 (48.4)	65 (51.6)
Not in school or working	159 (46.0)	187 (54.0)	310 (89.6)	36 (10.4)	205 (59.3)	141 (40.8)
Income level (\$/month), <i>n</i> (%) <sup>*</sup>						
<400	78 (41.3)	111 (58.7)	166 (87.8)	23 (12.2)	101 (53.4)	88 (46.6)
≥400	137 (50.7)	133 (49.3)	246 (91.1)	24 (8.9)	156 (57.8)	114 (42.2)
Prenatal smoking, <i>n</i> (%) <sup>*‡</sup>						
None	115 (50.0)	115 (50.0)	204 (88.7)	26 (11.3)	116 (50.4)	114 (49.6)
<0.5 packs day <sup>-1</sup>	49 (54.4)	41 (45.6)	83 (92.2)	7 (7.8)	49 (54.4)	41 (45.6)
0.5 to <1 packs day <sup>-1</sup>	33 (40.7)	48 (59.3)	77 (95.1)	4 (4.9)	59 (72.8)	22 (27.2)
≥1 packs day <sup>-1</sup>	25 (35.2)	46 (64.8)	59 (83.1)	12 (16.9)	42 (59.2)	29 (40.9)
Prenatal alcohol use, <i>n</i> (%)						
None	87 (49.7)	88 (50.3)	151 (86.3)	24 (13.7)	92 (52.6)	83 (47.4)
>0 to <1 drink day <sup>-1</sup>	94 (45.0)	115 (55.0)	189 (90.4)	20 (9.6)	123 (58.9)	86 (41.2)
≥1 drinks day <sup>-1</sup>	41 (46.6)	47 (53.4)	83 (94.3)	5 (6.7)	51 (58.0)	37 (42.1)
Prenatal marijuana use, <i>n</i> (%) <sup>†</sup>						
None	136 (48.8)	143 (51.3)	242 (86.7)	37 (13.3)	161 (57.7)	118 (42.3)
>0 to <1 joint month <sup>-1</sup>	58 (44.3)	73 (55.7)	121 (92.4)	10 (7.6)	75 (57.3)	56 (42.8)
≥1 joints month <sup>-1</sup>	28 (45.2)	34 (54.8)	60 (96.8)	2 (3.2)	30 (48.4)	32 (51.6)
Prenatal anxiety (STPI), <i>n</i> (%) <sup>*</sup>						
Elevated (≥75th percentile)	56 (39.7)	85 (60.3)	122 (86.5)	19 (13.5)	77 (54.6)	64 (45.4)
Not elevated (<75th percentile)	166 (50.2)	165 (49.9)	301 (90.9)	30 (9.1)	189 (57.1)	142 (42.9)
Prenatal depression (CES-D), <i>n</i> (%) <sup>*</sup>						
Elevated (≥75th percentile)	38 (31.9)	81 (68.1)	100 (84.0)	19 (16.0)	65 (54.6)	54 (45.4)
Not elevated (<75th percentile)	182 (52.0)	168 (48.0)	321 (91.7)	29 (8.3)	199 (56.9)	151 (43.1)

BMI (in kg m<sup>-2</sup>), body mass index; CES-D, Center for Epidemiologic Studies-Depression Scale; CTQ, Childhood Trauma Questionnaire; GWG, gestational weight gain; IOM, Institute of Medicine; SD, standard deviation; STPI, State Trait Personality Inventory. <sup>\*</sup>Pearson's chi-square test  $P < 0.05$  between confounder and CTQ score ≥50th percentile. <sup>†</sup>Pearson's chi-square test  $P < 0.05$  between confounder and obesity. <sup>‡</sup>Pearson's chi-square test  $P < 0.05$  between confounder and GWG > IOM.

Prenatal depression did not modify the association ( $P = 0.34$ ).

No difference was observed in mean CTQ score or any subtype of childhood maltreatment by GWG. CTQ score was not associated with the adjusted risk of excessive gestational gain in the overall study

population (Table 3). However, prenatal anxiety modified the relationship between childhood maltreatment and excessive GWG for the continuous CTQ score ( $P = 0.01$ ). Among anxious women, an increase in continuous CTQ score was associated with an increased risk of excessive weight gain. There was

**Table 2.** Association between maternal history of childhood maltreatment and the likelihood of pre-pregnancy obesity stratified by prenatal anxiety

Total CTQ score	Pregavid BMI (kg m <sup>-2</sup> )		Unadjusted RR (95% CI)	Adjusted RR (95% CI)
	<30.0	≥30.0		
Overall				
1 SD increase	–	–	1.27 (1.02, 1.58)	1.31 (1.08, 1.59)
CTQ score categories				
Not elevated (<50th percentile) <sup>†</sup>	206 (48.7)	16 (32.7)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	217 (51.3)	33 (67.4)	1.83 (1.04, 3.24)	2.18 (1.22, 3.87)
Not elevated anxiety				
1 SD increase	–	–	1.06 (0.76, 1.48)	1.10 (0.81, 1.51)
CTQ score categories				
Not elevated (<50th percentile)	153 (50.8)	13 (43.3)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	148 (49.2)	17 (56.7)	1.32 (0.66, 2.62)	1.51 (0.74, 3.07)
Elevated anxiety				
1 SD increase	–	–	1.47 (1.13, 1.90)	1.45 (1.12, 1.88)
CTQ score categories				
Not elevated (<50th percentile) <sup>†</sup>	53 (43.4)	3 (15.8)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	69 (56.6)	16 (84.2)	3.51 (1.07, 11.55)	3.82 (1.23, 11.85)

BMI, body mass index; CI, confidence interval; RR, relative risk; SD, standard deviation. CTQ, Childhood Trauma Questionnaire; not elevated anxiety (<75th percentile of State Trait Personality Inventory); elevated anxiety (≥75th percentile of State Trait Personality Inventory).

<sup>†</sup>Pearson's chi-square test,  $P < 0.05$ . Adjusted for race; smoking; alcohol; marijuana; adjustment for other covariates had no meaningful impact on the results.

**Table 3.** Association between maternal childhood maltreatment and the likelihood of excessive gestational weight gain stratified by prenatal anxiety

Total CTQ score	Gestational weight gain		Unadjusted RR (95% CI)	Adjusted RR (95% CI)
	≤IOM	>IOM		
Overall				
1 SD increase	–	–	1.03 (0.93, 1.13)	1.00 (0.92, 1.10)
CTQ score categories				
Not elevated (<50th percentile)	123 (48.2)	99 (45.6)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	132 (51.8)	118 (54.4)	1.06 (0.87, 1.29)	0.99 (0.81, 1.21)
Not elevated anxiety				
1 SD increase	–	–	0.93 (0.81, 1.07)	0.89 (0.78, 1.02)
CTQ score categories				
Not elevated (<50th percentile)	90 (49.5)	76 (51.0)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	92 (50.6)	73 (49.0)	0.97 (0.76, 1.23)	0.88 (0.69, 1.12)
Elevated anxiety				
1 SD increase	–	–	1.17 (1.04, 1.32)	1.21 (1.07, 1.37)
CTQ score categories				
Not elevated (<50th percentile)	33 (45.2)	23 (33.8)	1.0 (Ref)	1.0 (Ref)
Elevated (≥50th percentile)	40 (54.8)	45 (66.2)	1.29 (0.89, 1.87)	1.28 (0.88, 1.86)

CI, confidence interval; RR, relative risk; SD, standard deviation. CTQ, Childhood Trauma Questionnaire; not elevated anxiety (<75th percentile of State Trait Personality Inventory); elevated anxiety (≥75th percentile of State Trait Personality Inventory). <sup>†</sup>Pearson's chi-square test,  $P < 0.05$ . Adjusted for pre-pregnancy BMI (continuous); race; smoking; alcohol; marijuana; adjustment for other covariates had no meaningful impact on the results.



no association among less anxious women. Prenatal depression also modified the association between continuous CTQ score and the risk of excessive GWG ( $P = 0.05$ ). Every 1 SD increase in CTQ score was associated with a 21% increase in the adjusted risk of excessive GWG (95% CI: 1.06, 1.37) among women with higher levels of depression (results not shown). There was no association among less depressed women [relative risk, RR (95% CI): 0.92 (0.82, 1.04)]. The exclusion of heavy alcohol or marijuana users as well as the application of inverse probability sample weights did not meaningfully change the results of any model.

## Discussion

Our study showed that a history of abuse/neglect in childhood was associated with future risk of pre-pregnancy obesity, particularly among women with elevated levels of anxiety and depression in pregnancy. Furthermore, women with elevated anxiety and depression during pregnancy and childhood abuse/neglect had increased risk of excessive GWG. These associations were independent of the measured confounders.

Our results are consistent with two studies that examined a history of abuse in relation to pregnancy weight. At an Australian prenatal clinic, 239 reported maltreatment based upon the CTQ; those with moderate to severe levels of physical or emotional abuse had a greater likelihood of pre-pregnancy obesity compared with those classified as having no to minimal abuse (Hollingsworth *et al.* 2012). In a low-income cohort of 127 pregnant black teenagers, pre-pregnancy BMI was slightly higher among those reporting physical or sexual abuse before conception compared with those reporting no abuse (Stevens-Simon & McAnarney 1994). The rate of total GWG was similar for abused and non-abused teens. Abused teens delivered significantly earlier, so the investigators may have observed a difference in GWG if they had accounted for gestational age confounding. In a retrospective study of 304 low-income adult women from an urban US prenatal clinic, a history of sexual and/or physical abuse was associated with increased risk of excessive GWG (odds ratio 2.4;

95% CI 1.1–5.5) compared with non-abused women (Johnson *et al.* 2002). Neither of these previous papers specified whether abuse histories were recent or more distal to the index pregnancy.

We found that prenatal anxiety and prenatal depression modified the effect of maltreatment on the risk of excessive GWG. Previous studies of GWG have not assessed mental health as an effect modifier, although an association has been demonstrated in a sample of midlife women (Midei *et al.* 2010). Mood disorders may exacerbate the effect of childhood maltreatment on pregnancy weight (Heim *et al.* 2010). Anxiety and depression may mediate the association between abuse in childhood and eating disordered behaviours (Mazzeo & Espelage 2002; Mazzeo *et al.* 2008; Kong & Bernstein 2009), which may share a mechanism similar to our findings of maltreatment in childhood associated with gestational weight. Our objective was to study the total effect of the association between maltreatment and maternal weight, through all possible paths.

Our results are consistent with previous study findings in which pre-pregnancy BMI was positively associated with levels of anxiety (Bogaerts *et al.* 2013) and the likelihood of major depression (Bodnar *et al.* 2009). The literature on GWG and mood disorders is mixed; some studies have found that depressed women gain more weight (Webb *et al.* 2009) and fat (Casanueva *et al.* 2000), yet others suggest that depressed women gain less weight (Siega-Riz & Hobel 1997; Bodnar *et al.* 2009). In a previous study, there was no association between GWG adequacy and anxiety (Webb *et al.* 2009). Further work must determine whether early factors, particularly stressors, predict the development of obesity over time, and mediation analyses are necessary to understand the mechanism(s) of this association.

Childhood maltreatment may impact weight through neuroendocrine or behaviour-driven pathways. Recent studies suggest that the biological response to stress, the adoption of poor health behaviours and the enduring dysphoria after childhood maltreatment may not precipitate obesity development immediately, but may explain the maintenance of adulthood obesity (Noll *et al.* 2007). Stress may promote hormonal imbalances in the



hypothalamic–pituitary–adrenal axis, resulting in altered metabolism or fat storage and subsequent weight gain. Alternatively, the path to weight gain may be behaviour-driven through stress-reducing coping strategies such as chronic overeating (Sanci *et al.* 2008) or declining physical activity, resulting in weight gain. It is likely that these biological and behavioural mechanisms are not independent. We are unable to discern whether first trimester anxiety or depression among those with childhood maltreatment preceded or followed early pregnancy weight gain as reported at study enrolment.

Pregnancy is a major life event and our measures of anxiety may not be specific to the anxiety experienced during pregnancy. The STAI has been validated for use in pregnant populations (Spielberger *et al.* 1983) and a recent meta-analysis found that the STAI was the most commonly used questionnaire to measure anxiety during pregnancy (Littleton *et al.* 2007).

Our study sample consisted of healthy, low-income women selected from a prenatal clinic. The cohort was racially balanced and reflected the distribution of the clinic population. As the MHPCD study was designed to examine the intrauterine effects of maternal substance use, these groups were over-sampled; however, we do not believe that selection for the cohort impacted the risk of maternal weight outcome, and thus it is unlikely that selection bias impacts our study. While substance use was prevalent, no women in the sample abused substances and the majority of women did not use heavily. Many women (18%) abstained from alcohol, marijuana and tobacco; for those who did not abstain, most women decreased their use over the course of pregnancy. Further, our results were unchanged after excluding heavy users or when applying inverse probability sample weights. Substance use is common in pregnancy (Substance Abuse and Mental Health Services Administration 2009) and we adjusted for prenatal substance use using well-defined measures. Levels of substance use were unrelated to maternal anxiety or depression and were included in multivariable models, strengthening our findings. Nevertheless, our findings may not be generalisable to all pregnant women. Few women were obese before pregnancy (10.4%) in this study

compared with modern cohorts (Chu *et al.* 2009), so it is uncertain whether our results are generalisable.

In our study, the assessment of childhood maltreatment took place 16 years after the index pregnancy. However, adult recall of childhood victimisation is more likely to be biased in the direction of under-reporting (Fergusson *et al.* 2000). We used a validated and reliable instrument to assess the women's history of exposure to five types of childhood maltreatment (Bernstein *et al.* 2003). Misreporting is a known limitation of recalled maternal weight and height; we know of no reason that the reporting of maternal weight would change based upon a woman's history of child maltreatment and thus we reason that if any misclassification is present, it is likely to be non-differential. However, maternal weights were recalled prospectively over pregnancy where pre-pregnancy weight was self-reported at the first trimester visit and final pregnancy weight gain was recalled at delivery which strengthens their validity. Our findings may be affected by unmeasured factors such as whether women were seeking therapy for child maltreatment or mental health treatment, which may have impacted maternal weight.

We found that a history of childhood maltreatment is associated with a greater likelihood of pre-pregnancy obesity and excessive pregnancy weight gain among women with elevated anxiety. Screening for childhood maltreatment and anxiety may aid health care providers to identify women at high risk of obesity and excessive GWG. These women may benefit from individualised nutritional counselling.

## Source of funding

This research was supported by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) (AA06666, AA00312); the National Institute on Drug Abuse (NIDA) (DA03874); and the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) (HD072008).

## Conflicts of interest

The authors declare that they have no conflicts of interest.

## Contributions

JCD, LMB and CAL designed the research; JCD analysed the data; JCD, LMB and CAL wrote the paper; JCD had primary responsibility for final content. All authors read and approved the final manuscript.

## References

- Aaron D.J. & Hughes T.L. (2007) Association of childhood sexual abuse with obesity in a community sample of lesbians. *Obesity (Silver Spring)* **15**, 1023–1028.
- Bernstein D.P. & Fink L. (1998) *Childhood Trauma Questionnaire: A Retrospective Self-Report Manual*. The Psychological Corporation: San Antonio, TX.
- Bernstein D.P., Stein J.A., Newcomb M.D., Walker E., Pogge D., Ahluvalia T. et al. (2003) Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse and Neglect* **27**, 169–190.
- Bodnar L.M., Wisner K.L., Moses-Kolko E., Sit D.K. & Hanusa B.H. (2009) Prepregnancy body mass index, gestational weight gain, and the likelihood of major depressive disorder during pregnancy. *The Journal of Clinical Psychiatry* **70**, 1290–1296.
- Bodnar L.M., Siega-Riz A.M., Simhan H.N., Himes K.P. & Abrams B. (2010) Severe obesity, gestational weight gain, and adverse birth outcomes. *The American Journal of Clinical Nutrition* **91**, 1642–1648.
- Bogaerts A.F., Devlieger R., Nuyts E., Witters I., Gyselaers W. & Van den Bergh B.R. (2013) Effects of lifestyle intervention in obese pregnant women on gestational weight gain and mental health: a randomized controlled trial. *International Journal of Obesity (London)* **37**, 814–821.
- Boynton-Jarrett R., Rosenberg L., Palmer J.R., Boggs D.A. & Wise L.A. (2012) Child and adolescent abuse in relation to obesity in adulthood: the Black Women's Health Study. *Pediatrics* **130**, 245–253.
- Casanueva E., Labastida J., Sanz C. & Morales-Carmona F. (2000) Depression and body fat deposition in Mexican pregnant adolescents. *Archives of Medical Research* **31**, 48–52.
- Catalano P.M. (2007) Management of obesity in pregnancy. *Obstetrics and Gynecology* **109**, 419–433.
- Chu S.Y., Kim S.Y. & Bish C.L. (2009) Prepregnancy obesity prevalence in the United States, 2004–2005. *Maternal and Child Health Journal* **13**, 614–620.
- Day N.L., Leech S.L., Richardson G.A., Cornelius M.D., Robles N. & Larkby C. (2002) Prenatal alcohol exposure predicts continued deficits in offspring size at 14 years of age. *Alcoholism, Clinical and Experimental Research* **26**, 1584–1591.
- Fergusson D.M., Horwood L.J. & Woodward L.J. (2000) The stability of child abuse reports: a longitudinal study of the reporting behaviour of young adults. *Psychological Medicine* **30**, 529–544.
- Greenland S., Pearl J. & Robins J.M. (1999) Causal diagrams for epidemiologic research. *Epidemiology* **10**, 37–48.
- Heim C., Shugart M., Craighead W.E. & Nemeroff C.B. (2010) Neurobiological and psychiatric consequences of child abuse and neglect. *Developmental Psychobiology* **52**, 671–690.
- Hernan M.A., Hernandez-Diaz S. & Robins J.M. (2004) A structural approach to selection bias. *Epidemiology* **15**, 615–625.
- Hollingsworth K., Callaway L., Duhig M., Matheson S. & Scott J. (2012) The association between maltreatment in childhood and pre-pregnancy obesity in women attending an antenatal clinic in Australia. *PLoS ONE* **7**, e51868.
- Hussey J.M., Chang J.J. & Kotch J.B. (2006) Child maltreatment in the United States: prevalence, risk factors, and adolescent health consequences. *Pediatrics* **118**, 933–942.
- IOM (2009) *Weight Gain During Pregnancy: Reexamining the Guidelines*. National Academy Press: Washington, DC.
- Johnson P.J., Hellerstedt W.L. & Pirie P.L. (2002) Abuse history and nonoptimal prenatal weight gain. *Public Health Reports* **117**, 148–156.
- Kong S. & Bernstein K. (2009) Childhood trauma as a predictor of eating psychopathology and its mediating variables in patients with eating disorders. *Journal of Clinical Nursing* **18**, 1897–1907.
- Littleton H.L., Breitkopf C.R. & Berenson A.B. (2007) Correlates of anxiety symptoms during pregnancy and association with perinatal outcomes: a meta-analysis. *American Journal of Obstetrics and Gynecology* **196**, 424–432.
- Mamun A.A., Lawlor D.A., O'Callaghan M.J., Bor W., Williams G.M. & Najman J.M. (2007) Does childhood sexual abuse predict young adult's BMI? A birth cohort study. *Obesity (Silver Spring)* **15**, 2103–2110.
- Mazzeo S.E. & Espelage D. (2002) Association between childhood physical and emotional abuse and disordered eating behaviors in female undergraduates: an investigation of the mediating role of alexithymia and depression. *Journal of Counseling Psychology* **49**, 86–100.
- Mazzeo S.E., Mitchell K.S. & Williams L.J. (2008) Anxiety, alexithymia, and depression as mediators of the association between childhood abuse and eating disordered behavior in African American and European American Women. *Psychology of Women Quarterly* **32**, 267–280.
- Midei A.J., Matthews K.A. & Bromberger J.T. (2010) Childhood abuse is associated with adiposity in midlife

- women: possible pathways through trait anger and reproductive hormones. *Psychosomatic Medicine* **72**, 215–223.
- MMWR (2010) Adverse childhood experiences reported by adults – five states, 2009. *MMWR. Morbidity and Mortality Weekly Report* **59**, 1609–1613.
- Nicolson N.A., Davis M.C., Kruszewski D. & Zautra A.J. (2010) Childhood maltreatment and diurnal cortisol patterns in women with chronic pain. *Psychosomatic Medicine* **72**, 471–480.
- Noll J.G., Zeller M.H., Trickett P.K. & Putnam F.W. (2007) Obesity risk for female victims of childhood sexual abuse: a prospective study. *Pediatrics* **120**, e61–e67.
- Radloff L. (1977) The CES-D scale: a self-report depression scale for research in the general population. *Applied Psychological Measurement* **1**, 385–401.
- Richardson A.S., Dietz W.H. & Gordon-Larsen P. (2013) The association between childhood sexual and physical abuse with incident adult severe obesity across 13 years of the National Longitudinal Study of Adolescent Health. *Pediatric Obesity* 20 September 2013; doi: 10.1111/j.2047-6310.2013.00196.x. [Epub ahead of print] PMID: 3961565.
- Sanci L., Coffey C., Olsson C., Reid S., Carlin J.B. & Patton G. (2008) Childhood sexual abuse and eating disorders in females: findings from the Victorian Adolescent Health Cohort Study. *Archives of Pediatrics and Adolescent Medicine* **162**, 261–267.
- Scher C.D., Stein M.B., Asmundson G.J., McCreary D.R. & Forde D.R. (2001) The childhood trauma questionnaire in a community sample: psychometric properties and normative data. *Journal of Traumatic Stress* **14**, 843–857.
- Siega-Riz A.M. & Hobel C.J. (1997) Predictors of poor maternal weight gain from baseline anthropometric, psychosocial, and demographic information in a Hispanic population. *Journal of the American Dietetic Association* **97**, 1264–1268.
- Spielberger C.D., Gorsuch R.L., Lushene R., Vagg P.R. & Jacobs G.A. (1983) *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press: Palo Alto, CA.
- Stevens-Simon C. & McAnarney E.R. (1994) Childhood victimization: relationship to adolescent pregnancy outcome. *Child Abuse and Neglect* **18**, 569–575.
- STPI; Spielberger C.D. (1979) *Preliminary Manual for the State-Trait Personality Inventory (STPI)*. Center for Research in Behavioral Medicine and Health Psychology, PCD 4118G, University of South Florida: Tampa, FL.
- Substance Abuse and Mental Health Services Administration, Office of Applied Studies. (2009) *The NSDUH Report: Substance Use among Women During Pregnancy and Following Childbirth*. Rockville, MD.
- US Bureau of Labor Statistics (2014) U.S. Bureau of Labor Statistics CPI Inflation Calculator. Retrieved from [http://www.bls.gov/data/inflation\\_calculator.htm](http://www.bls.gov/data/inflation_calculator.htm).
- Vanderwerker L.C., Day N.L., Baker C.E., Richardson G.A. & Stone R.A. (2003) *Depression in Children: A Comparison of Mother and Child Reports*. University of Pittsburgh: Pittsburgh, PA.
- Webb J.B., Siega-Riz A.M. & Dole N. (2009) Psychosocial determinants of adequacy of gestational weight gain. *Obesity (Silver Spring)* **17**, 300–309.
- Westreich D. & Greenland S. (2013) The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. *American Journal of Epidemiology* **177**, 292–298.
- Widom C.S. & Morris S. (1997) Accuracy of adult recollections of childhood victimization: Part 2. Childhood sexual abuse. *Psychological Assessment* **9**, 34–46.
- Widom C.S. & Shepard R.L. (1996) Accuracy of adult recollections of childhood victimization: Part 1. Childhood physical abuse. *Psychological Assessment* **8**, 412–421.
- Williamson D.F., Thompson T.J., Anda R.F., Dietz W.H. & Felitti V. (2002) Body weight and obesity in adults and self-reported abuse in childhood. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* **26**, 1075–1082.
- Zou G. (2004) A modified Poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology* **159**, 702–706.