

# Maternal Depression and Childhood Overweight in the CHAMACOS Study of Mexican-American Children

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**Abstract** *Objective* Although previous studies have examined the impact of maternal depression on child overweight and obesity, little is known about the relationship in Latino families, who suffer from high risks of depression and obesity. We prospectively investigated the association between depressive symptoms in women with young children and child overweight and obesity (overweight/obesity) at age 7 years among Latino families. *Methods* Participants included 332 singletons with anthropometric measures obtained at 7 years from the Center for the Health Assessment of Mothers and Children

of Salinas (CHAMACOS) study, a birth cohort study. Maternal depression was assessed using the Center for Epidemiologic Studies-Depression (CES-D) scale when the children were 1, 3.5, and 7 years. Overweight and obesity was measured by body mass index ( $\text{kg}/\text{m}^2$ ) at age 7 years. *Results* 63 % of women had CES-D scores consistent with depression in at least one of the 3 given assessments. Compared to children whose mothers were never depressed, children whose mothers were depressed at all three assessments had 2.4 times the adjusted odds of overweight/obesity at age 7 years (95 % CI 1.1–5.6). However, a single positive maternal depression screen was not associated with child overweight/obesity and there was no difference in the odds of overweight/obesity by the age of the child when maternal depression occurred. *Conclusion* Chronic maternal depression during a child's early life was associated with child overweight/obesity at 7 years. Addressing maternal depression is a critical component of comprehensive obesity prevention and treatment strategies for Latino children.

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Jocelyn Audelo and Katherine Kogut are jointly first author.

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## Abbreviations

|          |   |
|----------|---|
| BMI      | Body mass index   |
| CDC      | Centers for Disease Control and Prevention                          |
| CES-D    | Center for Epidemiologic Studies-Depression                         |
| CHAMACOS | Center for the Health Assessment of Mothers and Children of Salinas |
| CI       | Confidence interval   |
| DAG      | Directed acyclic graph  |
| OR       | Odds ratio  |

## Significance

*What is known on this subject?* Prior studies have evaluated the impact of episodic perinatal depression on toddler and school-age child growth with inconsistent evidence. More dependably, research demonstrates that chronic maternal depression is associated with greater risk for child overweight. No literature explores these relationships specifically in Latino families, and few studies consider maternal pre-pregnancy body mass index, an important confounder.

*What this study adds?* In a predominately Mexican-American population, we found a significant association between chronic maternal depression and childhood overweight, independent of maternal weight status. We did not find a significant association between episodic maternal depression and child overweight.

## Introduction

Approximately 34 % of 6–11-year old children in the United States are overweight or obese, with the highest prevalence among Mexican American children (46 %) [26]. Maternal depression, which is estimated to afflict 14 % of women of reproductive age [12], has been implicated as a potential risk factor for childhood overweight and obesity [22]. The relationship of maternal depression and childhood overweight/obesity has been hypothesized to be associated with parenting practices [16], as depressed mothers may have difficulty sustaining exclusive breastfeeding [1], recognizing child satiety cues [18, 19], providing healthful food choices [18, 24], and modeling physical activity behaviors relative to non-depressed mothers [23]. Maternal depression also increases risk for depression in children [5, 14, 15], which may in turn influence children's weight [25].

Few prospective studies have tracked maternal depression or child weight throughout childhood. The Project Viva cohort ( $n = 838$ ), a longitudinal study of primarily white, educated women and their children, found a slight but significant increase in central body fat among 3-year-old children whose mothers were identified as depressed using the Edinburgh Postpartum Depression Scale (EPDS) [7, 8] in the first year after delivery [10]. However, studies of similar design using the EPDS found no association between maternal depressive symptoms during infancy and child overweight at 2 years in Europe ( $n = 929$ ) [17] or between maternal depression during toddlerhood and child overweight at 4 years in Brazil ( $n = 4,287$ ) [28]. Associations with chronic depression were more consistent. Wang et al. [33] reported an association between persistent maternal depressive symptoms during the first 3 years of a

child's life and an increased risk of childhood overweight/obesity at school age in a cohort ( $n = 1090$ ) of primarily white, educated women and their children. Duarte et al. [9] found complex associations between maternal depressive symptoms and child body mass index (BMI) in 21,260 children that varied by child age and sex. However, neither study controlled for maternal BMI, an important covariate that may explain part of the relationship between maternal depression and child weight status. Lampard et al. [22] published a systematic review of literature of maternal depression and concluded that in studies measuring depression on multiple occasions, chronic but not episodic maternal depression was consistently related to a greater risk for childhood overweight. To our knowledge, no literature explores this relationship among Latina women and children, a high-risk population.

The goal of the present study was to examine the relationship of maternal depression when children were 1–7 years of age with child overweight and obesity at age 7 years in low-income Latina women and their children. We hypothesized that children exposed to maternal depression, particularly chronic or recurrent depression, would have higher BMI than children whose mothers were not depressed. We also hypothesized that we would find significant differences in obesity risk factors between children of depressed and non-depressed mothers.

## Methods

### Participants

The Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS) is a prospective birth cohort study examining the health of women and their children living in the Salinas Valley, an agricultural region of California [11]. Pregnant women were recruited from Salinas Valley medical clinics which served a primarily low-income farmworker population. Women who presented for a prenatal care visit prior to 20 weeks gestation between October 1999 and October 2000 were screened for eligibility and invited to participate. Eligible women were  $\geq 18$  years of age, qualified for Medi-Cal (state low-income health insurance), planned to deliver at the county medical center, and spoke Spanish or English. Written informed consent was obtained from all women. At age 7 years, children provided oral assent. Study protocols were approved by the institutional review board at University of California, Berkeley.

A total of 601 pregnant women were enrolled in the study and 526 remained in the study at delivery of liveborn, singleton infants. These mother–child pairs were invited to participate in follow-up visits at child ages 6 months,

1 year, 2 years, 3.5 years, 5 years, and 7 years of age. The present analysis was limited to 332 mother–child pairs who remained in the study and completed child anthropometry and assessment of maternal depression at the 7-year study visit. Compared to women who delivered live-born singletons but were lost to follow-up ( $n = 194$ ), women in this sample were older, had lived in the U.S. longer, were less likely to smoke, and were more likely to be overweight or obese, but did not differ significantly in rates of depression at the 1-year study visit (Supplemental Table 1).

### Interviews and Assessments

Women were interviewed using structured questionnaires during pregnancy, shortly after delivery, and at each follow-up visit. Demographic information (e.g. maternal age, country of birth, marital status, parity, education, years in the U.S., housing density, income) was gathered during pregnancy, and poverty level was calculated by dividing household income by the number of people supported and comparing it to federal poverty thresholds [31]. Social support was assessed during pregnancy using a modified version of the Duke-University of North Carolina Functional Social Support Questionnaire (FSSQ) [3]. Food insecurity was measured at the 7-year visit using the U.S. Household Food Security Instrument [2], and households were classified as “food secure” or not based on U.S. Department of Agriculture Guidelines [32].

Information on child diet and related factors was also gathered from maternal interviews. Questions on duration of breastfeeding and age at introduction of solids were asked at 6 month, 1 year, and 2 year interviews. We assessed the quality of the children’s home environment when the children were 1 and 3.5 years of age using the Infant-Toddler Home Observation for Measurement of the Environment (H.O.M.E.) instrument [4]. At the 7 year visit, we gathered data on consumption of soda, fast food, and sweets, frequency of family meals [i.e. child sharing meal with parent(s)], and hours of outdoor play and TV viewing.

Additional data used in analyses include maternal pre-pregnancy BMI status, calculated using self-reported pre-pregnancy weight and measured height, and then categorized as “Normal” ( $18.0 \text{ kg/m}^2$  –  $24.9 \text{ kg/m}^2$ ) versus “Overweight or Obese” ( $\geq 25.0 \text{ kg/m}^2$ ) according to Centers for Disease Control and Prevention (CDC) Adult BMI guidelines (2010). Maternal BMI at child age 7 years was calculated based on weight and height as measured at this visit and categorized as above. Child birthweight was abstracted from delivery medical records by a registered nurse. At 7 years, we evaluated depression in children using the Children’s Depression Inventory (CDI) [21], and use age- and sex-standardized t-scores here.

### Measure of Maternal Depression

Maternal depression was first assessed at the 1-year study visit, and assessed again at 3.5- and 7-year visits, using the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D) [27]. The CES-D elicits symptom-based responses that are not equivalent to a clinical diagnosis of depression. Scores range from 0 to 60, with higher scores indicating more symptoms; respondents with scores of 16 or greater are considered at risk for clinical depression [27]. For this analysis, scores  $\geq 16$  were used to classify mothers as “depressed” at each visit; while CES-D scores  $\geq 20$  were used to classify mothers as “severely depressed.” We classified a subset of women who were missing depression data at 1-year ( $n = 25$  missing) or 3.5-year visits ( $n = 36$  missing) as “non-depressed” at these visits, though we later assessed the impact on results of changing this classification or excluding them from analyses. Based on depressive symptoms by time point, women were categorized into time-specific descriptive groups, i.e. “never depressed” versus depressed at “1 year only”, “3.5 years only”, “7 years only”, “1 year and 3.5 years”, “3.5 years and 7 years”, “1 year and 7 years”, and “1 year, 3.5 years, and 7 years.” Women were further categorized as “never depressed,” “depressed once,” “depressed twice” and “always depressed” to capture symptom chronicity.

### Measures of Child Overweight and Obesity

Age- and sex-standardized BMI percentiles were used as an indicator of childhood obesity at 7 years. Barefoot standing height was measured three times (to the nearest 1 mm) using a SECA brand stadiometer, and the three measurements were averaged. Standing weight was measured (to the nearest 0.1 kg) using a digital scale (Tanita Mother-Baby Scale Model 1582, Tanita Corp). Standardized BMI-for-age percentiles for boys and for girls were calculated based on the 2000 CDC growth charts. Per CDC definitions, children were categorized as “overweight” if their age- and sex-specific BMI was  $\geq 85$ th but  $< 95$ th percentile, “obese” if  $\geq 95$ th percentile, and “normal” otherwise [6]. No children were underweight ( $< 5$ th percentile). Main analyses use a binary “overweight/obese” versus “normal” variable.

### Data Analysis

We conducted bivariate analyses ( $\chi^2$ ,  $t$  tests, and analyses of variance) to compare women included in versus excluded from analyses, to examine associations of demographic characteristics with both maternal depression and child overweight/obesity, and to examine whether potential

obesity risk factors which we believed to be theoretical mediators of a relationship between maternal depression and child overweight/obesity (see directed acyclic graph or DAG, Supplemental Figure 1) were associated with either factor. We used the four-category depression chronicity variable in bivariate analyses and present  $p$  values in tables that reflect differences among these groups. However, to describe in the text how “always” depressed women differed from others, we also reran analyses using a binary “always” versus “never or ever” variable.

We used logistic regression modelling to assess the association of maternal depression with child overweight/obesity status. Both unadjusted and adjusted models included time-specific maternal depression (i.e. CES-D  $\geq 16$  “never,” at “1 year only”, etc.) or severe maternal depression (i.e. CES-D  $\geq 20$ ) as the independent variable and child overweight/obesity status as the dependent variable. Models were adjusted for potential confounders we identified using a DAG (see Supplemental Figure 1), namely: child birthweight (continuous); maternal years in the U.S.; pre-pregnancy weight status; prenatal smoking status; prenatal social support; family poverty status and housing density during pregnancy; and family food security at child age 7 years (all categorical as in Table 1, with indicator terms used). Associations are presented as odds ratios (ORs) reflecting the odds of overweight/obesity for children whose mothers experienced depression at any specific time point(s) relative to the odds for children whose mothers were never depressed. We lacked statistical power to assess effect modification (i.e. interaction). We crudely examined the potential mediation of obesity risk factors by adding each variable separately to the final adjusted CES-D  $\geq 16$  model to assess if main associations were deflated.

In sensitivity analyses, we ran logistic regression models using child obesity as the dependent variable, modelling this outcome as “obese” versus “normal or overweight” and separately as “obese” versus “normal weight” (excluding overweight children). We also ran models with women who were missing depression data at 1- or 3.5-year visits reclassified as “depressed” at those visits or excluded from analyses.

Our DAG was generated using DAGitty version 2.3 (daggity.net). All statistical analyses were performed using STATA version 11.1.

## Results

As presented in Table 1, most women in this sample were born outside the U.S. (87 %), and many were relatively recent immigrants (46 %). Most lived below the federal poverty level at enrollment (62 %) and were overweight or

obese prior to pregnancy (65 %). Only 36 % of women in this sample “never” experienced depression (CES-D  $\geq 16$ ); 28 % of women were depressed at one, 22 % were depressed at two, and 14 % were depressed at all three time points (“always” depressed). As seen in Table 1, chronicity of depression varied in association with maternal education, social support, food security, and maternal BMI at the 7-year visit. Compared to women who were “never or ever” depressed, women who were “always” depressed were significantly more likely to have smoked ( $p = 0.01$ ) and to have experienced low social support ( $p = 0.02$ ) during pregnancy, and to be food insecure at the 7-year visit ( $p = 0.001$ ), but did not differ significantly in other attributes (comparisons not shown).

Among children in this sample, 155 (47 %) were normal weight at age 7 years and 177 (53 %) were either overweight or obese (18 % overweight, 36 % obese; not shown). Mothers who were depressed at the 7 year visit (regardless of earlier depression status) were marginally more likely to have an overweight/obese child than women who were not depressed at this visit (60 vs 51 %;  $\chi^2$   $p$  value = 0.16, results not shown). As presented in Supplemental Table 2, women who were overweight/obese, were older at delivery, smoked during pregnancy, or lived in moderately crowded conditions (1.01–1.50 people/room) during pregnancy were all more likely to have overweight/obese children, while children born at low birthweight were less likely to be overweight/obese.

Table 2 presents unadjusted and adjusted ORs for child overweight/obesity at age 7 years as a function of mothers’ depression or severe depression at specific time points. A statistically significant increased odds (adjusted OR 2.4, 95 % CI 1.1–5.6) of overweight/obesity was only observed among children of mothers who were depressed (CES-D  $\geq 16$ ) at all three time points. Children whose mothers were depressed at any one or two points did not differ in odds of overweight/obesity compared to children of mothers who were never depressed; this was confirmed when the model was repeated comparing “once,” “twice,” and “always” depressed to “never” depressed women (adjusted OR for “once”: 1.2, 95 % CI 0.7–2.2; OR for “twice”: 1.3, 95 % CI 0.7–2.5; OR for “always” the same as presented above; results not shown). It is also reflected in Fig. 1, which shows a higher percentage of overweight/obese children in this “always” depressed category relative to others. As presented in Table 2, a mother’s severe depression (CES-D  $\geq 20$ ) at all three time points was associated with increased odds of child overweight/obesity (adjusted OR 3.3, 95 % CI 1.2–9.0), as was severe depression at both 1 year and 3.5 years (adjusted OR 2.5, 95 % CI 1.1–5.9).

As presented in Table 3 and Supplemental Table 3, several theoretical mediators varied in association with either the chronicity of mothers’ depression or child

**Table 1** Background characteristics of  $n = 332$  CHAMACOS<sup>a</sup> mothers and children followed to 7 years of age, by frequency of mothers' positive screen ( $\geq 16$ ) on Center for Epidemiological Studies-Depression (CES-D)<sup>b</sup>: Salinas Valley, California, 2000–2008

| Characteristic                              | Total      | Positive CES-D depression screen |            |            |            | <i>p</i> value <sup>c</sup> |
|---|------------|----------------------------------|------------|------------|------------|-----------------------------|
|   |            | Never                            | Once       | Twice      | Always     |                             |
| Total [n (%)]                               |            | 121 (36.5)                       | 94 (28.3)  | 72 (21.7)  | 45 (13.6)  | –                           |
| <b>Maternal characteristics<sup>d</sup></b> |            |                                  |            |            |            |                             |
| Age at delivery (years) [Mean (SD)]         | 26.6 (5.2) | 26.5 (4.9)                       | 26.1 (5.6) | 26.8 (4.7) | 27.6 (6.1) | 0.43                        |
| Age at delivery (years) [n (%)]             |            |                                  |            |            |            |                             |
| 18–24                                       | 134 (40.4) | 53 (43.8)                        | 44 (46.8)  | 20 (27.8)  | 17 (37.8)  | 0.06                        |
| 25–29                                       | 113 (34.0) | 40 (33.0)                        | 29 (30.9)  | 33 (45.8)  | 11 (24.4)  |                             |
| 30–45                                       | 85 (25.6)  | 28 (23.1)                        | 21 (22.3)  | 19 (26.4)  | 17 (37.8)  |                             |
| Marital status at 7 years [n (%)]           |            |                                  |            |            |            |                             |
| Not married                                 | 55 (16.6)  | 18 (14.9)                        | 18 (19.2)  | 9 (12.5)   | 10 (22.2)  | 0.46                        |
| Married/living as married                   | 277 (83.4) | 103 (85.1)                       | 76 (80.9)  | 63 (87.5)  | 35 (77.8)  |                             |
| Education [n (%)]                           |            |                                  |            |            |            |                             |
| <6th grade                                  | 149 (44.9) | 48 (39.7)                        | 46 (48.9)  | 38 (52.8)  | 17 (37.8)  | <0.01                       |
| 7th to 12th grade                           | 112 (33.7) | 32 (26.5)                        | 35 (37.2)  | 26 (36.1)  | 19 (42.2)  |                             |
| >High school                                | 71 (21.4)  | 41 (33.9)                        | 13 (13.8)  | 8 (11.1)   | 9 (20.0)   |                             |
| Socioeconomic status [n (%)]                |            |                                  |            |            |            |                             |
| At or below poverty                         | 207 (62.4) | 73 (60.3)                        | 55 (58.5)  | 48 (66.7)  | 31 (68.9)  | 0.53                        |
| >Poverty                                    | 125 (37.6) | 48 (39.7)                        | 39 (41.5)  | 24 (33.3)  | 14 (31.1)  |                             |
| Country of birth [n (%)]                    |            |                                  |            |            |            |                             |
| U.S.  | 44 (13.3)  | 19 (15.7)                        | 15 (16.0)  | 6 (8.3)    | 4 (8.9)    | 0.32                        |
| Mexico or other                             | 288 (86.7) | 102 (84.3)                       | 79 (84.0)  | 66 (91.7)  | 41 (91.1)  |                             |
| Years in United States [n (%)]              |            |                                  |            |            |            |                             |
| 0–5 years                                   | 154 (46.4) | 55 (45.5)                        | 44 (46.8)  | 29 (40.3)  | 26 (57.8)  | 0.32                        |
| $\geq 6$ years <sup>e</sup>                 | 178 (53.6) | 66 (54.6)                        | 50 (53.2)  | 43 (59.7)  | 19 (42.2)  |                             |
| Social support [n (%)]                      |            |                                  |            |            |            |                             |
| Lowest tertile                              | 123 (37.1) | 23 (19.0)                        | 40 (42.6)  | 37 (51.4)  | 23 (51.1)  | <0.001                      |
| Middle tertile                              | 112 (33.7) | 41 (33.9)                        | 34 (36.2)  | 21 (29.2)  | 16 (35.6)  |                             |
| Highest tertile                             | 97 (29.2)  | 57 (47.1)                        | 20 (21.3)  | 14 (19.4)  | 6 (13.3)   |                             |
| Parity [n (%)]                              |            |                                  |            |            |            |                             |
| 0   | 104 (31.3) | 40 (33.1)                        | 28 (29.8)  | 23 (31.9)  | 13 (28.9)  | 0.94                        |
| 1+  | 228 (68.7) | 81 (66.9)                        | 66 (70.2)  | 49 (68.1)  | 32 (71.1)  |                             |
| Smoking during pregnancy [n (%)]            |            |                                  |            |            |            |                             |
| Non-smoker                                  | 318 (95.8) | 119 (98.4)                       | 90 (95.7)  | 69 (95.8)  | 40 (88.9)  | 0.06                        |
| Smoker                                      | 14 (4.2)   | 2 (1.7)                          | 4 (4.3)    | 3 (4.2)    | 5 (11.1)   |                             |
| Pre-pregnancy BMI <sup>f</sup> [n (%)]      |            |                                  |            |            |            |                             |
| Normal                                      | 116 (34.9) | 49 (40.5)                        | 28 (29.8)  | 24 (33.3)  | 15 (33.3)  | 0.41                        |
| Overweight/Obese                            | 216 (65.1) | 72 (59.5)                        | 66 (70.2)  | 48 (66.7)  | 30 (66.7)  |                             |
| BMI <sup>f</sup> at 7-year visit [n (%)]    |            |                                  |            |            |            |                             |
| Normal                                      | 40 (12.7)  | 22 (19.3)                        | 6 (6.9)    | 9 (13.2)   | 3 (6.7)    | 0.04                        |
| Overweight/Obese                            | 274 (87.3) | 92 (80.7)                        | 81 (93.1)  | 59 (86.8)  | 42 (93.3)  |                             |
| <b>Child characteristics</b>                |            |                                  |            |            |            |                             |
| Birth order [n (%)]                         |            |                                  |            |            |            |                             |
| 1   | 108 (32.5) | 40 (33.1)                        | 31 (33.0)  | 23 (31.9)  | 14 (31.1)  | 0.99                        |
| 2+  | 224 (67.5) | 81 (66.9)                        | 63 (67.0)  | 49 (68.1)  | 31 (68.9)  |                             |
| Birthweight (grams) [n (%)]                 |            |                                  |            |            |            |                             |
| $\geq 2500$                                 | 319 (96.1) | 117 (96.7)                       | 91 (96.8)  | 69 (95.8)  | 42 (93.3)  | 0.76                        |
| <2500                                       | 13 (3.9)   | 4 (3.3)                          | 3 (3.2)    | 3 (4.2)    | 3 (6.7)    |                             |



**Table 1** continued

| Characteristic                        | Total      | Positive CES-D depression screen |            |            |            | <i>p</i> value <sup>c</sup> |
|---------------------------------------|------------|----------------------------------|------------|------------|------------|-----------------------------|
|                                       |            | Never                            | Once       | Twice      | Always     |                             |
| Birthweight (grams) [Mean (SD)]       | 3439 (528) | 3445 (477)                       | 3444 (507) | 3448 (553) | 3403 (660) | 0.97                        |
| Sex [n (%)]                           |            |                                  |            |            |            |                             |
| Male                                  | 156 (47.0) | 66 (54.6)                        | 37 (39.4)  | 32 (44.4)  | 21 (46.7)  | 0.16                        |
| Female                                | 176 (53.0) | 55 (45.5)                        | 57 (60.6)  | 40 (55.6)  | 24 (53.3)  |                             |
| Home characteristics                  |            |                                  |            |            |            |                             |
| Housing density (people/room) [n (%)] |            |                                  |            |            |            |                             |
| <1.00                                 | 80 (24.1)  | 32 (26.5)                        | 22 (23.4)  | 17 (23.6)  | 9 (20.0)   | 0.73                        |
| 1.01–1.50                             | 127 (38.3) | 51 (42.2)                        | 35 (37.2)  | 25 (34.7)  | 16 (35.6)  |                             |
| >1.51                                 | 125 (37.7) | 38 (31.4)                        | 37 (39.4)  | 30 (41.7)  | 20 (44.4)  |                             |
| Food security at 7 years [n (%)]      |            |                                  |            |            |            |                             |
| Food secure                           | 202 (60.8) | 93 (76.9)                        | 53 (56.4)  | 39 (53.2)  | 17 (37.8)  | <0.001                      |
| Food insecure                         | 130 (39.2) | 28 (23.1)                        | 41 (43.6)  | 33 (45.8)  | 28 (62.2)  |                             |

<sup>a</sup> CHAMACOS, Center for the Health Assessment of Mothers and Children of Salinas

<sup>b</sup> Center for Epidemiologic Studies-Depression Scale [21]

<sup>c</sup> *p* value based on one way analysis of variance for continuous variables and on  $\chi^2$  analyses for categorical variables

<sup>d</sup> Characteristics from pregnancy interview unless otherwise noted

<sup>e</sup> This category includes women who were born and raised in the U.S

<sup>f</sup> BMI categorized by CDC Adult BMI guidelines (2010): Normal = 18.0 kg/m<sup>2</sup>–24.9 kg/m<sup>2</sup>; Overweight/Obese  $\geq$ 25.0 kg/m<sup>2</sup>

overweight/obesity, but there was not overlap between the two. Compared to women who were “never or ever” depressed, women who were “always” depressed breastfed their children marginally longer ( $p = 0.17$ ), had less frequent family meals with their children (daily for 60 % of “never/ever” versus 45 % of “always” depressed women,  $p < 0.01$ ), and their children had higher child depression scores ( $p = 0.03$ ; analyses not shown). Children’s overweight/obesity status only varied in association with soda consumption (Supplemental Table 3). In crude mediation analyses, we observed only slight changes in the adjusted OR for depression at all three time points versus “never” upon addition of each risk factor in Table 3. From an initial adjusted OR of 2.4 (see Table 2;  $p$  value = 0.04), adjusted ORs ranged from 2.0 to 2.8 (and  $p$  values from 0.02 to 0.12) after controlling for each potential mediator. The greatest deflation in adjusted ORs was seen when controlling for age at introduction of solids and HOME score at 1 year (results not shown).

In sensitivity analyses, neither reclassifying women with missing depression scores nor removing them from analyses altered results. When “obese” versus “normal or overweight” status was used as the dependent variable, results were ameliorated and non-significant, though the highest OR was still observed for children of always-depressed (CES-D  $\geq$ 16) mothers (adjusted OR 1.7, 95 % CI 0.8–3.8; results not shown). When overweight children were omitted from the analysis and “obese” versus

“normal weight” was used as the dependent variable, the OR was unchanged relative to that shown in Table 2, though results did not maintain statistical significance (adjusted OR 2.4, 95 % CI 0.9–6.0).

## Discussion

The results of this study of low-income Latina mothers and their children indicate that exposure to recurrent maternal depressive symptoms at ages 1, 3.5, and 7 years is a risk factor for overweight/obesity at age 7 years, as is recurrent severe depression (CES-D  $\geq$ 20) in earlier life (1 and 3.5 years). This is the first study among Latino children to demonstrate an association between chronic maternal depression and children’s weight status at school age, and improves upon previous studies [9, 33] by demonstrating that the relationship between maternal depression and offspring overweight is not explained by maternal weight status.

Previous investigators have suggested that maternal depression may impact parenting practices [16], potentially limiting positive interactions with children and impairing ability to breastfeed, offer healthy and balanced meals, and encourage active play [13, 18, 20, 24]. Thus, we examined whether these factors were associated with both maternal depression and child overweight/obesity in this sample, intending to highlight potential causal pathways. In fact,

**Table 2** Odds ratios (OR) with 95 % confidence intervals for overweight/obese BMI at age 7 years from logistic regression model with time-specific depression and severe depression exposure categories, CHAMACOS<sup>a</sup>: Salinas Valley, California, 2000–2008

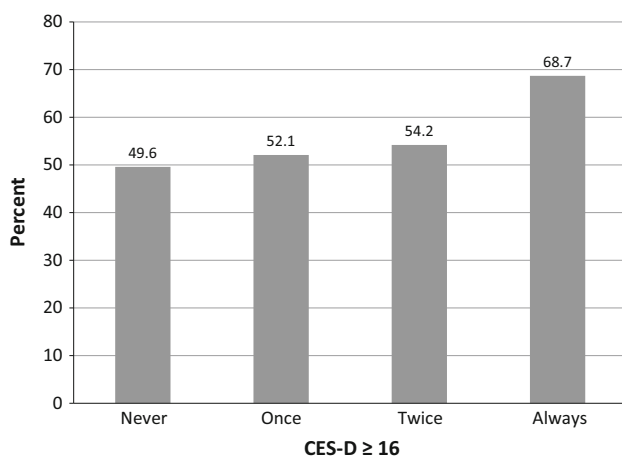
|  | N   | Unadjusted OR (95 % CI) | Adjusted <sup>b</sup> OR (95 % CI) |
|--|-----|-------------------------|------------------------------------|
| Depression (CES-D <sup>c</sup> score ≥16)        |     |                         |                                    |
| Never  | 121 | ref                     | ref                                |
| 1 year only                                      | 48  | 1.0 (0.5–2.0)           | 1.2 (0.6–2.6)                      |
| 1 and 3.5 years                                  | 47  | 1.2 (0.6–2.3)           | 1.4 (0.7–3.1)                      |
| 3.5 year only                                    | 29  | 1.3 (0.6–2.8)           | 1.3 (0.5–3.1)                      |
| 3.5 and 7 years                                  | 12  | 2.0 (0.6–7.1)           | 2.2 (0.6–8.4)                      |
| 7 years only                                     | 17  | 1.1 (0.4–3.2)           | 1.1 (0.4–3.4)                      |
| 1 and 7 years                                    | 13  | 0.6 (0.2–2.1)           | 0.6 (0.2–2.0)                      |
| 1, 3.5, and 7 years                              | 45  | 2.0 (1.0–4.2)           | 2.4* (1.1–5.6)                     |
| Severe depression (CES-D <sup>c</sup> score ≥20) |     |                         |                                    |
| Never  | 160 | ref                     | ref                                |
| 1 year only                                      | 41  | 1.1 (0.6–2.2)           | 1.2 (0.5–2.5)                      |
| 1 and 3.5 years                                  | 37  | 2.2* (1.0–4.7)          | 2.5* (1.1–5.9)                     |
| 3.5 years only                                   | 29  | 1.3 (0.6–2.9)           | 1.0 (0.4–2.5)                      |
| 3.5 and 7 years                                  | 11  | 1.3 (0.4–4.3)           | 1.4 (0.4–5.1)                      |
| 7 years only                                     | 15  | 1.2 (0.4–3.5)           | 1.0 (0.3–3.0)                      |
| 1 and 7 years                                    | 12  | 0.5 (0.2–1.8)           | 0.6 (0.1–2.2)                      |
| 1, 3.5, and 7 years                              | 27  | 2.5* (1.0–6.0)          | 3.3* (1.2–9.0)                     |

<sup>a</sup> CHAMACOS, Center for the Health Assessment of Mothers and Children of Salinas

<sup>b</sup> Adjusted for maternal years in the US; pre-pregnancy maternal weight status; pregnancy smoking, family poverty status, housing density, and social support; child birthweight; and family food security at child age 7 years

<sup>c</sup> Center for Epidemiological Studies-Depression [21]

\*  $p \leq 0.05$



**Fig. 1** Percent of children overweight/obese according to BMI at 7 years of age, by frequency of mothers' positive screen (≥16) on CES-D, CHAMACOS mothers and children followed to 7 years; Salinas, CA, 2000–2008

relatively few of the parenting practices we examined differed as a function of maternal depression. Women who were chronically depressed practiced exclusive breastfeeding marginally longer than women who were never or intermittently depressed, which challenges the hypothesis that maternal depression interferes with early feeding mode. While children of chronically depressed mothers were less likely to enjoy family meals on a daily basis, and showed more symptoms of depression themselves at age 7 years, these risk factors were not themselves associated with overweight/obesity status in bivariate analyses (Supplemental Table 3). Similarly, the one dietary factor that was linked with overweight/obesity—soda consumption—was not associated with maternal depression. One reason our crude analysis may have failed to detect an association between obesity risk factors and overweight/obesity was that many factors were assessed concurrently to the measured weight outcome. Mothers' awareness of their children's overweight status may have influenced them to alter behaviors and/or to under-report behaviors associated with overweight, and it is conceivable that depressed mothers of overweight children could alter their accounts more than non-depressed mothers. Another possibility is that unmeasured parenting practices facilitated greater weight gain among children of depressed mothers. Taveras et al. [29] observed that Hispanic mothers were significantly more likely than white mothers to employ feeding restrictions and pressure to eat with their infants, both risk factors for later overweight; we did not assess these dynamics in this cohort.

There are other important limitations to this study. We did not have information about maternal depressive symptoms during pregnancy or the early postpartum months, which have been hypothesized to be influential in the development of obesity [10, 28]. Second, the CES-D does not guarantee the presence of clinically significant depression. The positive predictive validity of a CES-D screen of ≥16 for major depressive disorder was relatively low (0.28) in at least one sample of low income women, meaning that two-thirds of women who screened positive did not meet criteria for major depressive disorder [30]. Similarly, though a woman's positive CES-D screen at three points suggests recurrence of symptoms, our use of the term "always" depressed is not strictly accurate, since there were long stretches between these visits when symptoms may have abated. Thus, our designation of women as "always depressed" should be understood as experiencing relatively higher depressive symptoms relatively frequently during this period in their children's lives. It is also worth noting that our sample was a non-random regional sample which is not representative of the general U.S. or U.S. Latino population. Finally, we experienced attrition in our study, with younger, more recent immigrant,

**Table 3** Theoretical mediators of a relationship between maternal depression and child overweight/obesity, by frequency of mothers' positive screen ( $\geq 16$ ) on Center for Epidemiological Studies-Depression (CES-D)<sup>a</sup>: CHAMACOS,<sup>b</sup> Salinas Valley, California, 2000–2008

|  | Positive CES-D depression screen |            |            |            | <i>p</i> value <sup>c</sup> |
|--|----------------------------------|------------|------------|------------|-----------------------------|
|  | Never                            | Once       | Twice      | Always     |                             |
| Exclusive breastfeeding (months) [Mean (SD)]                 | 2.0 (2.3)                        | 2.0 (2.2)  | 2.3 (2.7)  | 2.6 (2.4)  | 0.42                        |
| Age at introduction of solid foods [n (%)]                   |                                  |            |            |            |                             |
| $\leq 3$ months  | 10 (9.6)                         | 17 (18.7)  | 9 (12.9)   | 8 (17.8)   | 0.28                        |
| $> 3$ months   | 94 (90.4)                        | 74 (81.3)  | 61 (87.1)  | 37 (82.2)  |                             |
| H.O.M.E. Score <sup>d</sup> at 1y [Mean (SD)]                | 36.4 (3.1)                       | 35.5 (2.8) | 35.0 (3.1) | 36.0 (2.7) | 0.02                        |
| H.O.M.E. Score <sup>d</sup> at 3.5y [Mean (SD)]              | 17.4 (2.3)                       | 16.7 (2.2) | 16.6 (2.6) | 16.5 (2.3) | 0.05                        |
| Child depression score <sup>e</sup> at 7 years [Mean (SD)]   | 46.5 (6.1)                       | 47.0 (6.4) | 48.7 (7.0) | 49.3 (5.4) | 0.02                        |
| Soda consumption at age 7 years [n (%)]                      |                                  |            |            |            |                             |
| $< 1$ serving per week                                       | 80 (66.1)                        | 65 (69.2)  | 45 (62.5)  | 30 (68.2)  | 0.83                        |
| 1+ servings per week   | 41 (33.9)                        | 29 (30.9)  | 27 (37.5)  | 14 (31.8)  |                             |
| Fast food consumption at age 7 years [n (%)]                 |                                  |            |            |            |                             |
| $< 1$ meal per week  | 63 (52.1)                        | 47 (50.0)  | 26 (36.1)  | 18 (40.9)  | 0.13                        |
| 1+ meals per week  | 58 (47.9)                        | 47 (50.0)  | 46 (63.9)  | 26 (59.1)  |                             |
| Family meals at age 7 years [n (%)]                          |                                  |            |            |            |                             |
| Daily  | 81 (67.5)                        | 62 (66.0)  | 51 (70.8)  | 20 (45.5)  | 0.03                        |
| Less than daily  | 39 (32.5)                        | 32 (34.0)  | 21 (29.2)  | 24 (54.6)  |                             |
| Sweets consumption at age 7 years (servings/day) [Mean (SD)] | 0.4 (0.4)                        | 0.4 (0.4)  | 0.5 (0.7)  | 0.4 (0.5)  | 0.63                        |
| Playing outside at age 7 years (h/day) [n (%)]               |                                  |            |            |            |                             |
| $< 1$ h per day  | 12 (10.0)                        | 11 (12.4)  | 10 (13.9)  | 6 (13.6)   | 0.59                        |
| 1–2 h per day  | 67 (55.8)                        | 55 (61.8)  | 41 (56.9)  | 20 (45.5)  |                             |
| 3+ hours per day   | 41 (34.2)                        | 23 (25.8)  | 21 (29.2)  | 18 (40.9)  |                             |
| Watch television at age 7 years (h/day) [n (%)]              |                                  |            |            |            |                             |
| $< 1$ h per day  | 21 (17.4)                        | 17 (18.1)  | 15 (20.8)  | 7 (15.9)   | 0.99                        |
| 1–2 h per day  | 36 (29.8)                        | 27 (28.7)  | 23 (31.9)  | 14 (31.8)  |                             |
| 2+ hours per day   | 64 (52.9)                        | 50 (53.2)  | 34 (47.2)  | 23 (52.3)  |                             |

<sup>a</sup> Center for Epidemiologic Studies-Depression Scale [21]

<sup>b</sup> CHAMACOS, Center for the Health Assessment of Mothers and Children of Salinas

<sup>c</sup> *p* value based on oneway analysis of variance for continuous variables and on  $\chi^2$  analyses for categorical variables

<sup>d</sup> Infant-Toddler Home Observation for Measurement of the Environment (H.O.M.E.) instrument [4]

<sup>e</sup> Children's Depression Inventory (CDI) [21]

and normal weight women, as well as women who smoked, dropping from the study at higher rates. This may have affected our results in unknown ways.

Despite these limitations, this investigation has important strengths. Our longitudinal study with three depression screening points allowed us to distinguish women with chronic symptoms from women with episodic symptoms. Interestingly, a single report of maternal depression at any time point was not associated with obesity. We were also able to consider child depression as a potential mediator between maternal depression and child overweight/obesity, though our crude analyses did not support such mediation. Lastly, we have focused on a population of Latino children, who, despite exceptionally high rates of overweight and

obesity [26], have not to our knowledge been previously investigated in relation to maternal depression.

## Conclusion

Our study showed a significant association between chronic maternal depressive symptoms during childhood and increased risk of overweight/obesity in 7-year-old children. Given the increase in child obesity among Latino populations in particular, and the recognized importance of psychosocial support on child growth and development, illuminating the role of maternal depression is important to understanding the current obesity epidemic and alleviating



its impact on vulnerable populations. These findings suggest that addressing mental health issues in mothers while their children are young may indirectly reduce the risk of childhood obesity.

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**Author Contribution** Jocelyn Audelo, Conducted all literature reviews, analyzed initial data, drafted the manuscript and approved the final manuscript as submitted; Katherine Kogut, Conducted subsequent data analyses, reviewed and revised the manuscript and approved the final manuscript as submitted; Kim G. Harley, Assisted in conceptualization and designing the CHAMACOS study, oversaw data analysis strategy, reviewed and revised the manuscript, and approved the final manuscript as submitted; Lisa G. Rosas, Designed the tool used to assess risk factors for childhood obesity, supervised the use of these data, reviewed and revised the manuscript, and approved the final manuscript as submitted; Lauren Stein, Updated literature reviews, conducted subsequent data analyses, reviewed and revised the manuscript; Brenda Eskenazi, Conceptualized and designed the CHAMACOS study, supervised the data analysis strategy, reviewed and revised the manuscript, and approved the final manuscript as submitted.

#### Compliance with Ethical Standards

**Conflict of Interest** The authors have no financial or other conflicts of interest to disclose.

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