

Pre- and Early Pregnancy Onset Depression and Subsequent Rate of Gestational Weight Gain

Sylvia E. Badon, PhD, Monique M. Hedderson, PhD, Rebecca J. Hyde, MPH,
Charles P. Quesenberry, PhD, and Lyndsay A. Avalos, PhD

Abstract

Background: Depression is associated with weight change outside of pregnancy. We assessed associations of prepregnancy or early pregnancy onset depression with gestational weight gain (GWG) rate overall and according to Institute of Medicine (IOM) recommendations.

Materials and Methods: Depression from 6 months prepregnancy through 20 weeks gestation was identified in a health care system in northern California with perinatal depression screening (2011–2016; $n=87,600$). GWG rate (lbs/week) was calculated using weight at delivery and at diagnosis or depression screening ≤ 20 weeks.

Results: Compared to women without prepregnancy or early pregnancy depression, women with prepregnancy onset depression had 11% greater risk of GWG rate $<$ IOM recommendations (95% confidence intervals [CI]: 1.07–1.15) and 3% greater risk of GWG rate $>$ IOM recommendations (95% CI: 1.01–1.05), with a stronger association for $>$ IOM in normal weight women. Early pregnancy onset depression was associated with 0.04 lbs/week greater GWG rate (95% CI: 0.02–0.07) and 4% greater risk of GWG rate $>$ IOM recommendations (95% CI: 1.02–1.07) compared to no prepregnancy or early pregnancy depression, with stronger associations in obese women.

Conclusions: Women with prepregnancy onset depression may be at higher risk for GWG both below and above recommendations. Women with early onset prenatal depression may be at slightly higher risk for GWG rate above recommendations. Our results suggest that the relationship between depression and GWG may vary based on timing of depression onset, prepregnancy body mass index category, and antidepressant use. Additional research should identify factors that predict how a woman's lifestyle behaviors and weight change after depression diagnosis.

Keywords: pregnancy, depression, gestational weight gain, perinatal depression

Introduction

BOTH INADEQUATE AND EXCESSIVE gestational weight gain (GWG) are associated with adverse maternal and newborn outcomes. The Institute of Medicine (IOM) recommends prepregnancy body mass index (BMI)-specific ranges for total GWG across pregnancy and weekly GWG rate across the second and third trimesters that balance the risks for adverse maternal outcomes, such as cesarean delivery, and adverse newborn outcomes, such as small- and large-for-gestational age birth weight and preterm birth.^{1,2} GWG within the IOM recommendations is associated with reduced risk of preterm birth and small-for-gestational age compared to GWG below the recommendations.³ GWG within the IOM recommendations is also associated with reduced risk of

cesarean delivery and large-for-gestational age compared to GWG above the recommendations.³

Reproductive-age women are at high risk of depression.⁴ In the United States, depression affects 14% of nonpregnant reproductive-age women and between 7% and 12% of pregnant women.^{5–7} Women with depressive symptoms before and during pregnancy may be at especially high risk for GWG outside the IOM recommendations, given associations of depression with both weight loss and weight gain outside of pregnancy.^{8–11} Individuals with depression may experience either increased or decreased appetite,¹² decreased dietary quality,^{13,14} and reduced physical activity,^{15–17} which may contribute to weight changes. Previous studies have found inconsistent associations of prenatal depression with total GWG, calculated from the beginning of pregnancy, and

were unable to look at the prospective association between depression and subsequent GWG.^{18–20} The objective of this study was to determine whether pre- or early pregnancy depression was prospectively associated with GWG rate or risk of GWG rate outside the IOM recommendations after depression screening.

Materials and Methods

Study setting and study population

This study was conducted within Kaiser Permanente Northern California (KPNC), an integrated health care delivery system that provides medical care for about one third of the population in the San Francisco Bay Area. KPNC members are representative of the underlying population of this region.²¹ KPNC members with pregnancies from 2011 to 2016 that ended in a live singleton birth were identified from the KPNC electronic health record database. Inclusion and exclusion criteria are described in Figure 1. The final analytic sample consisted of 87,600 pregnancies among 79,506 women.

Data collection

Data were collected during routine primary and prenatal care visits and entered into the electronic health record database. Prepregnancy BMI was calculated using the prepregnancy (within 12 months before pregnancy) weight measured closest to the start of pregnancy (88% of analytic sample). If a measured weight within 12 months before pregnancy was not available, the first measured weight in the first 10 weeks of pregnancy was used (12%). In women 15–19 years of age, prepregnancy BMI was categorized using the Centers for Disease Control and Prevention 2000 BMI-for-age Growth Charts: underweight: <5th percentile, normal weight: 5th–84.9th percentile, overweight: 85th–94.9th percentile, and obese: ≥95th percentile.²² In women

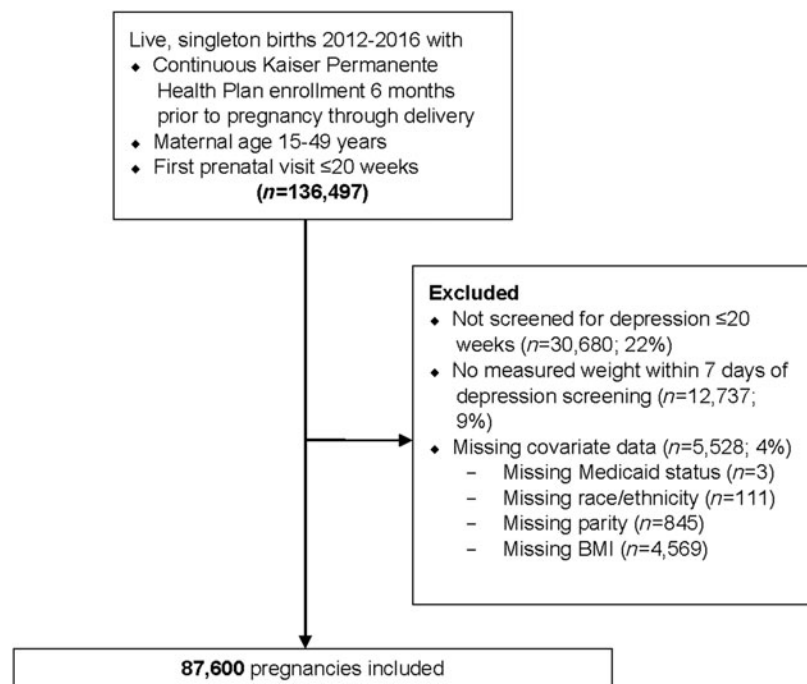
20 years of age and older, prepregnancy BMI was categorized using standard adult cutoff points: underweight: <18.5 kg/m², normal weight: 18.5–24.9 kg/m², overweight: 25–29.9 kg/m², and obese: ≥30 kg/m².²³ This study was approved by the KPNC institutional review board.

Pre- and early pregnancy depressive symptoms

Pregpregnancy onset depression was identified using depression diagnosis codes and antidepressant medication dispensing. Women were considered to have prepregnancy onset depression if they had at least one International Classification of Diseases, 9th Revision diagnosis code for depression (296.20–296.25, 296.30–296.35, 296.82, 298.0, 300.4, 309.0, 309.1, 309.28, 311, or 648.41–648.44), at least one International Classification of Diseases, 10th Revision diagnosis code for depression (F32.0–F32.4, F32.89, F32.9, F33.0–F33.3, F33.41, F33.9, F34.1, F43.21, F43.23, 099.341, 099.342, or 099.343), at least one Kaiser Permanente combination code for depression (501223 or 5027004), or at least one antidepressant medication dispensing (selective serotonin reuptake inhibitor, serotonin and norepinephrine reuptake inhibitors, tricyclic antidepressants, serotonin antagonist and reuptake inhibitor, norepinephrine dopamine reuptake inhibitor, monoamine oxidase inhibitor, serotonin partial agonist-reuptake inhibitor, selective norepinephrine reuptake inhibitor, noradrenergic and specific serotonergic antidepressant; Supplementary Table S1) in the 6 months before pregnancy. Used together, depression diagnosis codes and antidepressant medication dispensing information in the electronic health record is a valid measure of depression (sensitivity = 85%, specificity = 73%, area under the curve = 0.79).²⁴

In women with no prepregnancy onset depression, early onset prenatal depression was identified using depression diagnosis codes or PHQ-9 screening scores. The PHQ-9 is

FIG. 1. Inclusion and exclusion criteria.



a reliable and valid self-administered questionnaire, which assesses each of the nine criteria upon which depression diagnosis is based.²⁵ The PHQ-9 has high sensitivity (>88%) and specificity (>88%) in obstetric patients for scores ≥ 10 .²⁵⁻²⁹ It has been adopted by clinicians and researchers for screening in populations, including pregnant and postpartum women,³⁰⁻³⁴ and is considered the dimensional depression measure in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) classification manual.³⁵ Each of the nine items is scored from 0 (not at all) to 3 (nearly every day) for a total score ranging from 0 to 27. Scores of 5, 10, and 15 are considered the lower cutoff points for mild, moderate, and moderately severe to severe depression, respectively.²⁵ Women were considered to have early onset prenatal depression if they had at least one depression code (listed above) or a positive depression screening (PHQ-9 score ≥ 10) within the first 20 weeks of pregnancy. For women with early onset prenatal depression, severity of depressive symptoms was categorized as mild (PHQ-9 < 10), moderate (PHQ-9 10-14), or severe (PHQ-9 ≥ 15).

GWG rate

Among women with early onset prenatal depression, rate of GWG (lbs/week) was calculated using weight at depression screening (weight measured within 7 days of early pregnancy depression diagnosis or positive depression screening) and last prenatal weight before delivery divided by the difference in gestational weeks between the two measurements (Fig. 2). Among women without early onset prenatal depression, GWG rate was calculated using weight at last depression screening before 20 weeks gestation and last prenatal weight before delivery divided by the difference in gestational weeks between the two measurements. Rate of GWG was categorized based on the recommended ranges for rate of GWG according to the IOM (below, within, above; Supplementary Table S2).¹

Statistical analyses

Descriptive statistics were calculated in the overall analytic population and stratified by categories based on prepregnancy onset depression and early onset prenatal depression. Mean and standard deviation were used to describe the distribution of continuous variables. Frequency and percent were used to describe categorical variables.

Multiple linear regression was used to estimate mean differences and 95% confidence intervals (CI) in GWG rate associated with prepregnancy onset depression and early onset prenatal depression. Modified Poisson regression³⁶ was used to estimate relative risks (RR) and 95% CIs for GWG rate category associated with prepregnancy onset depression and early onset prenatal depression. Depression categories were treated as a three-level exposure (pregnancy onset depression, early pregnancy onset depression, and no pre- or early pregnancy onset depression). Separate Poisson regression models were run comparing below versus within IOM recommendations and above versus within IOM recommendations. Regression parameter estimates were obtained using generalized estimating equations to account for the nonindependence of pregnancies for women with multiple pregnancies during the study period. The model was adjusted for *a priori* selected covariates associated with perinatal depression and GWG^{37,38}: maternal age (years), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, Native American/multiracial, other/unknown), nulliparity (Y/N), Medicaid (Y/N), smoking in the first 20 weeks of pregnancy (Y/N), alcohol use in the first 20 weeks of pregnancy (Y/N), and prepregnancy BMI category (underweight, normal weight, overweight, and obese). In additional analyses, models were stratified by prepregnancy BMI category, early pregnancy depression severity (mild, moderate, and severe), and race/ethnicity. Exposure groups taking antidepressant treatment during pregnancy into account were also created (pregnancy onset depression treated with antidepressants in early pregnancy, prepregnancy onset depression not treated with antidepressants in early pregnancy, early pregnancy onset depression treated with antidepressants, and early pregnancy onset depression not treated with antidepressants).

We conducted sensitivity analyses using GWG rate calculated using weight at the first depression screening through 20 weeks gestation, as opposed to weight at the last depression screening through 20 weeks gestation, among women without early onset prenatal depression. This was done to account for potential differences in timing of depression screening between women with early onset prenatal depression and women without early onset prenatal depression. We also conducted sensitivity analyses excluding women without a measured prepregnancy weight in the 12 months before pregnancy and sensitivity analyses in nulliparous women with last measured weight ≥ 37 weeks. A two-sided alpha

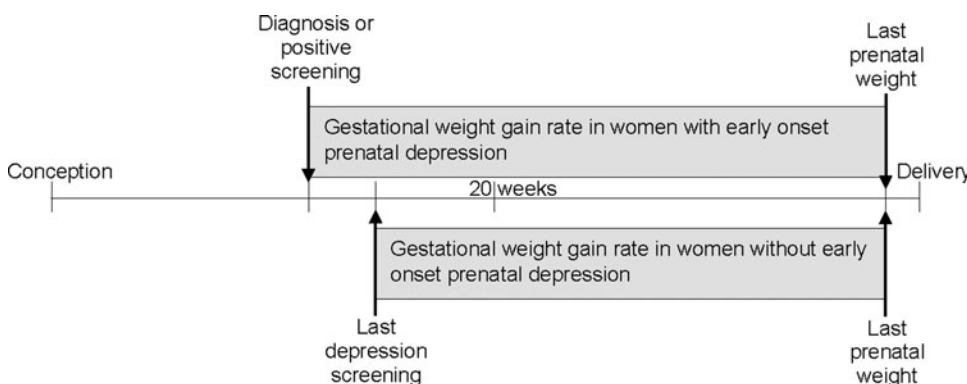


FIG. 2. Gestational weight gain rate in women with and without early onset prenatal depression.

TABLE 1. CHARACTERISTICS OF PREGNANCIES BY PREPREGNANCY DEPRESSION AND EARLY ONSET PRENATAL DEPRESSION, KAISER PERMANENTE NORTHERN CALIFORNIA 2011–2016

	Total (N=87,600)	Prepregnancy onset depression (N=7696)	Early pregnancy onset depression (N=7337)	No pre- or early pregnancy depression (N=72,567)
Sociodemographic characteristics				
Age (years), mean (SD)	30.2 (5.4)	30.1 (5.8)	29.3 (6.0)	30.3 (5.3)
Race/ethnicity, <i>n</i> (%)				
Non-Hispanic white	35,991 (41)	4238 (55)	1963 (27)	29,790 (41)
Non-Hispanic black	5011 (6)	535 (7)	807 (11)	3669 (5)
Hispanic	21,733 (25)	1878 (24)	2223 (30)	17,632 (24)
Asian/Pacific Islander	20,994 (24)	639 (8)	1987 (27)	18,368 (25)
Native American/multiracial	3117 (4)	352 (5)	281 (4)	2484 (3)
Other/unknown	754 (1)	54 (1)	76 (1)	624 (1)
Prepregnancy BMI category, <i>n</i> (%)				
Underweight	2390 (3)	174 (2)	223 (3)	1893 (3)
Normal weight	42,304 (48)	3072 (40)	3430 (47)	35,802 (49)
Overweight	23,605 (27)	2085 (27)	1994 (27)	19,526 (27)
Obese	19,401 (22)	2365 (31)	1690 (23)	15,346 (21)
Timing of measured weight used for prepregnancy BMI, <i>n</i> (%)				
Within 12 months before pregnancy	76,713 (88)	7357 (96)	6549 (89)	62,807 (87)
Within first 10 weeks of pregnancy	10,887 (12)	339 (4)	788 (11)	9760 (13)
Medicaid, <i>n</i> (%)	5688 (6)	984 (13)	771 (11)	3933 (5)
Pregnancy characteristics				
Nulliparous, <i>n</i> (%)	31,545 (36)	2674 (37)	2742 (37)	26,129 (36)
Smoking during early pregnancy, <i>n</i> (%)	3591 (4)	717 (9)	567 (8)	2307 (3)
Alcohol use during early pregnancy, <i>n</i> (%)	31,411 (36)	3096 (40)	2424 (33)	25,891 (36)
Gestational age at first prenatal visit (weeks), mean (SD)	6.3 (2.2)	5.9 (2.2)	6.2 (2.2)	6.3 (2.2)
Gestational age at diagnosis or last PHQ-9 before 20 weeks gestation (weeks), mean (SD)	9.2 (2.6)	8.9 (3.3)	9.3 (3.3)	9.2 (2.4)
Gestational age at last weight before delivery (weeks), mean (SD)	38.6 (1.9)	38.4 (2.1)	38.5 (2.0)	38.6 (1.9)
GWG rate (lbs/week), mean (SD)	0.92 (0.42)	0.92 (0.49)	0.94 (0.48)	0.92 (0.41)
IOM GWG rate category, <i>n</i> (%)				
Below guidelines	20,582 (24)	1877 (24)	1721 (23)	16,984 (23)
Meets guidelines	18,534 (21)	1373 (18)	1448 (20)	15,713 (22)
Exceeds guidelines	48,484 (55)	4446 (58)	4168 (57)	39,870 (55)
Depression severity and treatment				
Depression treatment in prepregnancy, <i>n</i> (%)				
Medication and counseling		2174 (28)		
Medication only		3502 (46)		
Counseling only		1146 (15)		
No treatment		874 (11)		
Early pregnancy depressive symptom severity, <i>n</i> (%)				
Very mild (PHQ-9 0–4)		3893 (51)	584 (8)	
Mild (PHQ-9 5–9)		2299 (30)	480 (7)	
Moderate (PHQ-9 10–14)		912 (12)	4699 (64)	
Severe (PHQ-9 ≥ 15)		592 (27)	1574 (21)	
Depression treatment in early pregnancy, <i>n</i> (%)				
Medication and counseling		1354 (18)	221 (3)	95 (0)
Medication only		788 (10)	66 (1)	94 (0)
Counseling only		2656 (35)	3042 (41)	17,859 (25)
No treatment		2898 (38)	4008 (55)	54,519 (75)
Later pregnancy depressive symptoms (after 20 weeks), <i>n</i> (%)				
Yes	10,922 (12)	3754 (49)	2230 (30)	4938 (7)
No	49,614 (57)	2568 (33)	3190 (43)	43,856 (60)
No PHQ-9 after 20 weeks	27,064 (31)	1374 (18)	1917 (26)	23,773 (33)

SD, standard deviation; IOM, Institute of Medicine; GWG, gestational weight gain; BMI, body mass index.

level of 0.05 was used for statistical significance in all analyses. Analyses were performed using SAS 9.3 (SAS Institute, Inc., Cary NC) and R 3.4.1.³⁹

Results

In our study population, women had prepregnancy onset depression in 9% of pregnancies and early onset prenatal depression in 8% of pregnancies (Table 1). Women with prepregnancy onset depression were more likely to be non-Hispanic white and prepregnancy obese than women with early onset prenatal depression or no pre- or early pregnancy onset depression. Women with early onset prenatal depression were more likely to be non-Hispanic black or Hispanic compared to women with prepregnancy onset depression or no pre- or early pregnancy depression. Women with pregnancies with either pre- or early pregnancy onset depression were more likely to receive Medicaid and smoke during early pregnancy than women with pregnancies without pre- or early pregnancy onset depression. Most women with prepregnancy onset depression were treated with medication, with or without counseling. Most women with early onset prenatal depression were treated with counseling only or did not receive any treatment.

Prepregnancy onset depression was not associated with GWG rate (mean difference=0.00; 95% CI: -0.01 to 0.01; Table 2). Adjustment for depression treatment in early pregnancy did not change the results. Early onset prenatal depression was associated with 0.04 lbs/week greater GWG rate (95% CI: 0.02-0.07) compared to no pre- or early pregnancy onset depression.

Prepregnancy onset depression was associated with 11% greater risk of GWG rate below the IOM recommendations and 3% greater risk of GWG rate above the IOM recommendations (95% CI: 1.07-1.15 and 1.01-1.05, respectively; Table 3). Early onset prenatal depression was associated with 4% greater risk of GWG rate above the IOM recommendations (95% CI: 1.02-1.07).

Associations of prepregnancy onset depression or early pregnancy onset depression with GWG rate did not differ by prepregnancy BMI category (P for interaction=0.17; Table 4). Associations of prepregnancy onset depression with greater risk of GWG rate below IOM recommendations were similar in normal weight, overweight, and obese women (P for interaction = 0.20). Associations of prepregnancy onset depression with greater risk of GWG rate above IOM recommendations were stronger among normal weight women than overweight and obese women (RR=1.06 in normal weight women, RR=1.01 in overweight and obese women). Associations of early pregnancy onset depression with GWG rate or GWG rate categories did not differ by early pregnancy depression severity (Supplementary Table S3). Associations may differ by race/ethnicity (P for interaction=0.04 for continuous GWG rate, 0.001 for GWG below IOM, 0.001 for GWG above IOM) (Supplementary Table S4). Differences in associations of prepregnancy onset depression or early pregnancy onset depression with GWG by race/ethnicity need further exploration.

In analyses considering antidepressant treatment in early pregnancy, associations of prepregnancy onset depression with GWG rate and GWG rate categories were similar in women with and without antidepressant use during early

TABLE 2. ASSOCIATIONS OF PREPREGNANCY AND EARLY PREGNANCY ONSET DEPRESSION WITH GESTATIONAL WEIGHT GAIN RATE STARTING AT DEPRESSION SCREENING OR DIAGNOSIS (LBS/WEEK)

	N	Mean difference ^a (95% CI)
No pre- or early pregnancy depression	72,567	Reference
Prepregnancy onset depression	7696	0.00 (-0.01 to 0.01)
Early pregnancy onset depression	7337	0.04 (0.02 to 0.07)

^aModel is adjusted for maternal age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, Native American/multiracial, other/unknown), nulliparity (Y/N), Medicaid (Y/N), smoking in first 20 weeks of pregnancy (Y/N), alcohol use in first 20 weeks of pregnancy (Y/N), prepregnancy BMI category (underweight, normal weight, overweight, obese), and severity of early pregnancy depressive symptoms (mild, moderate, severe).
CI, confidence intervals.

pregnancy (Table 5). There was an association of early pregnancy onset depression with greater risk of GWG rate below IOM recommendations in women with antidepressant use in early pregnancy (RR=1.44; 95% CI: 1.07-1.93), which was not present in women without antidepressant use in early pregnancy (RR=1.02; 95% CI: 0.96-1.09). Associations of early pregnancy onset depression with GWG rate above IOM recommendations were similar in women with and without antidepressant use during early pregnancy.

Results of sensitivity analyses using GWG rate calculated using weight at the first depression screening through 20 weeks gestation among women without early pregnancy

TABLE 3. ASSOCIATIONS OF PREPREGNANCY AND EARLY PREGNANCY ONSET DEPRESSION WITH GESTATIONAL WEIGHT GAIN RATE CATEGORY

	N	RR ^a (95% CI)
GWG rate <i>below</i> the IOM recommendations		
No pre- or early pregnancy depression	16,970	Reference
Prepregnancy onset depression	1880	1.11 (1.07, 1.15)
Early pregnancy onset depression	1716	1.03 (0.97, 1.10)
GWG rate <i>above</i> the IOM recommendations		
No pre- or early pregnancy depression	39,908	Reference
Prepregnancy onset depression	4451	1.03 (1.01, 1.05)
Early pregnancy onset depression	4176	1.04 (1.02, 1.07)

^aModel is adjusted for maternal age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, Native American/multiracial, other/unknown), nulliparity (Y/N), Medicaid (Y/N), smoking in first 20 weeks of pregnancy (Y/N), alcohol use in first 20 weeks of pregnancy (Y/N), prepregnancy BMI category (underweight, normal weight, overweight, obese), and severity of early pregnancy depressive symptoms (mild, moderate, severe).
RR, relative risks.

TABLE 4. ASSOCIATIONS OF PRE- AND EARLY PREGNANCY ONSET DEPRESSION WITH GESTATIONAL WEIGHT GAIN RATE STARTING AT DEPRESSION SCREENING OR DIAGNOSIS (LBS/WEEK) STRATIFIED BY PREPREGNANCY BODY MASS INDEX CATEGORY

	N	Mean difference ^a (95% CI)	N	RR ^a (95% CI) for GWG rate below the IOM recommendations	N	RR ^a (95% CI) for GWG rate above the IOM recommendations
Underweight						
No pre- or early pregnancy depression	1962	Reference	1096	Reference	258	Reference
Prepregnancy onset depression	244	0.02 (−0.04 to 0.08)	93	0.96 (0.82 to 1.11)	35	Did not converge
Early pregnancy onset depression	188	0.02 (−0.07 to 0.11)	122	0.97 (0.76 to 1.22)	49	
Normal weight						
No pre- or early pregnancy depression	35,593	Reference	9421	Reference	16,604	Reference
Prepregnancy onset depression	3383	0.01 (−0.01 to 0.02)	806	1.14 (1.08 to 1.20)	1574	1.06 (1.03 to 1.10)
Early pregnancy onset depression	3044	0.03 (−0.01 to 0.07)	854	0.97 (0.88 to 1.08)	1694	1.03 (0.98 to 1.08)
Overweight						
No pre- or early pregnancy depression	19,632	Reference	2649	Reference	14,004	Reference
Prepregnancy onset depression	2011	0.01 (−0.01 to 0.03)	315	1.15 (1.05 to 1.25)	1499	1.01 (0.99 to 1.03)
Early pregnancy onset depression	2097	0.04 (0.00 to 0.08)	309	1.13 (0.98 to 1.31)	1416	1.02 (0.98 to 1.07)
Obese						
No pre- or early pregnancy depression	15,380	Reference	3804	Reference	9042	Reference
Prepregnancy onset depression	1699	−0.01 (−0.04 to 0.02)	666	1.08 (1.02 to 1.14)	1343	1.01 (0.98 to 1.04)
Early pregnancy onset depression	2367	0.06 (0.01 to 0.11)	431	1.06 (0.97 to 1.17)	1017	1.07 (1.02 to 1.12)

^aModel is adjusted for maternal age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, Native American/multiracial, other/unknown), nulliparity (Y/N), Medicaid (Y/N), smoking in first 20 weeks of pregnancy (Y/N), alcohol use in first 20 weeks of pregnancy (Y/N), and severity of early pregnancy depressive symptoms (mild, moderate, severe).

P for interaction=0.17 for mean difference, 0.20 for GWG below IOM, <0.0001 for GWG above IOM (excluding underweight).

depressive symptoms (Supplementary Table S5), excluding women without a measured prepregnancy weight in the 12 months before pregnancy (Supplementary Table S6), and in nulliparous women with last measured weight at term (Supplementary Table S7) were similar to main results.

Discussion

We observed associations of prepregnancy onset depression with greater risk of GWG rate below and above the IOM recommendations, with stronger associations with GWG rate above the IOM recommendations observed in normal weight women. Early pregnancy onset depression was associated with a greater rate of GWG after identification of depression and slightly greater risk of GWG rate above the IOM recommendations, with stronger associations in obese women. Women with early pregnancy onset depression who are treated with antidepressants may also be at greater risk of GWG rate below the IOM recommendations.

Our study was the first to assess associations of prepregnancy onset depression and early pregnancy onset depression with rate of GWG after diagnosis. Previous studies of

prenatal depression and GWG have evaluated total GWG from the beginning of pregnancy and have not separated new onset depression in early pregnancy from prepregnancy onset depression. In contrast to our findings, these studies have reported associations of prenatal depression with lower GWG,¹⁸ lower likelihood of GWG above the IOM recommendations,¹⁹ or no associations of prenatal depression with GWG.²⁰ To determine the correct temporal sequence of the association between depression during pregnancy and GWG, it is important to examine GWG starting after the diagnosis of depression. Lifestyle behaviors, such as nutrition, which may contribute to weight change after depression diagnosis may also influence depression risk.⁴⁰ In addition, some previous studies have adjusted for health behaviors, such as diet and physical activity at the time of depression assessment.^{19,20} Diet and physical activity changes are likely mechanisms through which depression influences GWG. Adjusting for these lifestyle behaviors at or after depression diagnosis may “adjust away,” or mask, the true association between depression and GWG, possibly explaining null results in previous studies.

The association between prenatal depression and GWG is complicated. Our study found that prepregnancy onset

TABLE 5. ASSOCIATIONS OF PRE- AND EARLY PREGNANCY ONSET DEPRESSION AND EARLY PREGNANCY ANTIDEPRESSANT TREATMENT WITH GESTATIONAL WEIGHT GAIN RATE STARTING AT DEPRESSION SCREENING OR DIAGNOSIS (LBS/WEEK)

	N	Mean difference ^a (95% CI)	N	RR ^a (95% CI) for GWG rate below the IOM recommendations	N	RR ^a (95% CI) for GWG rate above the IOM recommendations
No pre- or early pregnancy depressive symptoms	72,567	Reference	16,970	Reference	39,908	Reference
Prepregnancy onset depression treated with antidepressants in early pregnancy	2142	-0.04 (-0.10 to 0.02)	532	1.34 (1.04 to 1.72)	1256	1.10 (0.99 to 1.22)
Prepregnancy onset depression not treated with antidepressants in early pregnancy	5554	0.01 (0.00 to 0.02)	1348	1.09 (1.05 to 1.13)	3195	1.02 (1.00 to 1.04)
Early pregnancy onset depression treated with antidepressants	287	-0.03 (-0.12 to 0.05)	77	1.44 (1.07 to 1.93)	164	1.12 (0.98 to 1.27)
Early pregnancy onset depression not treated with antidepressants	7050	0.05 (0.02 to 0.08)	1639	1.02 (0.96 to 1.09)	4012	1.05 (1.01 to 1.08)

^aModel is adjusted for maternal age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, Native American/multiracial, other/unknown), nulliparity (Y/N), Medicaid (Y/N), smoking in first 20 weeks of pregnancy (Y/N), alcohol use in first 20 weeks of pregnancy (Y/N), and severity of early pregnancy depressive symptoms (mild, moderate, severe).

depression and early pregnancy onset depression were both associated with a greater rate of GWG after depression screening and slightly higher risk of GWG rate above the IOM recommendations with stronger associations for prepregnancy onset depression in normal weight women and stronger associations for early pregnancy onset depression in obese women. Some studies in nonpregnant adult populations have also reported associations of depression with greater risk of weight gain^{8,11} and developing obesity,^{9,10} particularly among women.⁹ Some studies have found associations of depression with unhealthy lifestyle behaviors, including poor diet quality,^{13,14} emotional eating (eating in response to negative emotions),⁴¹ low levels of physical activity,¹⁷ and greater sedentariness,¹⁶ which contribute to weight gain. Depression before and during early pregnancy may result in similar unhealthy diet and physical activity changes, which may contribute to greater GWG rate. Perinatal depression and GWG below and above the IOM recommendations are risk factors for pregnancy complications.^{2,42,43} Increasing the number of high risk women with GWG within the IOM recommendations, even by modest amounts, may be beneficial for preventing pregnancy complications.

Our study also found that prepregnancy onset depression, regardless of early pregnancy antidepressant use, and early onset prenatal depression in women with antidepressant use were associated with greater risk of GWG rate below the IOM recommendations. Some previous studies in nonpregnant adult populations have similarly reported associations of depression with both weight loss and weight gain.^{8,11} Identifying which individuals with depression are at risk of weight gain and which are at risk of weight loss is challenging. In a previous study, younger age, lower weight, fewer chronic disease comorbidities, and comorbid anxiety disorder at depression assessment were associated with weight gain, and

being a former smoker was associated with weight loss.⁸ In our study, women with prepregnancy onset depression who were normal weight before pregnancy, parous, or receiving counseling but not antidepressant medications were more likely to have a GWG rate below the IOM recommendations (Supplementary Table S8). Unlike the previous study in nonpregnant adults, maternal age and smoking were not associated with less weight gain. We did not assess comorbid anxiety disorders in our study. There may be differences in how depression and antidepressant medications influence weight change during pregnancy and outside of pregnancy.

Strengths of our study include perinatal depression screening in our study population, consideration of GWG starting after early pregnancy depression screening to establish temporality of associations, consideration of prepregnancy onset and early onset prenatal depression separately, and adjustment for depression severity. We were not able to assess severity or duration of prepregnancy depression, or history of depression before 6 months before pregnancy, which may play a role in subsequent weight change. We did not have information about chronic medical conditions and lifestyle behaviors during pregnancy, such as diet and physical activity, which may help clarify which women with chronic depression are at risk for GWG below (vs. above) recommendations. We were not able to determine the reason for counseling. It is possible that women had counseling for reasons other than depression, which may have introduced misclassification in our assessment of depression treatment. About 25% of women eligible for our study were not screened for perinatal depression in early pregnancy. Women who were pregnant at the end of the perinatal depression screening rollout (2012⁴⁴) and women who reported alcohol use during pregnancy were more likely to be included in our analytic cohort (Supplementary

Table S9). Women excluded from our cohort may have been receiving care at a medical center in which perinatal depression screening may not yet have been implemented (missing at random) or may have had low risk behaviors during pregnancy. Although we adjusted for high risk behaviors in our analyses, our analytic population may include some women at higher risk than the general population of pregnant women, especially for the earlier years of the study.

Conclusions

Women with prepregnancy onset depression may be at greater risk of GWG either below or above the IOM recommendations. Women with early onset prenatal depression may be at slightly greater risk of GWG rate above the IOM recommendations. Our findings suggest that the relationship between prepregnancy and early pregnancy onset depression and GWG rate is complex and may vary based on timing of depression onset, prepregnancy BMI category, and antidepressant use in early pregnancy. Women with depression during early pregnancy may benefit from lifestyle-related counseling for healthy GWG. Further research is needed to clarify the association between depression and GWG and identify factors that predict how a woman's lifestyle behaviors and weight change after depression diagnosis.

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Author Disclosure Statement

No competing financial interests exist.

Supplementary Material

Supplementary Table S1
 Supplementary Table S2
 Supplementary Table S3
 Supplementary Table S4
 Supplementary Table S5
 Supplementary Table S6
 Supplementary Table S7
 Supplementary Table S8
 Supplementary Table S9

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Address correspondence to:

*Sylvia E. Badon, PhD
Division of Research, Kaiser Permanente
Northern California
2000 Broadway
Oakland, CA 94612*

E-mail: sylvia.e.badon@kp.org