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REVIEW

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Associations between anxiety, depression, and weight status during and after pregnancy: A systematic review and meta-analysis

Alex Griffiths[1] | Oliver M. Shannon[2] | Tamara Brown[1] | Monica Davison[3] | Catherine Swann[3] | Andrew Jones[4] | Louisa Ells[1] | Jamie Matu[1]

[1]Obesity Institute, School of Health, Leeds Beckett University, Leeds, UK

[2]Human Nutrition Research Centre, Centre for Healthier Lives, Population Health Sciences Institute, Newcastle University, Newcastle upon Tyne, UK

[3]Office for Health Improvement and Disparities, London, UK

[4]School of Psychology, Liverpool John Moore's University, Liverpool, UK

Correspondence
Jamie Matu, Calverley Building, Leeds Beckett University City Campus, Leeds LS1 3HE, UK.
Email: j.matu@leedsbeckett.ac.uk

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Office for Health Improvement and Disparities.

Summary

Previous work has found adverse mental health symptomology in women living with obesity, compared with those of healthy weight, around the time of pregnancy. This meta-analysis aimed to explore the association between anxiety, depression, and weight status in women living with obesity before, during, and after pregnancy. Bibliographic databases were systematically searched, and 14 studies were included, which aimed to assess the association between excess weight and anxiety or depression outcomes in women before, during, or after pregnancy. Data were analyzed via narrative synthesis and random effects multi-level meta-analyses. Scores on mental health indices were significantly greater (indicative of worse anxiety/depression) in women with obesity compared to women of a healthy weight, around the time of pregnancy (SMD = 0.21 [95% CI: 0.11–0.31; 95% prediction intervals: 0.13–0.56], I^2 = 73%, $p < 0.01$). Depressive symptoms were greater during and after pregnancy (SMD = 0.23 [95% CI: 0.13–0.34; 95% prediction intervals: −0.12 to 0.59], I^2 = 75.0%, $p < 0.01$), and trait anxiety symptoms were greater during pregnancy (SMD = 0.24 [95% CI: 0.01–0.47; 95% prediction intervals: −0.25 to 0.72], I^2 = 83.7%, $p = 0.039$) in women living with obesity, compared to those of healthy weight. Narrative evidence suggests that socioeconomic status and ethnicity may modify the relationship between obesity and mental health symptomology. The findings indicate that maternal obesity is associated with greater anxiety and depression symptoms. These findings may inform the design of maternal weight management interventions.

KEYWORDS
anxiety, depression, obesity, pregnancy

1 | INTRODUCTION

In 2019, 29% of women in England were living with obesity (Body Mass Index [BMI] > 30 kg/m^2), which has increased from 16% in 1993.[1] Of note, the prevalence of obesity in women of childbearing age has also increased; therefore, more women are entering pregnancy with obesity.[2] Obesity is associated with the risk of developing numerous non-communicable diseases and can lead to

premature mortality.[3] Obesity during pregnancy carries additional risks, including increased risk of gestational diabetes, pre-eclampsia, babies being large for gestational age, and maternal mortality.[4] Evidence suggests that pregnant women living with obesity have an elevated risk of adverse mental health outcomes, including greater risk of depression[5] and anxiety.[6] Such disorders exacerbate psychological distress around the time of pregnancy and may lead to difficulties regarding mother–infant attachment,[7] as well as parenting stress.[8] Psychological distress during pregnancy may also induce adverse birth outcomes such as preterm birth, low birth weight, and intrauterine growth restriction.[9,10]

Molyneaux et al.[11] previously conducted a broad systematic review and meta-analysis in this area and observed a greater risk of depression in women living with overweight and obesity in both the antenatal (living with obesity odds ratio [OR] = 1.43, 95% confidence interval [CI] = 1.27–1.61; living with overweight OR = 1.19, 95% CI = 1.09–1.31) and postnatal period (living with obesity OR = 1.30, 95% CI = 1.20–1.42; living with overweight OR = 1.09, 95% CI = 1.05–1.13). Molyneaux et al.[11] also observed a greater risk of antenatal anxiety in pregnant women living with overweight or obesity compared with those living with a healthy weight (OR = 1.41, 95% CI = 1.10–1.80). Since publication of this review, several subsequent studies have been published,[5,12–17] demonstrating inconsistent results. For example, recent studies have shown associations between weight status with depression before or during pregnancy,[13,15] whereas others have found no association between maternal obesity and depression[5] or anxiety.[14] Therefore, an updated review of the evidence base is required.

The equivocal findings in the literature could be related to inconsistencies in study design and/or between-study differences in participant characteristics. For example, it appears likely that socio-economic status (i.e., education, income, and occupation) may moderate the association between maternal obesity and mental health outcomes given the known association between low socio-economic status and greater risk of obesity,[18] as well as poorer mental health outcomes.[19] In a prospective cohort study of 5,522 women, a significant interaction of socio-economic status and BMI was observed on the risk of antenatal depression.[15] Women of a high socio-economic status living with obesity were twice as likely to encounter antenatal depression than a control group living with a healthy weight, and no association between obesity and antenatal depression was observed in women of a low socio-economic status. Similar moderator effects may also be observed regarding socio-demographic factors, given the physical and mental health disparities related to factors such as ethnicity.[20,21] A greater understanding of how socio-economic and sociodemographic factors influence the associations between weight and mental health outcomes around the time of pregnancy may help to tailor interventions.

As such, this systematic review and meta-analysis aimed to explore the associations between anxiety, depression, and maternal obesity before (up to 3 months), during, and after (12 months) pregnancy. In addition, this review aimed to evaluate socio-economic and socio-demographic factors, which may moderate this effect. A better understanding of these associations and moderating factors may inform strategies to manage mental health in women around the time of pregnancy.

2 | METHODS

This study was registered prospectively in the International prospective register of systematic reviews (PROSPERO) database (CRD42021267682) and was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[22]

2.1 | Search strategy

Electronic bibliographic databases MEDLINE, PsycINFO, and Embase were searched via Ovid and limited to English language and publication date of the 2000 onwards. The prospectively registered search strategy utilized Medical Subject Headings (MeSH), Boolean operators, and was run through to July 15, 2021. The search strategies included terms for pregnancy, weight, mental health, and study design (cohorts). For a detailed overview of the search terms, see the supporting information. Search results were exported to EndNote, where automated and manual deduplication was performed. Search results were then exported to an online systematic review management system (Covidence), where further automated deduplication was performed. Reference lists of eligible articles were also screened for any further eligible studies.

2.2 | Eligibility criteria

2.2.1 | Inclusion criteria

The following types of studies were included: prospective cohort and longitudinal studies of any duration, which aimed to assess the association between excess weight and anxiety and/or depression.

Additional eligibility criteria included studies published in English; studies conducted in high-income countries (gross national income per capita of $12,536 or more using the World Bank Atlas method), so that conclusions can be drawn from countries generalizable to the United Kingdom; participants aged 16 years or older; participants living with obesity (defined as a BMI of >30 or ≥27.5 kg/m^2 in those who identify as being of Asian ethnicity) and a reference group of individuals without obesity; studies conducted in women who were planning pregnancy (up to 3 months prior to conception), pregnant, or post-pregnancy (up to 12 months after pregnancy); and mental health conditions (anxiety and/or depression) evaluated with validated diagnostic or screening tools.

2.2.2 | Exclusion criteria

The following types of studies were excluded: systematic reviews, meta-analyses, narrative reviews, randomized controlled trials (RCTs), retrospective studies, case–control studies, cross-sectional studies, gray literature such as dissertations, conference proceedings, magazine

articles, books or book chapters, opinion pieces, information obtained from websites, reports, and other non-peer reviewed literature.

Additional reasons for exclusion included studies conducted exclusively in women with gestational diabetes.

2.3 | Screening and data extraction

The titles and abstracts of records were screened by two independent reviewers to evaluate their eligibility for inclusion in this review. The full texts of potentially eligible articles were retrieved and independently appraised by two independent reviewers. Data from eligible papers were extracted into a pre-piloted spreadsheet by one reviewer and checked by a second reviewer. If there were discrepancies between reviewers, these were resolved via a group discussion including a third reviewer. Data extracted included first author, year, study design, country, pregnancy stage when BMI was measured, pregnancy stage when outcome was measured, participant health status, ethnicity, socioeconomic status, BMI, method used to evaluate BMI (e.g., self-report or objectively measured), age, outcome measure and domain, and outcome data for BMI ≥30 and <30 kg/m^2.

It should be noted that where data have been extracted *verbatim* from included reviews, we have altered language that reduced people to their medical condition. The alterations made ensure person first language throughout this report (e.g., "living with obesity" has replaced "obese individual").

2.4 | Quality assessment

The quality of each included study was assessed by one reviewer using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies.[23] Studies were rated as strong, moderate, or weak in the following six domains: selection bias, study design, confounders, blinding, data collection methods, and withdrawals and dropouts. An overall rating was given to each study as strong (no weak ratings), moderate (one weak rating), or weak (two or more weak ratings). Quality appraisals were checked by a second reviewer, with disagreement resolved by group discussion including a third reviewer.

Analyses were carried out to explore whether associations between weight status and depression differed between studies, which were appraised as strong and moderate according to quality appraisals. We did this for depression outcomes only, due to the larger number of effect sizes available. Two studies were rated as "weak," one of which was included in the meta-analyses. A sensitivity analysis was conducted by removing this study.

2.5 | Data analysis

Data were analyzed via narrative synthesis and random effects multilevel meta-analyses. Studies were heterogeneous in their methods and also their outcomes, which led to a variety of different effect sizes of interest (e.g., ORs and mean differences). As such, we followed guidance from Polanin and Snilstveit[24] and converted all effects to a common effect size, in this case, the standardized mean difference (SMD). Here, the SMD represents the difference in mental health symptomology between individuals with healthy weight and individuals with obesity. Positive values represent greater anxiety/depression symptoms in individuals with obesity relative to individuals of a healthy weight. The SMD is expressed as a change in the pooled standard deviation between the two groups and is calculated as follows:

$$\text{Mental Health Symptoms in Individuals Living with Obesity} - \text{Mental Health Symptoms in Individuals Living with Healthy Weight} \;/\; \text{Pooled Standard Deviation}.$$

Rules of thumb suggest SMD = 0.20 is an effect size that is small in magnitude, SMD = 0.5 is moderate in magnitude, and SMD = 0.80 is large in magnitude.[25,26]

Where only one effect size was provided, we aimed to include this; however, several studies provided multiple effect sizes of interest. For example, in Bogaerts et al.,[6] we were able to extract information to compute effect sizes for mental health outcomes at each pregnancy trimester. To ensure all these effects could be accounted for, we conducted a multi-level meta-analysis. Multi-level meta-analysis separates the variability of effect sizes within studies from the variability of effect sizes between studies.[27] In this case, the addition of multiple effects from the same population does not increase the likelihood of Type 1 error. For the primary analyses, the multi-level model was a better fit of the data than a single-level model, as assessed by the loglikelihood ratio test (LRT = 4.31, $p = 0.038$).

We examined statistical heterogeneity using the I^2 statistic,[28] a relative statistic that can be expressed as a percentage, indicating the amount of statistical heterogeneity in the meta-analytic model. Conventional guidance suggests I^2 values >50% are indicative of moderate, and values >75% indicative of substantial heterogeneity. We also estimated 95% prediction intervals for each meta-analysis.[29] Prediction intervals provide a range by which the true effects are to be expected for 95% of similar studies that might be conducted in the future. To identify any potential outlying effect sizes, we created a box plot of the effect sizes and any that were >1.5 * interquartile range were identified as outliers and removed from analyses for sensitivity checks. Publication bias was examined using Egger's test.[30] All statistical analyses were conducted in the "R" programming language using the "metafor" package. To compute effect sizes and sampling variances, we used the "escalc" function. To convert ORs to SMDs, we used the "convert_odds_to_d" function in the "effectsize" package. This uses the formula EXP (SMD * π/SQRT (3)). ORs can be interpreted as the increased odds of worse mental health symptoms as a result of living with obesity during and after pregnancy (compared to healthy weight). Data and analysis scripts can be found online (https://osf.io/bxjru/).

3 | RESULTS

3.1 | Study selection

A total of 5,014 records were identified from searching the three databases. After duplicates were removed, there were 3,303 records that were screened on title and abstract. Of these, 3,207 were excluded, and 96 were screened as full texts. Following full text appraisal, a total 14 studies were eligible for inclusion in this review.[5,6,12–17,31–36] A PRISMA flow chart of the study selection process can be found in Figure 1. A list of the records that were excluded at full text screening, with their accompanying reason for exclusion, can be found in Table S2.

3.2 | Characteristics of included studies

Of the 14 articles included in this systematic review and meta-analysis, 14 explored associations between weight status and depression, and four explored associations between weight status and anxiety. Anxiety and/or depression were assessed at various points throughout pregnancy ranging from 12 weeks[12] up to 42 weeks,[34] and post-partum in two studies (up to 12 months[36]) (Table 1). No studies were found relating to the pre-pregnancy period. Additional study characteristics can be found in Table S3. Depression was most commonly measured using the Edinburgh Postnatal Depression Scale (EPDS, $n = 7$ studies). Studies also measured depression symptomology using the Centre for Epidemiological Studies Depression Scale (CES-D, $n = 4$ studies), the general health questionnaire (GHQ, $n = 1$ study), an adapted version of the Participant Health Questionnaire-2 (PHQ-2, $n = 1$ study), and via Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders: DSM-IV and 29-item Structured Interview Guide for the Hamilton Rating Scale for Depression-Atypical Depression Symptoms Version (SIGH-ADS, $n = 1$ study). Anxiety was measured using the State–Trait Anxiety Inventory (STAI, $n = 3$ studies) and the General Health Questionnaire (GHQ, $n = 1$ study). State anxiety refers to the current state of anxiety,

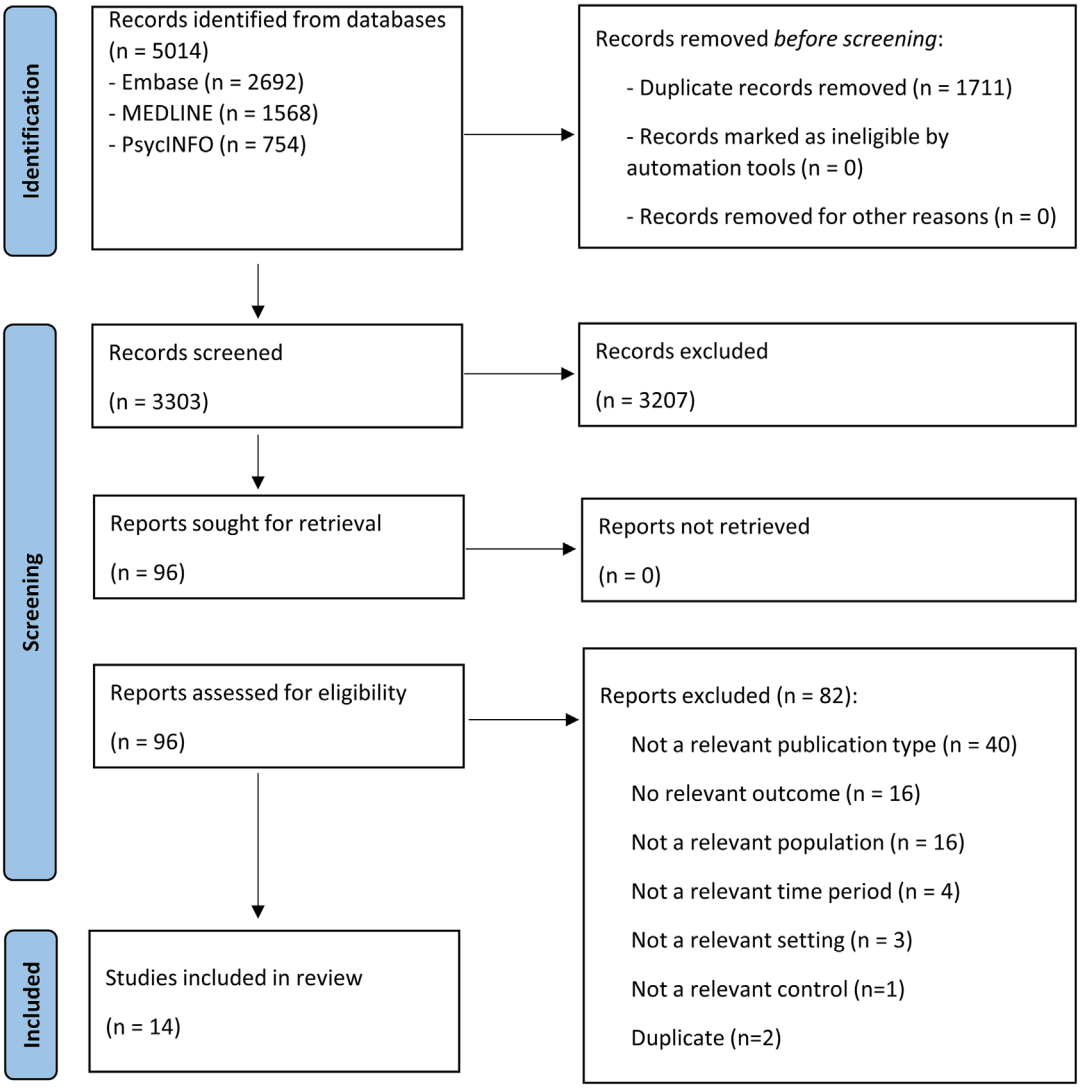

FIGURE 1 PRISMA flow diagram of study selection.

TABLE 1 Characteristics of included studies.

Citation	Study design	Location	Pregnancy stage (BMI)	Pregnancy stage (outcome)	Outcome (depression/anxiety)	Measurement tool(s)
Bodnar et al.[31]	Prospective cohort study	USA	Pre-pregnancy	20-, 30-, and 36-weeks gestation	Depression	Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders: DSM-IV and 29-item Structured Interview Guide for the Hamilton Rating Scale for Depression--Atypical Depression Symptoms Version (SIGH-ADS)
Bogaerts et al.[6]	Prospective cohort study	Belgium	Pre-pregnancy	18–22 weeks (2nd trimester) and 30–34 weeks (3rd trimester)	Depression & anxiety	Depression: Edinburgh Postnatal Depression Scale Anxiety: Dutch Standardised State–Trait Anxiety Inventory (STAI)
Ertel et al.[13]	Prospective cohort study	USA	Pre-pregnancy	Mid pregnancy (27.8 week gestation) and 6 months postpartum	Depression	Edinburgh Postnatal Depression Scale
Ertel et al.[12]	Prospective cohort study	USA	Pre-pregnancy	Early- (12.4 weeks), Mid- (21.3 weeks) and late- (30.8 weeks) pregnancy	Depression	Edinburgh Postnatal Depression Scale
Insan et al.[14]	Prospective cohort study	UK	Early pregnancy (10–12 weeks)	26–28 weeks gestation	Depression & anxiety	General Health Questionnaire
Kumpulainen et al.[5]	Prospective cohort study	Finland	Early pregnancy (8 weeks)	Multiple times from 12–39 weeks gestation and 2.4–28.2 weeks after pregnancy	Depression	Centre for Epidemiological Studies Depression Scale
LaCoursiere et al.[32]	Prospective cohort study	USA	Pre-pregnancy	6–8 weeks postpartum	Depression	Edinburgh Postnatal Depression Scale
Laraia et al.[33]	Prospective cohort study	USA	Pre-pregnancy	During pregnancy	Depression & anxiety	Depression: Centre for Epidemiological Studies Depression Scale Anxiety: State Trait anxiety Inventory
Leonard et al.[34]	Prospective cohort study	USA	Pre-pregnancy	Third trimester (between 30- and 42-weeks gestation)	Depression	Edinburgh Postnatal Depression Scale
Molyneaux et al.[15]	Prospective cohort study	Multi-national study: New Zealand, Ireland, Australiaand the UK	15 +/− 1 weeks' gestation	15 +/− 1 and 20 +/− 1 weeks' gestation	Depression	Edinburgh Postnatal Depression Scale
Molyneaux et al.[16]	Prospective cohort study	UK	Pre-pregnancy	18- and 32-weeks' gestation	Depression	Edinburgh Postnatal Depression Scale
Ruhstaller et al.[17]	Prospective cohort study	USA	First pre-natal visit	16–20 weeks gestation	Depression & anxiety	Depression: Centre for Epidemiologic Studies Depression Scale. Anxiety: State Trait Anxiety Instrument (STAI) utilizing only the state scale

(Continues)

TABLE 1 (Continued)

Citation	Study design	Location	Pregnancy stage (BMI)	Pregnancy stage (outcome)	Outcome (depression/anxiety)	Measurement tool(s)
Sundaram et al.[35]	Prospective cohort study	USA	Pre-pregnancy	Post-partum (2–4 months after delivery)	Depression	Adapted Patient Health Questionnaire-2 (PHQ-2)
Walker[36]	Prospective cohort study	USA	Pre-pregnancy	Immediately postdelivery, 6 weeks, and 3, 6, and 12 months postpartum	Depression	Centre for Epidemiologic Studies Depression Scale

asking how respondents feel "right now," whereas trait anxiety refers to stable aspects of "anxiety proneness."[37] Pre-pregnancy BMI was used as a measure of exposure in 10 studies and during pregnancy BMI in four studies, while anxiety and depression were monitored at various points during pregnancy (range: 12 to 36 weeks gestation) and up to 12 months post-partum.

3.3 | Anxiety and depression combined

Twenty-nine effect sizes from 14 studies contributed to the meta-analysis. Overall, scores on anxiety and depression were significantly greater (indicative of worse mental health) in women with obesity (BMI > 30 kg/m^2) compared to women of a healthy weight (BMI 18.5 to 25 kg/m^2), during and after pregnancy. The effect was small in magnitude (SMD = 0.21 [95% CI: 0.11 to 0.31; 95% prediction intervals: 0.13 to 0.56], I^2 = 73%, p < 0.01), which is the equivalent of an OR ~ 1.46 [95% CI: 1.22 to 1.75]. Removal of the one outlying effect size[33] slightly reduced the overall pooled effect, although it remained statistically significant (SMD = 0.20 [95% CI: 0.11 to 0.29; 95% prediction intervals: −0.09 to 0.49], p < 0.001). Egger's test of funnel plot asymmetry was non-significant (Z = −0.22, p = 0.827).

3.4 | Depression

There were 19 effect sizes (from 14 studies) examining depressive symptoms/diagnosis. Depressive symptoms were greater in women with obesity compared to those of healthy weight, during and after pregnancy (SMD = 0.23 [95% CI: 0.13 to 0.34; 95% prediction intervals: −0.12 to 0.59], I^2 = 75.0%, p < 0.01; see Figure 2), equivalent to OR ~ 1.52 [95% CI: 1.27 to 1.85]. Removal of the outlying effect size reduced the pooled effect to SMD = 0.20 ([95% CI: 0.12 to 0.29; 95% prediction intervals: −0.04 to 0.45], I^2 = 58.1%, p < 0.001), equivalent to OR ~ 1.44 [95% CI: 1.24 to 1.69]. For depression, 15 effect sizes came from during pregnancy and 4 from post-pregnancy. During pregnancy, the effect size was SMD = 0.25 [95% CI: 0.12 to 0.37; 95% prediction intervals: −0.14 to 0.64], I^2 = 75%, p < 0.001, and post-pregnancy the effect size was SMD = 0.19 [95% CI: 0.04 to 0.35; 95% prediction intervals: −0.07 to 0.46], I^2 = 58%, p = 0.016. There was no significant difference in the effect sizes during vs post pregnancy (X^2 [1] = 0.13, p = 0.719).

3.5 | State anxiety

There were three effect sizes (from one study) examining state anxiety symptoms. There was no significant difference between women with obesity and healthy weight during pregnancy (SMD = 0.08 [95% CI: −0.13 to 0.28; 95% prediction intervals: −0.21 to 0.36]), equivalent to OR ~ 1.16 [95% CI: 0.79 to 1.66]. However, care should be taken when interpreting this finding as it consists of only a small number of effects from a single study.[6]

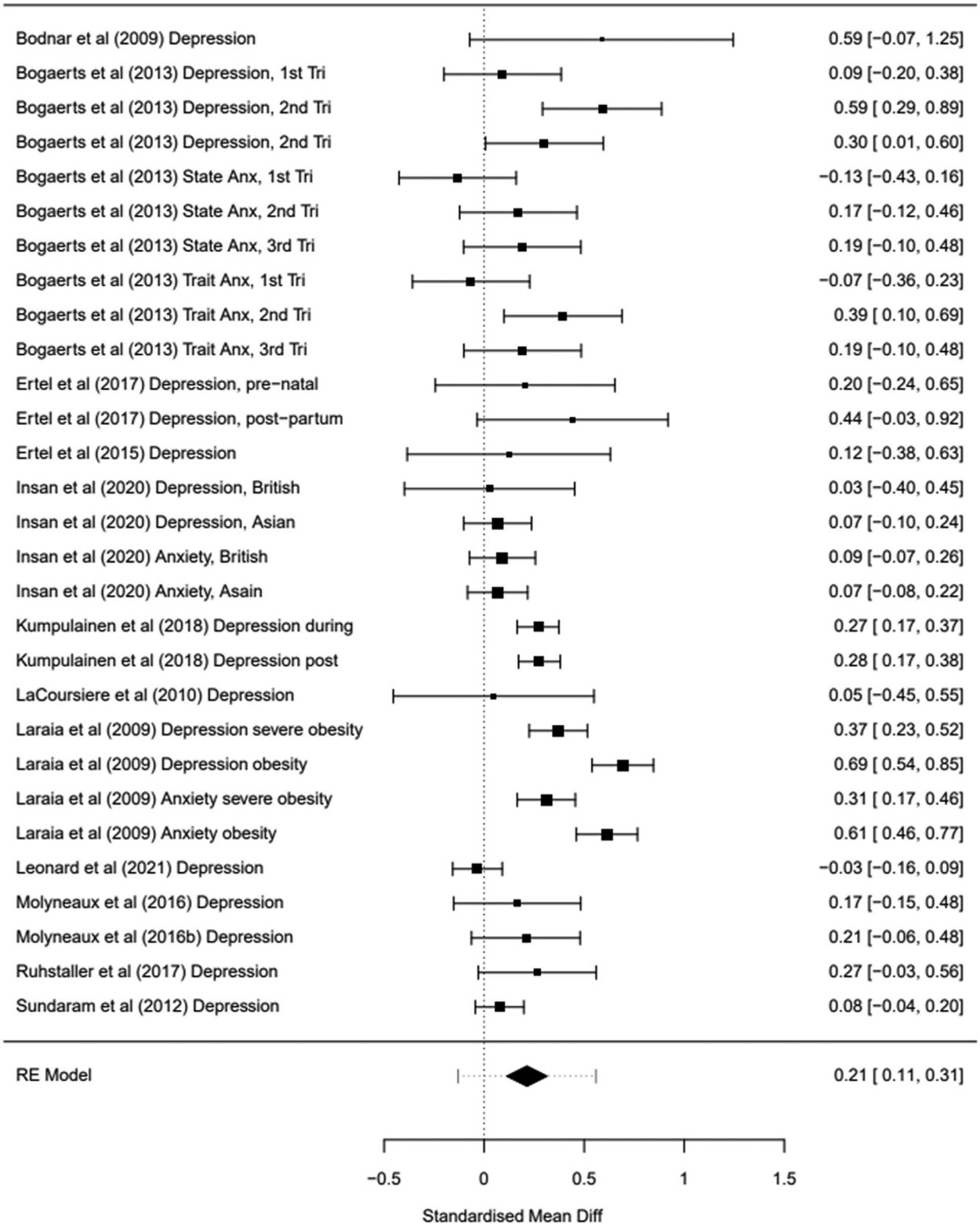

FIGURE 2 Forest plot of all effect sizes contributing to the pooled effect for studies evaluating depression before and during pregnancy in women living with obesity (BMI > 30 kg/m^2) compared to women of a healthy weight (BMI 18.5 to 25 kg/m^2).

3.6 | Trait anxiety

There were seven effect sizes (from three studies) examining trait anxiety symptoms. Symptoms were greater in women living with obesity compared to those of healthy weight during pregnancy (SMD = 0.24 [95% CI: .01 to .47; 95% prediction intervals: −0.25 to 0.72], $I^2 = 83.7\%$, $p = 0.039$; see Figure 3), equivalent to OR ~ 1.55 [95% CI: 1.02 to 2.35].

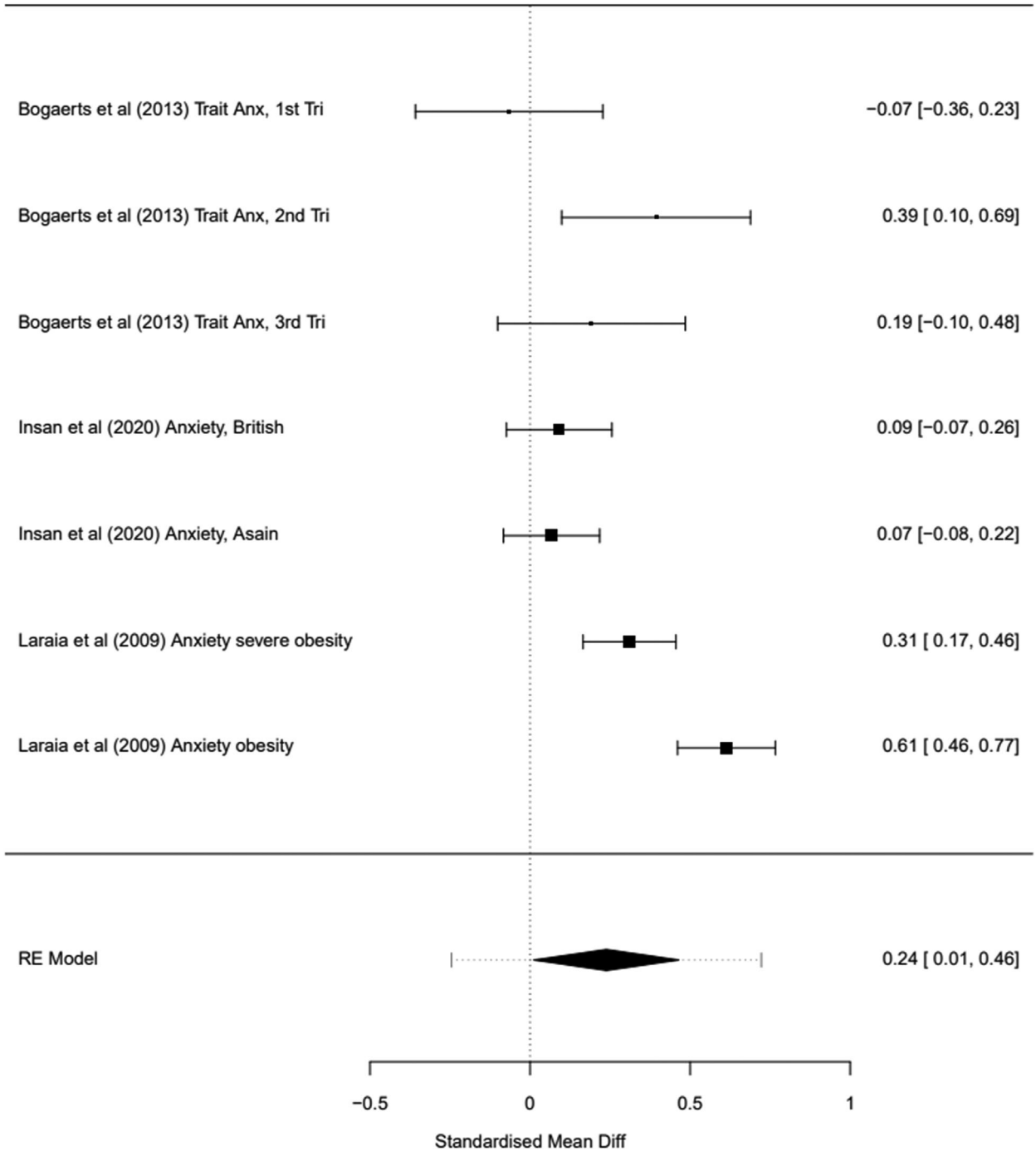

FIGURE 3 Forest plot of all effect sizes contributing to the pooled effect for studies evaluating trait anxiety during pregnancy in women living with obesity (BMI > 30 kg/m^2) compared to women of a healthy weight (BMI 18.5 to 25 kg/m^2).

3.7 | Methodological quality of included studies

Seven studies were rated as "strong," five studies as "moderate," and two studies as "weak." Specific details of the quality appraisal for each study and assessment domain are provided in Table S3. From studies that were rated as "strong,"[12,14–17,32,35] there were seven effect sizes. Within these studies, depressive symptoms were greater in women with obesity compared to those of a healthy weight (SMD = 0.10 [95% CI: 0.02 to 0.19; 95% prediction intervals: 0.02 to 0.19], $p = 0.013$). From studies rated as "moderate,"[5,6,13,31,33] there were 11 effect sizes. Within these studies, depressive symptoms were greater in women with obesity compared to those of a healthy weight (SMD = 0.36 [95% CI: 0.24 to 0.49; 95% prediction intervals: 0.04 to 0.69], $p < 0.001$). There was a significant difference in effect sizes between the strong and moderate studies (X^2 [1] = 7.86, $p = 0.005$). Specifically, higher quality studies had smaller effect sizes. Of the 14 included studies, all

were rated strong for confounders, and data collection methods, while no study achieved a strong rating for selection bias, or study design. Removal of the one study rated as weak overall did not substantially influence the overall effect size for depression (SMD = 0.26 [95% CI: 0.16 to 0.36]; 95% prediction intervals: −0.06 to 0.59).

3.8 | Moderating factors

It was not possible to formally synthesize the impact of socio-economic or sociodemographic characteristics on associations between anxiety, depression, and weight status, given we found just one study that reported on socioeconomic status[15] and one study that reported on ethnicity.[14]

4 | DISCUSSION

This systematic review and meta-analysis explored the associations between anxiety, depression, and weight status in women living with obesity during and after pregnancy. Findings from this meta-analysis demonstrate that overall mental health is significantly worse in women living with obesity compared with women living with a healthy weight, during and after pregnancy. Specifically, depressive symptoms were greater in women living with obesity compared with those of a healthy weight, during and after pregnancy, and greater trait anxiety symptoms during pregnancy. No statistical differences were observed in state anxiety, albeit findings were derived from just one study. There were insufficient data available to statistically assess whether, and to what extent, socio-economic and socio-demographic status may affect this association.

The finding that women living with obesity demonstrate greater prevalence of depressive symptoms compared to those living with a healthy weight, during and after pregnancy, is in accordance with a previous meta-analysis conducted in this area.[11] Specifically, Molyneaux et al.[11] demonstrated greater prevalence of depressive symptoms in women living with obesity in both the antenatal and post-natal period. The findings are also concordant with the extensive body of literature demonstrating the association between obesity and depression in women of a child-bearing age who are not pregnant.[38] Reasons for greater prevalence of depressive symptoms in women living with obesity during and after pregnancy are likely synonymous with non-pregnant women. From a biological perspective, depression may occur due to the obesity-related activation of inflammatory pathways[39] and/or dysregulation of the hypothalamic–pituitary–adrenal axis.[40] Alternatively, and likely a larger contributor to depressive symptoms in women living with obesity during and after pregnancy, is the psychological distress associated with weight stigmatization and discrimination.[41] Mental health symptomology may be further exacerbated by both obesity and pregnancy related health conditions such as gestational diabetes.[11]

This meta-analysis is also consistent with Molyneaux et al.[11] in demonstrating that women living with obesity during pregnancy have greater trait anxiety symptoms compared to those living with a healthy weight. This elevated anxiety may be a result of pre-existing knowledge regarding the risk of diseases associated with obesity during pregnancy such as hypertension and gestational diabetes.[6,42,43] It should also be noted that in the non-pregnant population, weight has been found to positively associated with both anxiety and depression.[44] Interestingly, no significant association was observed between weight status and state anxiety around the time of pregnancy; however, these data were only derived from one study.[6] Further research should be conducted regarding state anxiety symptoms given its suitability in detecting anxiety in relation to specific events. This may be particularly useful in this context given the prevalence of anxiety inducing events throughout the course of pregnancy.[45,46]

In the present review, it was found that the quality of the included studies significantly influenced the strength of the pooled effect size for depression, with higher quality studies having a smaller effect size. The main reason for the differentiation between studies rated as "moderate" or "strong" was the blinding of outcome assessors and participants. Therefore, it is potentially possible when outcome assessors and participants are not blinded, bias could be introduced, and effects observed in the studies could be artificially inflated.[47] Although this is speculative, it is recommended that outcome assessors be blinded to protect against detection bias, and participants be blinded from the research question to protect against reporting bias.[23] There was insufficient data to definitively determine moderating effects in meta-analytic models. Future research is required to further establish the moderating effect of socio-economic and socio-demographic variables on the association between weight status, depression, and anxiety around the time of pregnancy.

4.1 | Implications for policy and practice

Findings from the present systematic review and meta-analysis suggest consideration must be given to anxiety and depression, in addition to traditional weight-related outcomes in maternal weight management interventions. Maternal weight management interventions should consider how mental health support can be integrated into relevant interventions, given elevated risk of anxiety and depression. Maternal weight management interventions should assess mental health symptomology to identify those individuals at risk and allow signposting to relevant mental health support services. This support may be provided in a number of settings including community mental health centers, residential treatment facilities and housing, and clinical and hospital settings.[48]

Future research is required to evaluate how mental health support services may be integrated into current maternal weight management services. Early treatment of anxiety and depression may increase the likelihood of mitigating associated psychological distress, as well as birth outcomes such as preterm birth, low birth weight, and intrauterine growth restriction.[9,10] In addition, further research is required to establish the influence of socio-economic and socio-

demographic factors on the association between weight status and anxiety/depression in women around the time of pregnancy.

It should be noted that this research area is one of an evolving nature, and this review includes literature published up to July 2021. Since our systematic search was conducted, further relevant research could have been published. On October 2, 2023, we conducted a non-systematic search for further eligible articles and did not find any additional literature that met all the inclusion criteria of this review.

4.2 | Limitations

Although this meta-analysis provides a valuable synthesis of evidence, it is important to acknowledge several limitations. This meta-analysis relied upon observational evidence, which means that causal inferences cannot be made. However, our focus on prospective cohort studies minimized the risk of reverse causality, which may be greater in other observational study designs (e.g., cross-sectional studies). Additionally, the tools that were used to assess anxiety and depression were heterogeneous, making comparisons between studies difficult. Finally, studies do not always control for pre-pregnancy depression/anxiety status or the use of medications to treat these conditions. Similarly, the presence of comorbid psychiatric conditions was rarely measured or controlled for, which could have biased results.

5 | CONCLUSION

This meta-analysis demonstrates that obesity during and after pregnancy is associated with greater anxiety and depression. These findings should be considered in the design of maternal weight management services. It may be useful for such services to identify individuals with anxiety and depression and subsequently signpost and/or provide relevant support. Future research should consider how mental health support can be integrated into existing weight management settings.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest statement.

ORCID

Alex Griffiths https://orcid.org/0000-0002-6044-3618
Tamara Brown https://orcid.org/0000-0003-1285-7098
Jamie Matu https://orcid.org/0000-0002-0204-2197

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