Environmental risk factors, protective factors, and biomarkers for postpartum depressive symptoms: an umbrella review

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Abstract (169/170 words)

We performed an umbrella review on environmental risk/protective factors and biomarkers for postpartum depressive symptoms to establish a hierarchy of evidence. We systematically searched PubMed, Embase, and the Cochrane Database of Systematic Reviews from inception until 12 January 2021. We included systematic reviews providing meta-analyses related to our research objectives. Methodological quality was assessed by AMSTAR 2, and the certainty of evidence was evaluated by GRADE. This review was registered in PROSPERO (CRD42021230784). We identified 30 articles, which included 45 environmental risk/protective factors (154594 cases, 7302273 population) and 9 biomarkers (2018 cases, 16757 population). The credibility of evidence was convincing (class I) for antenatal anxiety (OR 2.49, 1.91-3.25) and psychological violence (OR 1.93, 1.54-2.42); and highly suggestive (class II) for intimate partner violence experience (OR 2.86, 2.12-3.87), intimate partner violence during pregnancy (RR 2.81, 2.11-3.74), smoking during pregnancy (OR 2.39, 1.78-3.2), history of premenstrual syndrome (OR 2.2, 1.81-2.68), any type of violence experience (OR 2.04, 1.72-2.41), primiparity compared to multiparity (RR 1.76, 1.59-1.96), and unintended pregnancy (OR 1.53, 1.35-1.75).

Keywords

- Postpartum depressive symptoms
- Environmental risk and protective factors
- Biomarkers
- Umbrella review

Main text

1. Introduction

Postpartum depression is defined as a major depressive episode occurring within four weeks after delivery, which is encompassed by the "with peripartum onset" specifier in the DSM-5. In the eleventh revision of the ICD, postpartum depression is included in "mental or behavioral disorders associated with pregnancy, childbirth or the puerperium." In the clinical and research settings, however, postpartum depression is typically defined as the presence of depressive symptoms occurring up to 12 months after birth rather than the DSM or ICD definition (Stewart and Vigod, 2016). As one of the most common complications of pregnancy, the prevalence of postpartum depression is estimated to be approximately 9.2-19.2% (Banti et al., 2011; Gavin et al., 2005), with variability arising from different diagnostic criteria and population-specific factors (O'Hara and McCabe, 2013). The disorder has a profound impact on the quality and function of the mother's life (Field, 2010; Salmela-Aro et al., 2001), affecting her children's behavior, cognitive development, and physical health (Goodman et al., 2011; Gump et al., 2009) and can lead to potentially fatal consequences for both the mother and her children (Gressier et al., 2017; Pearson et al., 2013).

Because of this high personal, clinical, and societal burden of postpartum depression, preventive approaches have been investigated. Understanding risk and protective factors associated with postpartum depression is a prerequisite to advancing preventive care (Jones, 2021). Accordingly, numerous primary studies have explored genetic and environmental factors, as well as biomarkers that might reflect their effects, showing that postpartum depression is caused by a complex interaction of genetic predispositions and environmental factors (Mahon et al., 2009; Payne and Maguire, 2019; Robertson et al., 2004; Segman et al., 2010). Although these studies have been summarized by meta-analyses, these are typically restricted to a single factor and do not carefully examine important biases including publication bias or reporting bias (Ioannidis, 2005, 2008). Therefore, the consistency and magnitude of environmental factors or biomarkers associated with postpartum depression are undetermined. Meanwhile, given that most previous studies used questionnaires such as the Edinburgh Postnatal Depression Scale (EPDS) rather than the DSM or ICD diagnosis, it would be more accurate to note that they investigated postpartum depressive 'symptoms' rather than 'disorder.' Moreover, some previous meta-analyses included less objective diagnostic methods such as self-reports or set too liberal cutoffs for determining postpartum depressive symptoms, which may have resulted in potential false positives and exaggerated effects. In this regard, this umbrella review aimed to provide a bird's eye view on environmental risk factors, protective factors, and biomarkers for postpartum depressive symptoms by applying the state-of-the-art hierarchical system and presenting detailed underlying mechanisms.

2. Methods

2.1. Protocol, registration, and study design

We performed an umbrella review of systematic reviews and meta-analyses in compliance with the updated PRISMA guidelines (Appendix pp 5-7) (Page et al., 2021). This review is registered with PROSPERO, number

CRD42021230784, which is available online. The screening process, data extraction, and methodological appraisal of eligible articles were conducted independently by two investigators (JHK and SL), and any disagreement was resolved through discussion among four authors (JHK, JYK, SL, and JIS).

2.2. Search strategy and eligibility criteria

We systematically searched PubMed, Embase, and the Cochrane Database of Systematic Reviews from database inception to Jan 12, 2021, without any language restrictions. We used predetermined search terms including "postpartum", "depress*", and "meta-analysis", and full search strategies for each database are presented in appendix p 8. To find eligible articles among the searched articles, each investigator screened titles, abstracts, and full texts in order. We also manually searched the references of relevant articles (Figure 1).

We included systematic reviews providing meta-analyses that examined associations between postpartum depressive symptoms and environmental risk factors, protective factors, or biomarkers. The definitions of environmental risk factor, protective factor, and biomarker are presented in appendix p 9. Since most meta-analyses used questionnaires such as the EPDS rather than DSM or ICD criteria, we investigated 'postpartum depressive symptoms' that occurred within 12 months after childbirth. We included studies that used the validated diagnostic methods for determining postpartum depressive symptoms including not only DSM (any edition), ICD (any edition), and medical records but also EPDS, the Center for Epidemiologic Studies Depression scale (CES-D), Beck Depression Inventory (BDI), etc.

We excluded articles that did not study environmental risk factors, protective factors, or biomarkers for postpartum depressive symptoms; articles that did not provide meta-analyses; articles that did not provide sufficient data for the re-analysis of a meta-analysis (i.e., individual study estimates or the data to calculate them). We also excluded non-human studies, purely genetic studies, primary studies, and conference abstracts. If more than one meta-analysis covered the same topic, we prioritized the one with the largest number of individual studies, then the most recent one, and lastly, the one with the largest number of cases with postpartum depressive symptoms. The list of articles excluded at the full-text screening stage is presented in appendix pp 13-18.

2.3. Data extraction

From each eligible meta-analysis, we extracted the following data: the names of the authors; publication year; environmental risk factors, protective factors, or biomarkers; operationalization of depressive symptoms and applied cutoff for each individual study if available; number of cases with postpartum depressive symptoms and total study population; maximally adjusted individual study estimates and corresponding 95% confidence intervals (95% CIs); metrics used in the original analyses (e.g. odds ratio [OR], relative risk [RR], Hedge's g); and study designs of individual studies (e.g. cohort, case-control, cross-sectional).

2.4. Data analysis

2.4.1. Main data analysis

We conducted a series of statistical tests to examine the robustness and consistency of data in accordance with

previous umbrella reviews (Belbasis et al., 2015; Bellou et al., 2017; Kim et al., 2020; Kim et al., 2019) and recent guidance for umbrella review (Fusar-Poli and Radua, 2018). We re-analyzed each eligible meta-analysis based on extracted individual study estimates, using metrics used in the original meta-analysis. We calculated the summary effect estimate, corresponding 95% CI, and p values under both random and fixed effects models. We further assessed whether p values < 0.001 or 0.000001 (Ioannidis et al., 2011; Sterne and Davey Smith, 2001). To evaluate heterogeneity, we performed Cochran's Q test and calculated the I^2 statistic ($I^2 > 50\%$ indicates high heterogeneity) (Cochran, 1954). We assessed the existence of small study effects (i.e., larger studies have significantly more conservative results than smaller studies) with the regression asymmetry test proposed by Egger and colleagues (Egger et al., 1997), and small study effects were noted at Egger p value < 0.1. We estimated the 95% prediction interval, the range in which we expect the effect of association would lie for 95% of future studies (Higgins et al., 2009). We performed p-curve analysis and assessed the distribution of statistically significant p values to detect publication bias or p-hacking among the individual studies (Simonsohn et al., 2014a, b), and we denoted a set of individual studies to have evidential value when the possibility of selective reporting was ruled out (p value for the right-skewness test for the half curve < 0.05 or p value for the right-skewness test < 0.1 for both the half and full curve) (Simonsohn et al., 2014b). We also performed random-effects meta-analyses under 5%, 10%, 15%, and 20% credibility ceilings to account for the potential methodological limitations of observational studies that might result in spurious significance (Papatheodorou et al., 2015; Salanti and Ioannidis, 2009).

The methodological quality of each eligible article was assessed using A Measurement Tool to Assess Systematic Reviews 2 (AMSTAR 2) by two independent investigators (JHK and SL) and any disagreements were resolved by consensus (Shea et al., 2017). The overall certainty of the estimate was evaluated based on the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) method by two authors (JHK and JYK), and any disagreements were resolved by consensus (Balshem et al., 2011). Because all included individual studies were observational studies, the decision for the certainty of evidence started at 'low' and downgraded to 'very low' when at least one reason to downgrade was identified, while upgraded to 'moderate' when some reason was found to upgrade such as large effect size.

2.4.2. Sensitivity analyses

We performed sensitivity analyses of the validated cutoff scores for determining postpartum depressive symptoms by excluding individual studies that used lower cutoffs than the validated ones, which may lead to false positive and exaggerated effects. The validated cutoffs we used for each included operationalization of depressive symptoms are presented in appendix p 10. We also conducted sensitivity analyses of cohort studies (retrospective or prospective), prospective cohort studies, and study estimates adjusted for at least one confounder to further assess the robustness of the evidence. All sensitivity analyses were performed for associations graded as providing convincing or highly suggestive evidence. All statistical tests were two-sided and statistical significance was set at p < 0.05. All statistical analyses were performed by R version 4.0.4 and its packages.

2.5. Determining the credibility of evidence

Referring to the classification system of recent umbrella reviews (Belbasis et al., 2015; Bellou et al., 2017; Kim et al., 2020; Kim et al., 2019), we classified the identified associations into five classes by their level of credibility, based on the results of our statistical analyses – convincing (class I), highly suggestive (class II), suggestive (class III), weak (class IV), and not significant (NS) (Table 1). Criteria for classifying the level of evidence included p value under a random-effects model, number of cases with postpartum depressive symptoms, the p value of the largest study, the I^2 statistic, small study effects, results of the p-curve analysis, the 95% prediction interval, and a random-effects p value under a 10% credibility ceiling.

3. Results

3.1. Search results

From database inception to Jan 12, 2021, we identified 454 articles of which only 30 met the inclusion criteria (Figure 1). Among the 30 articles, 54 unique meta-analyses were identified (45 environmental risk/protective factors and nine biomarkers; Table 2, Appendix p 19, 22-24, 28-122) (Azami et al., 2019a; Azami et al., 2019b; Bacchus et al., 2018; Beydoun et al., 2012; Cao et al., 2020; Chen et al., 2019; Dachew et al., 2021; Dadi et al., 2020; de Paula Eduardo et al., 2019; Desta et al., 2021; Falah-Hassani et al., 2015; Grigoriadis et al., 2019; Howard et al., 2013; Kang et al., 2020; Kountanis et al., 2020; Lin et al., 2017; Minaldi et al., 2020; Moameri et al., 2019; Molyneaux et al., 2014; Necho et al., 2020; Qiu et al., 2020; Tan et al., 2021; Tokumitsu et al., 2020; Tolossa et al., 2020; Wang et al., 2018; Yang et al., 2020; Yargawa and Leonardi-Bee, 2015; Ye et al., 2020; Zhang et al., 2019; Zhu et al., 2019).

3.2. Environmental risk factors and protective factors

The 45 meta-analyses of environmental risk/protective factors were based on 154594 cases with postpartum depressive symptoms (median 1031 per meta-analysis, interquartile range [IQR] 551-5835, range 89-17954) and included 7302273 total population (median 11758 per meta-analysis, IQR 4437-77838, range 875-2302311). Among them, 34 meta-analyses were based on cohorts, of which, 23 also included case-control or cross-sectional studies. The median number of study estimates was eight (IQR 5-12, range 2-39). Effect metrics were either OR or RR. Among 45 associations, 43 (96%) associations were statistically significant with $p<0.05$, 35 of 45 (78%) with $p<0.001$, and 13 of 45 (29%) with $p<0.000001$. Among 43 statistically significant associations, 25 (58%) included more than 1000 cases with postpartum depressive symptoms. Only 14 of 45 (31%) associations showed no heterogeneity ($I^2<50\%$). Among 45 associations, three (7%) were not appropriate for Egger's test since they included less than three individual studies. Subsequently, 30 of 42 (71%) associations presented no small study effect. Further, 39 of 45 (87%) associations suggested no problems in the p-curve analysis, 33 of 45 (73%) retained statistical significance with a 10% credibility ceiling, and the 95% prediction interval excluded the null value in 7 of 45 (16%).

Only two environmental risk factors were graded as convincing evidence (class I; Table 2, Figure 2): antenatal anxiety (OR 2.49, 95% CI 1.91-3.25) and psychological violence (OR 1.93, 95% CI 1.54-2.42). Seven were graded as highly suggestive evidence (class II; Table 2, Figure 2): intimate partner violence experience (OR 2.86, 95%

CI 2.12-3.87), intimate partner violence during pregnancy (RR 2.81, 95% CI 2.11-3.74), smoking during pregnancy (OR 2.39, 95% CI 1.78-3.2), history of premenstrual syndrome (OR 2.2, 95% CI 1.81-2.68), any type of violence experience (OR 2.04, 95% CI 1.72-2.41), primiparity compared to multiparity (RR 1.76, 95% CI 1.59-1.96), and unintended pregnancy (OR 1.53, 95% CI 1.35-1.75). Remarkably, 4 of 9 (44%) factors with high level of evidence were related to violence against the mother. Other factors included preterm birth, pre-pregnancy obesity, cesarean section (class III), low income, poor social support, and poor marital relationship (class IV). Meanwhile, active husband participation in maternal healthcare/services during pregnancy and postpartum showed protective effects against postpartum depressive symptoms with statistical significance (class IV).

3.3. Biomarkers

The nine biomarker meta-analyses covered 2018 cases with postpartum depressive symptoms (median 201 per meta-analysis, IQR 200-215, range 168-404) and 16757 total population (median 1793 per meta-analysis, IQR 1741-1793, range 1432-2375). All nine meta-analyses were based on cohorts, of which, four also included case-control or cross-sectional studies. The median number of study estimates was five (IQR 5-6, range 3-7). Effect metrics were either OR, RR, or Hedge's g. Among nine associations, only three (33%) were statistically significant with $p<0.05$, while there was no association with $p<0.0001$. No association included more than 1000 cases with postpartum depressive symptoms, and only 3 of 9 (33%) associations showed no heterogeneity. All associations were available for Egger's test and 7 of 9 (78%) showed no small study effect. However, all but one suggested a problem in the p-curve analysis. No association retained statistical significance with a 10% credibility ceiling and excluded the null value in the 95% prediction interval. Accordingly, no association was graded as convincing or highly suggestive evidence (Appendix p 19).

3.4. AMSTAR 2 quality assessment

AMSTAR 2 quality assessment was available for all associations. Among 30 articles, 26 reported environmental risk/protective factors and four biomarkers. Of 26 meta-analysis articles on environmental risk/protective factors, only three (11%) were graded as high quality, two (8%) moderate, seven (27%) low, and 14 (54%) critically low. Of four meta-analysis articles on biomarkers, one (25%) was graded as low, and three (75%) were critically low. Among factors with a high level of evidence, only two (intimate partner violence experience and history of premenstrual syndrome) were graded as high quality.

3.5 Certainty of evidence using the GRADE method

Certainty of evidence was assessed for each estimate based on the GRADE method (Table 1, Appendix p 19). Out of 45 meta-analyses of environmental risk/protective factors, three (7%) were rated as moderate, 13 (29%) were low, and 29 (64%) were very low. Out of nine meta-analyses of biomarkers, one (11%) was rated as low and eight (89%) were very low. Among the factors with a high level of evidence, only one (antenatal anxiety) was graded as moderate. Detailed information on the decision of certainty of evidence for each estimate is presented in appendix pp 25-27.

3.6. Sensitivity analyses

Sensitivity analyses of the validated cutoff scores for meta-analyses with a high level of evidence (class I or II) were conducted. After excluding individual studies that used a lower cutoff than the validated one, 7 of 9 (78%) factors retained their level of evidence: antenatal anxiety (class I), intimate partner violence experience, intimate partner violence during pregnancy, smoking during pregnancy, history of premenstrual syndrome, any type of violence experience, and unintended pregnancy (class II), whereas the rest were downgraded to class III or IV. Sensitivity analyses of 1) cohort (retrospective and prospective), 2) prospective cohort, and 3) adjusted study estimates for meta-analyses with a high level of evidence (class I or II) were also performed. In the cohort sensitivity analyses, five factors retained their level of evidence: antenatal anxiety, psychologic violence (class I), any type of violence experience, primiparity compared to multiparity, and unintended pregnancy (class II), whereas the rest were downgraded to class III or IV, or inappropriate for subgroup analysis since they included fewer than two cohort studies. In the prospective cohort subgroup analysis, the same factors retained the level of evidence except for antenatal anxiety (class I to III). In the sensitivity analyses of adjusted study estimates, which was unavailable for one (intimate partner violence experience), 5 of 8 (63%) factors graded as class II: psychologic violence, intimate partner violence during pregnancy, any type of violence experience, primiparity compared to multiparity, and unintended pregnancy, whereas the rest were downgraded to class III or IV. All statistical details of the sensitivity analyses are presented in appendix pp 20-21.

4. Discussion

4.1. Summary of important results

To the best of our knowledge, this study is the first umbrella review based on the state-of-the-art evidence grading strategy, which systematically and quantitatively collected and assessed the hierarchy of evidence for environmental risk factors, protective factors, and biomarkers for postpartum depressive symptoms. Only nine associations of environmental risk factors showed evidence of high credibility (antenatal anxiety, psychological violence [class I], intimate partner violence experience, intimate partner violence during pregnancy, smoking during pregnancy, history of premenstrual syndrome, any type of violence experience, primiparity compared to multiparity, and unintended pregnancy [class II]).

4.1.1 Strength of the present study

Indeed, there are three previous studies attempted to summarize the evidence on environmental risk factors of postpartum depressive symptoms (Gastaldon et al., 2022; Hutchens and Kearney, 2020; Zhao and Zhang, 2020). However, two reviews (Hutchens and Kearney, 2020; Zhao and Zhang, 2020) did not apply a hierarchical system that can account for several types of biases (Fusar-Poli and Radua, 2018). Meanwhile, Gastaldon et al. (Gastaldon et al., 2022) established a hierarchy of the evidence but reported 12 potential risk factors which is fewer than 45 risk factors identified in our review. We also found two risk factors with convincing evidence (Class I) (antenatal anxiety and psychological violence), whereas Gastaldon et al. found none. It should also be noted that the criteria for convincing evidence (class I) is stricter in our review than the review by Gastaldon et al., given that we used

10% credibility ceilings test, which was introduced in previous umbrella reviews (Kim et al., 2020; Kim et al., 2019), and we also used a novel p-curve analysis to detect p hacking. Lastly, we endeavored to address the underlying biological and/or behavioral mechanisms in detail for each risk factors with high level of evidence (class I and II).

4.2. Psychological violence, intimate partner violence experience, intimate partner violence during pregnancy, and any type of violence experience

Various types of violence against the mother (psychological violence (Zhang et al., 2019) [class I]; intimate partner violence experience (Howard et al., 2013), intimate partner violence during pregnancy (Beydoun et al., 2012), and any type of violence experience (Zhang et al., 2019) [class II]) were associated with a higher risk of postpartum depressive symptoms. Of note, psychological violence was downgraded to class III in the sensitivity analysis of the validated cutoff scores, while others were not. Though the underlying mechanism is unclear, given that violence against the mother is a type of stress, stress-related neuroendocrine dysfunction and gene-stress interaction seem to be the most plausible explanations. The former suggests that the unbalanced secretion of glucocorticoids, the final product of the hypothalamic-pituitary-adrenal (HPA) axis, which is activated by a stress response, may affect psychological function, leading to depression (Brummelte and Galea, 2010; Meltzer-Brody, 2011). The latter proposes that reduced activity of brain-derived neurotrophic factors resulting from stressful events may lead to the diminished function of brain regions, including those involved in emotional processing and cognition, and eventually, subsequent changes in mood and depression (Begni et al., 2017; Brunoni et al., 2008; Molendijk et al., 2014). Notably, the majority of factors related to violence against the mother —including class I, II, and also others —had effect sizes larger than two. In this regard, the violence experience of the mother may be a robust predictor of postpartum depressive symptoms despite its somewhat large heterogeneity. These findings emphasize the necessity of screening for domestic and intimate partner violence and promoting maternal mental health.

4.3. Antenatal anxiety

Antenatal anxiety (Grigoriadis et al., 2019) provided convincing evidence for increasing the risk of postpartum depressive symptoms with an effect size larger than two (OR 2.64, 95% CI 2.02-3.46), retaining convincing evidence in sensitivity analysis of the validated cutoff scores. Notably, antenatal anxiety showed moderate certainty of evidence according to the GRADE method even though its analysis only contained observational studies. It should be mentioned that the factor is simply anxiety, which represents symptoms rather than the disorder. Indeed, individual studies in the meta-analysis included not only those that used the diagnostic criteria of anxiety disorder but also those that used anxiety questionnaire scores (e.g., state-trait anxiety inventory-trait score itself) or an additional cut-off system (e.g., state-trait anxiety inventory-trait score > 45). Of note, the latter distinguished excessively anxious mothers from those experiencing anxiety of a normal range by setting certain cutoff scores such as one standard deviation above the mean or the top 25th percentile. In terms of anxiety disorders, antenatal social phobia (Coelho et al., 2011), generalized anxiety disorder (Coelho et al., 2011), and panic disorder (Rambelli et al., 2010) are also suggested to be independent risk factors for postpartum depressive symptoms

respectively. Although robust biological mechanisms have yet to be identified, it is important to point out that 1) anxiety symptoms are frequently reported in pregnancy and often even considered a typical experience of pregnancy, and 2) problematic anxiety symptoms in pregnancy were not well distinguished from normal anxiety, and thereby the anxiety symptoms of mothers should not simply be considered to be a normal adaptive part of pregnancy.

4.4. Smoking during pregnancy

Smoking during pregnancy (Chen et al., 2019) was associated with an increased risk of postpartum depressive symptoms with highly suggestive evidence, retaining the level of evidence in sensitivity analysis of the validated cutoff scores while downgraded to weak in other sensitivity analyses. Regarding its biological mechanisms, it has been proposed that smoking may have anti-estrogenic effects by disrupting endogenous estrogen biosynthesis and bioavailability (Baron, 1984; Ruan and Mueck, 2015), given that women are prone to mood fluctuation during the period when hormone levels (especially sex steroid hormones such as estrogen and progesterone) change rapidly (Schiller et al., 2015). HPA axis activation due to immune system alteration (Lee et al., 2012; McEvoy et al., 2015; Pace and Miller, 2009), increased oxidative stress (Black et al., 2015; Yanbaeva et al., 2007), and nicotine acetylcholine receptors (Philip et al., 2010) induced by smoking are other potential mechanisms. Meanwhile, numerous investigations have been conducted regarding the various smoking cessation patterns and corresponding risk of postpartum depressive symptoms. Salimi et al. (Salimi et al., 2015) reported the odds of postpartum depressive symptoms in women who quit smoking during the final 3 months of pregnancy but resumed after parturition (OR 1.28, 1.06-1.53) and who did not quit at all (OR 1.48, 1.26-1.73) compared to those who quit during the final 3 months of pregnancy and remained non-smokers after parturition. Although using a less rigorous definition of postpartum depression, this finding demonstrates that smoking cessation is important not only before or during pregnancy but also in the postpartum period to prevent postpartum depressive symptoms. In addition, passive smoking should also be avoided (Song et al., 2019). Potential confounders of the association should be accounted for, such as prenatal stressful events which may be associated with both smoking and postpartum depressive symptoms (Kassel et al., 2003; Necho et al., 2020).

4.5. History of premenstrual syndrome

History of premenstrual syndrome (Cao et al., 2020) was associated with an increased risk of postpartum depressive symptoms with highly suggestive evidence, retaining the level of evidence in sensitivity analysis of the validated cutoff scores while downgraded to weak in other sensitivity analyses. This association is noteworthy because premenstrual syndrome has a high prevalence of around 70% (Ranjbaran et al., 2017). Regarding its underlying mechanisms, increased sensitivity to hormonal fluctuation has been suggested to be the most plausible one (Schiller et al., 2016; Yonkers et al., 2008). Two reproductive steroid hormones, estrogen and progesterone, may play a major role (Schiller et al., 2016; Stoner et al., 2017). The levels of both hormones increase before the luteal phase and during pregnancy but rapidly decrease in the luteal phase and after parturition, and this kind of fluctuation contributes to the development of the premenstrual syndrome and postpartum depressive symptoms respectively, in those vulnerable to it (Bloch et al., 2000; Franz, 1988). It should be emphasized that hormonal

fluctuation itself in patients with premenstrual syndrome or postpartum depressive symptoms is not the issue as these patients have been found to have a normal hormone level, rather, the problem is patients' vulnerability to hormonal fluctuation (Rubinow and Schmidt, 2006). Although this may not appliable to late-onset postpartum depressive symptoms since the hormones level recovers to a steady state, this explanation seems to be most persuasive given that depression is more prevalent in women from puberty to menopause than in men of the same age, but this is reversed in childhood or after menopause (Bebbington et al., 2003; Birmaher et al., 1996; Jung et al., 2015). Meanwhile, other mechanisms have also been proposed such as inadequate vitamin D status (Jarosz and El-Sohemy, 2019; Wang et al., 2018) and cytokine effects (Stoner et al., 2017).

4.6. Primiparity compared to multiparity

Primiparity (Tokumitsu et al., 2020) is associated with a higher risk of postpartum depressive symptoms compared to multiparity with highly suggestive evidence, which was confirmed in all subgroup analyses except for the validated cutoff score analysis. Indeed, several reasons have been suggested as to why postpartum depressive symptoms are more prevalent in primiparity than multiparity. First, multiparity may be more experienced in adapting to stress or other adversities accompanied by pregnancy and parturition. Second, given that history of postpartum depression may be another risk factor for postpartum depressive symptoms despite its low level of evidence (class IV) (Desta et al., 2021), those who have experienced postpartum depression may endeavor not to endure it again by receiving psychological education, taking preventive measures against depression, or being reluctant to conceive again. Third, primiparous women are at an increased risk of having anxiety and sexual problems, which may eventually lead to postpartum depressive symptoms (Martínez-Galiano et al., 2019). Although the aforementioned factors may not fully account for the association and other unidentified factors may exist, this association might have major implications for healthcare professionals or national health care planners by alerting them to the necessity of paying more attention to mothers who become pregnant for the first time.

4.7. Unintended pregnancy

Unintended pregnancy (Qiu et al., 2020) provided highly suggestive evidence for higher risk of postpartum depressive symptoms, which was confirmed in all sensitivity analyses. In the regard that women who conceive unintentionally seem to experience psychosocial stress due to concerns after pregnancy such as interruptions in their education, career, or other life aspirations (Faisal-Cury et al., 2017; Steinberg and Rubin, 2014), stress-related neuroendocrine dysfunction and gene-stress interaction seems to be the two most plausible biological mechanisms that underlie the association between unintended pregnancy and postpartum depressive symptoms. A detailed explanation of these suggested mechanisms has already been mentioned above. Further, other behavioral mechanisms have also been suggested. First, mothers conceive without intention tend to start late and seldom complete prenatal care, which can be detrimental to maternal mental health (Karaçam et al., 2011). Second, a pregnancy that is unexpected and thus unplanned may result in adjustment stress in the mother, leading to concerns about maternal and fetal health and even conflicts regarding maintaining versus terminating the pregnancy (Faisal-Cury et al., 2017). Third, mothers with unintended pregnancies tend to smoke more and take fewer vitamins than

those who have planned pregnancies, which plausibly explains their higher risk of postpartum depressive symptoms given that smoking (Chen et al., 2019) and lack of vitamin D supplementation (Sheikh et al., 2017) were significantly associated with postpartum depressive symptoms.

4.8. Limitations

The present study has some limitations. First, since all meta-analyses were based on observational studies, reported associations do not necessarily imply causality and we could not completely exclude potential confounders, which requires a caution in interpreting the findings. Second, most of the identified associations showed large heterogeneity. This may be due to the unstandardized way in which variables have been operationalized as well as various cutoff points for determining postpartum depression. Meanwhile, the operationalization of environmental factors may be also inconsistent across studies. Third, a large portion of meta-analyses showed "low" or "critically low" methodological quality. Majority of them did not report a protocol before conducting a review and did not provide the list of excluded articles and exclusion reason. Fourth, we could only address the associations which were synthesized by meta-analyses; that is, we may have inevitably missed some important factors. Besides, although the most current concept of "perinatal depression" includes both prenatal and postnatal maternal depression, which does not allow the discrimination between intrauterine and postnatal effects, we focused on the sole postpartum depressive symptoms. We may miss some factors related to both maternal/newborn outcomes and interventions that may directly affect and modulate the magnitude of the effects of the candidate environmental factors and biomarkers appraised herein. However, this is an intrinsic limitation since our study was based on previous meta-analyses that only focused on postpartum depression.

5. Conclusions

Our umbrella review identified convincing evidence indicating that antenatal anxiety and psychological violence are robustly associated with postpartum depressive symptoms, while no associated protective factors or biomarkers showed robust evidence. Since these associations cannot imply causality, further well-designed primary studies with the ICD/DSM-established operationalization of postpartum depression are needed to confirm these findings.

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Data sharing All data used in this study were from publicly available articles.

Appendix Supplementary material on this article can be found, in the online version.

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Figure captions

Figure 1. PRISMA flow chart of study selection

Figure 2. Summary estimates of environmental risk and protective factors for postpartum depressive symptoms

Figure 1. PRISMA flow chart of study selection

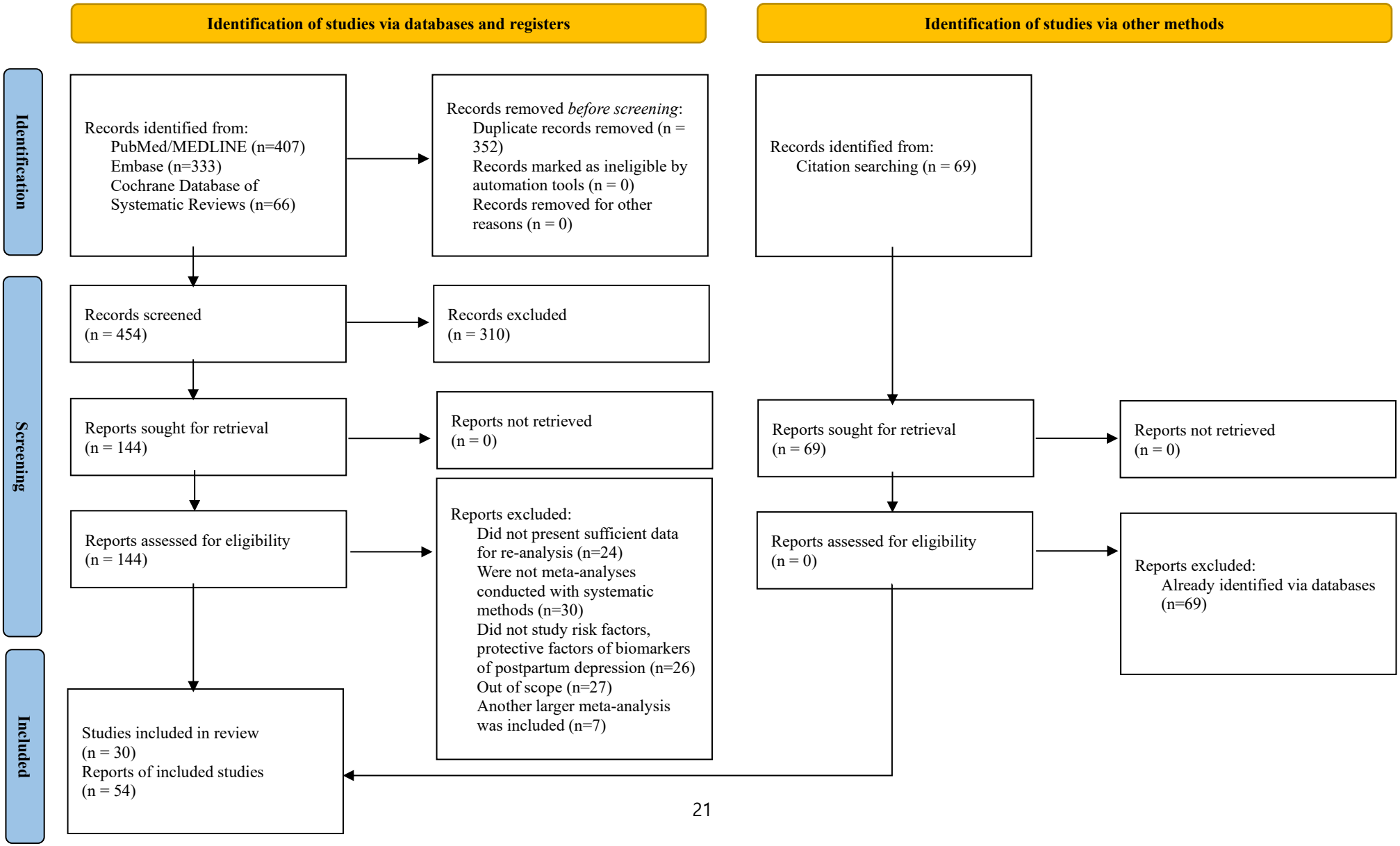

Figure 2. Summary estimates of environmental risk and protective factors for postpartum depressive symptoms

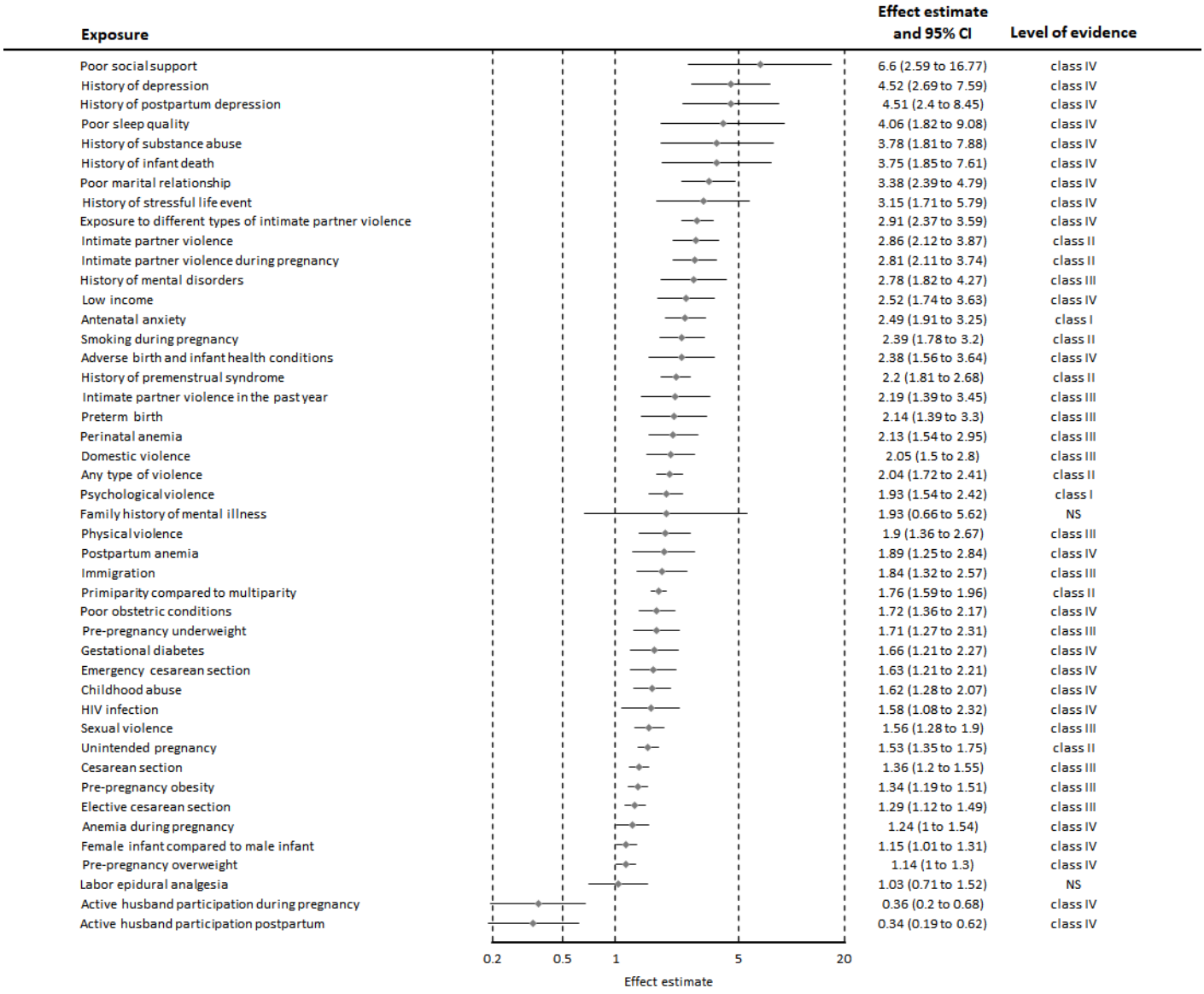

Table 1. Level of evidence for grading levels

Main analysis				
Evidence level Statistical analysis	Convincing (class I)	Highly suggestive (class II)	Suggestive (class III)	V (cl
Random effects p value	$< 10^{-6}$	$< 10^{-6}$	$< 10^{-3}$	<
Number of cases with postpartum depressive symptoms	> 1000	> 1000	> 1000	
P value of the largest study	< 0.05	< 0.05	x	
Heterogeneity: I^2	< 50%	x	x	
Small study effects	Not detected	x	x	
P curve analysis	Evidential value found	x	x	
95% prediction interval	Excludes the null	x	x	
P value under 10% credibility ceiling	< 0.05	x	x	

↓ ↓

Sensitivity analyses
Subgroup analysis after excluding individual studies using low cut-off symptom score
Subgroup analysis of adjusted study estimates
Subgroup analysis of cohort studies
Subgroup analysis of prospective cohort studies

Table 2. Environmental risk/protective factors of postpartum depressive symptoms

Exposure	Author, year	Number of cases / total population	Number of study estimates	Study design	Effect metrics	Random effects summary estimate (95% CI)	Random effects p-value	I^2	95% prediction interval
Convincing (class I)									
Antenatal anxiety	Grigoriadis 2019	1023 / 11758	7	Cohort	OR	2.49 (1.91 to 3.25)	< 0.000001	12%	1.54 to 4.04
Psychological violence	Zhang 2019	6734 / 59132	8	Cohort	OR	1.93 (1.54 to 2.42)	< 0.000001	48%	1.1 to 3.4
Highly suggestive (class II)									
Intimate partner violence experience	Howard 2013	1076 / 7497	12	Cohort, cross-sectional	OR	2.86 (2.12 to 3.87)	< 0.000001	58%	1.15 to 7.1
Intimate partner violence during pregnancy	Beydoun 2012	6106 / 21339	17	Cross-sectional	RR	2.81 (2.11 to 3.74)	< 0.000001	87%	0.86 to 9.21
Smoking during pregnancy	Chen 2019	2466 / 1424800	11	Cohort, case-control, cross-sectional	OR	2.39 (1.78 to 3.2)	< 0.000001	80%	0.88 to 6.45
History of premenstrual syndrome	Cao 2020	1400 / 8990	19	Cohort, case-control, cross-sectional	OR	2.2 (1.81 to 2.68)	< 0.000001	42%	1.21 to 4.01
Any type of violence experience	Zhang 2019	16953 / 177148	32	Cohort	OR	2.04 (1.72 to 2.41)	< 0.000001	94%	0.88 to 4.73
Primiparity compared to multiparity	Tokumitsu 2020	14048 / 102006	39	Cohort, case-control, cross-sectional	RR	1.76 (1.59 to 1.96)	< 0.000001	52%	1.2 to 2.58
Unintended pregnancy	Qiu 2020	5563 / 62778	30	Cohort, case-control	OR	1.53 (1.35 to 1.75)	< 0.000001	77%	0.88 to 2.68
Suggestive (class III)									
History of mental disorders	Dadi 2020	1106 / 14991	5	Cohort, cross-sectional	OR	2.78 (1.82 to 4.27)	0.000003	85%	0.61 to 12.69
Intimate partner violence in the past year	Bacchus 2018	> 1000 / 9175	7	Cohort	OR	2.19 (1.39 to 3.45)	0.00069	80%	0.51 to 9.4
Preterm birth	de Paula Eduardo 2019	1042 / 8357	12	Cohort, case-control, cross-sectional	OR	2.14 (1.39 to 3.3)	0.00052	66%	0.54 to 8.45
Perinatal anemia	Kang 2020	2741 / 77838	6	Cohort, case-control	RR	2.13 (1.54 to 2.95)	0.000005	44%	0.92 to 4.91
Domestic violence	Zhang 2019	2123 / 23996	16	Cohort	OR	2.05 (1.5 to 2.8)	0.000006	85%	0.6 to 7.03
Physical violence	Zhang 2019	6489 / 57783	8	Cohort	OR	1.9 (1.36 to 2.67)	0.00018	59%	0.76 to 4.78
Immigration	Falah-Hassani 2015	3857 / 32227	5	Cohort, cross-sectional	OR	1.84 (1.32 to 2.57)	0.0003	71%	0.65 to 5.21
Pre-pregnancy underweight	Dachew 2021	> 1000 / 617985	5	Cohort	OR	1.71 (1.27 to 2.31)	0.00042	45%	0.74 to 3.98
Sexual violence	Zhang 2019	6196 / 56117	6	Cohort	OR	1.56 (1.28 to 1.9)	0.000011	17%	1.04 to 2.33
Cesarean section	Moameri 2019	8870 / 614789	38	Cohort, case-control	OR	1.36 (1.2 to 1.55)	0.000001	54%	0.82 to 2.26
Pre-pregnancy obesity	Molyneaux 2014	9085 / 90777	14	Cohort, cross-sectional	OR	1.34 (1.19 to 1.51)	0.000003	48%	1 to 1.8
Elective cesarean section	Moameri 2019	8589 / 609598	28	Cohort, case-control	OR	1.29 (1.12 to 1.49)	0.00036	48%	0.8 to 2.1
Weak (class IV)									
Poor social support	Tolossa 2020	832 / 5104	5	Cross-sectional	OR	6.6 (2.59 to 16.77)	0.000075	96%	0.17 to 249.06
History of depression	Tolossa 2020	698 / 2876	6	Cross-sectional	OR	4.52 (2.69 to 7.59)	< 0.000001	79%	0.79 to 25.99
History of postpartum depression	Desta 2021	306 / 1361	3	Cross-sectional	OR	4.51 (2.4 to 8.45)	0.000003	65%	0 to 5009.21
Poor sleep quality	Yang 2020	89 / 7131	4	Cross-sectional	OR	4.06 (1.82 to 9.08)	0.00064	87%	0.1 to 171.18
History of substance abuse	Desta 2021	306 / 1261	3	Cross-sectional	OR	3.78 (1.81 to 7.88)	0.0004	82%	0 to 26468.56
History of infant death	Tolossa 2020	483 / 1909	5	Cross-sectional	OR	3.75 (1.85 to 7.61)	0.00025	83%	0.29 to 49.21
Poor marital relationship	Necho 2020	948 / 5505	6	Cross-sectional	OR	3.38 (2.39 to 4.79)	< 0.000001	100%	0.92 to 12.41
History of stressful life event	Necho 2020	529 / 3658	2	Cross-sectional	OR	3.15 (1.71 to 5.79)	0.00023	77%	NA

Exposure to different types of intimate partner violence	Dadi 2020	446 / 4473	10	Cohort, cross-sectional	OR	2.91 (2.37 to 3.59)	< 0.000001	17%	1.96 to 4.34
Low income	Necho 2020	699 / 4437	3	Cross-sectional	OR	2.52 (1.74 to 3.63)	< 0.000001	4%	0.21 to 30.86
Adverse birth and infant health conditions	Dadi 2020	554 / 13560	5	Cohort, cross-sectional	OR	2.38 (1.56 to 3.64)	0.000063	75%	0.56 to 10.14
Postpartum anemia	Azami 2019	1031 / 3084	10	Cohort, cross-sectional	RR	1.89 (1.25 to 2.84)	0.0023	75%	0.5 to 7.17
Poor obstetric conditions	Dadi 2020	939 / 17095	8	Cohort, cross-sectional	OR	1.72 (1.36 to 2.17)	0.000005	71%	0.86 to 3.44
Gestational diabetes	Azami 2019	17954 / 2302311	14	Cohort, case-control, cross-sectional	RR	1.66 (1.21 to 2.27)	0.0015	89%	0.52 to 5.3
Emergency cesarean section	Moameri 2019	4815 / 79442	10	Cohort, case-control	OR	1.63 (1.21 to 2.21)	0.0014	68%	0.66 to 4.04
Childhood abuse	Zhang 2019	800 / 5027	5	Cohort	OR	1.62 (1.28 to 2.07)	0.000085	44%	0.81 to 3.27
HIV infection	Zhu 2019	548 / 3780	10	Cohort, case-control, cross-sectional	OR	1.58 (1.08 to 2.32)	0.019	65%	0.48 to 5.17
Anemia during pregnancy	Azami 2019	261 / 2785	8	Cohort	RR	1.24 (1 to 1.54)	0.048	39%	0.73 to 2.12
Female infant compared to male infant	Ye 2020	14358 / 119281	29	Cohort, case-control	OR	1.15 (1.01 to 1.31)	0.035	75%	0.66 to 2
Pre-pregnancy overweight	Dachew 2021	983 / 619568	6	Cohort	OR	1.14 (1 to 1.3)	0.043	27%	0.85 to 1.53
Active husband participation in maternal healthcare/services during pregnancy	Yargawa 2015	156 / 875	2	Cohort, cross-sectional	OR	0.36 (0.2 to 0.68)	0.0014	48%	NA
Active husband participation in maternal healthcare/services postpartum	Yargawa 2015	484 / 2149	5	Cohort, case-control, cross-sectional	OR	0.34 (0.19 to 0.62)	0.00038	57%	0.06 to 2
Not significant (NS)									
Family history of mental illness	Necho 2020	299 / 1198	2	Cross-sectional	OR	1.93 (0.66 to 5.62)	0.23	75%	NA
Labor epidural analgesia	Kountanis 2020	609 / 5322	10	Cohort, case-control	OR	1.03 (0.71 to 1.52)	0.86	79%	0.3 to 3.55

All statistical tests are two-sided.
Abbreviations: AMSTAR 2, A Measurement Tool to Assess Systematic Reviews 2; CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Developm
NA, not available; OR, odds ratio; RR, relative risk

Supplementary material

Environmental risk factors, protective factors, and biomarkers for postpartum depressive symptoms: an umbrella review

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Andre F. Carvalho[11,12], Joaquim Radua[13,14,15,16], Trevor Thompson[17], Lee Smith[18], Hans Oh[19], Lin Yang[20,21], Michele Fornaro[22], Andrew Stickley[23,24], Gonzalo Salazar de Pablo[13,25,26], Kalthoum Tizaoui[27], Dong Keon Yon[28], Seung Won Lee[29], Jimin Hwang[30], Jae Il Shin[31*] and Paolo Fusar-Poli[13,32,33,34]

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PRISMA checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Manuscript p 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstract checklist.	Supplementary material p 7
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Manuscript p 4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Manuscript p 4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Manuscript p 5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Manuscript p 5, Figure 1
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Manuscript p 5, Supplementary material p 8
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Manuscript p 5
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Manuscript p 5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Manuscript p 5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Manuscript p 5-6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Manuscript p 6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Manuscript p 6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Manuscript p 6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Manuscript p 6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Manuscript p 6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Manuscript p 6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Manuscript p 6-7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Manuscript p 6-7
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Manuscript p 6-7
Certainty	15	Describe any methods used to assess certainty (or confidence) in the body of	Manuscript p 6

Section and Topic	Item #	Checklist item	Location where item is reported
assessment		evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Manuscript p 7, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Supplementary material pp 13-18
Study characteristics	17	Cite each included study and present its characteristics.	Table 2, Manuscript p 7, Supplementary material pp 11-12
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 2, Manuscript p 8
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 2, S1-3, Figure 2, S1-54
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Table 2, S1-3, Figure 2, S1-54
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Table 2, S1-3, Figure 2, S1-54
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Manuscript pp 8-9, Table S2
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Manuscript pp 8-9, Table S2
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Manuscript pp 7-8, Table S2
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Manuscript pp 7-8, Table 2, Figure 2
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Manuscript p 9
	23b	Discuss any limitations of the evidence included in the review.	Manuscript p 13
	23c	Discuss any limitations of the review processes used.	Manuscript p 13
	23d	Discuss implications of the results for practice, policy, and future research.	Manuscript pp 9-13
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Manuscript p 5
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Manuscript p 5
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	No amendments to information
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Manuscript p 14
Competing interests	26	Declare any competing interests of review authors.	Manuscript p 14
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Manuscript p 14

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

PRISMA Abstract checklist

Some checklist items cannot be included in the abstract due to the word count restriction. (<170 words)

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	No
Synthesis of results	6	Specify the methods used to present and synthesise results.	No
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	No
Interpretation	10	Provide a general interpretation of the results and important implications.	No
OTHER			
Funding	11	Specify the primary source of funding for the review.	No
Registration	12	Provide the register name and registration number.	Yes

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Full search strategy (The last search done in Jan 12, 2021)

PubMed
(Postpartum[Tiab] OR postnatal[Tiab] OR puerperal[Tiab] OR perinatal[Tiab]) AND (depression[Tiab] OR depress*[Tiab] OR "depression, postpartum"[MeSH Terms]) AND (meta-analy*[all fields] OR meta-analysis[publication type] OR "Meta-Analysis as Topic"[Mesh]) 407 articles were found.
Embase
(Postpartum OR postnatal OR puerperal OR perinatal) AND (depression OR depress* OR "depression, postpartum") AND meta-analy* NOT ('conference abstract':it OR 'conference paper':it OR 'conference review':it OR editorial:it OR note:it OR letter:it OR 'short survey':it) 333 articles were found.
Cochrane Database of Systematic Reviews
(Postpartum OR postnatal OR puerperal OR perinatal) AND (depression OR depress* OR "depression, postpartum") 66 articles were found.

Definitions of environmental risk/protective factor and biomarker

Environmental risk/protective factor
A risk factor is any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury. * Additionally, in our review, protective factors were defined as any attribute, characteristic, or exposure of an individual that decreases the likelihood of developing a disease or injury.
Biomarker
A biomarker is any substance, structure, or process that can be measured in the body or its products and influence or predict the incidence of outcome or disease.

Validated diagnostic criteria and cut-off values used to diagnose postpartum depressive symptoms

Validated diagnostic criteria	Cut-off values (≥n)
BDI-IA[1]	10
BDI-II[1]	14
BDI-FS[1]	4
BDI-SF[2]	10
BSI[3]	0.76
CES-D[1]	16
CES-D 8[4]	9
EPDS[5]	10
HADS[6]	7
HAM-D[7]	9
PDSS[8]	60
PHQ-2[9]	2
PHQ-8[10]	10
PHQ-9[11]	10
SCL-8[12]	1
SRQ-20[13]	7

Abbreviations: BDI- II, Beck Depression Inventory–II; BDI-FS, Beck Depression Inventory-Fast Screen; BDI-IA, Amended Beck Depression Inventory; BSI, Brief Symptom Inventory; CES-D, Center for Epidemiologic Studies Depression; CES-D 8, 8-item short version of the Center for Epidemiologic Studies-Depression Scale; EPDS, Edinburgh Postnatal Depression Scale; HADS, Hospital Anxiety and Depression Scale; HAM-D, Hamilton Depression Rating Scale; PDSS, Postpartum Depression Screening Scale; PHQ-2, Patient Health Questionnaire-2 ; PHQ-8, Patient Health Questionnaire-8 ; PHQ-9, Patient Health Questionnaire-9 ; SCL-8, (Hopkins) Symptom Checklist-8; SRQ-20, WHO Self-Reporting Questionnaire 20

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The list of excluded meta-analyses by full text screening with exclusion reason

Abajobir, et al. 2016[1]	Another larger meta-analysis of same topic was included
Almeida, et al. 2020[2]	Another larger meta-analysis of same topic was included
Arafa, et al. 2019[3]	Another larger meta-analysis of same topic was included
Sun, et al. 2020[4]	Another larger meta-analysis of same topic was included
Wilson, et al. 2020[5]	Another larger meta-analysis of same topic was included
Wu, et al. 2012[6]	Another larger meta-analysis of same topic was included
Xu, et al. 2017[7]	Another larger meta-analysis of same topic was included
Bahadoran, et al. 2014[8]	Did not present sufficient data for re-analysis
Beck, et al. 1996[9]	Did not present sufficient data for re-analysis
Beck, et al. 2001[10]	Did not present sufficient data for re-analysis
Caropreso, et al. 2020[11]	Did not present sufficient data for re-analysis
Cluxton-Keller, et al. 2018[12]	Did not present sufficient data for re-analysis
Edwards, et al. 2021[13]	Did not present sufficient data for re-analysis
Emamian, et al. 2019[14]	Did not present sufficient data for re-analysis
Fellmeth, et al. 2017[15]	Did not present sufficient data for re-analysis
Gong, et al. 2017[16]	Did not present sufficient data for re-analysis
Hessami, et al. 2020[17]	Did not present sufficient data for re-analysis
Molyneaux, et al. 2014[18]	Did not present sufficient data for re-analysis
Mu, et al. 2019[19]	Did not present sufficient data for re-analysis
Nakamura, et al. 2019[20]	Did not present sufficient data for re-analysis
O'Hara, et al. 1996[21]	Did not present sufficient data for re-analysis
Özcan, et al. 2017[22]	Did not present sufficient data for re-analysis
Paulson, et al. 2010[23]	Did not present sufficient data for re-analysis
Pilkington, et al. 2015[24]	Did not present sufficient data for re-analysis
Pritchett, et al. 2017[25]	Did not present sufficient data for re-analysis
Racine, et al. 2021[26]	Did not present sufficient data for re-analysis
Suradom, et al. 2020[27]	Did not present sufficient data for re-analysis
Thiel, et al. 2020[28]	Did not present sufficient data for re-analysis
Veenendaal, et al. 2020[29]	Did not present sufficient data for re-analysis
Veisani, et al. 2013[30]	Did not present sufficient data for re-analysis
Wilson, et al. 2019[31]	Did not present sufficient data for re-analysis
Carter, et al. 2019[32]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Dennis, et al. 2004[33]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Dennis, et al. 2005[34]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Dhillon, et al. 2017[35]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Dodd, et al. 2015[36]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Dol, et al. 2020[37]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Geller, et al. 2017[38]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Hall, et al. 2020[39]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Huang, et al. 2020[40]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Lavender, et al. 2013[41]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Lin, et al. 2018[42]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Littleton, et al. 2007[43]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Meyrel, et al. 2018[44]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
O'Connor, et al. 2019[45]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Poyatos-León, et al. 2017[46]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Shorey, et al. 2018[47]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Sockol, et al. 2013[48]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Sockol, et al. 2015[49]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Sockol, et al. 2018[50]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Stuart, et al. 2003[51]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Taylor, et al. 2016[52]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Tong, et al. 2019[53]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Warsiti, et al. 2020[54]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Wojcieszek, et al. 2018[55]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Woody, et al. 2017[56]	Did not study risk factors, protective factors, or biomarkers of postpartum depression

Yonemoto, et al. 2017[57]	Did not study risk factors, protective factors, or biomarkers of postpartum depression
Anderson, et al. 2017[58]	Out of scope
Azam, et al. 2014[59]	Out of scope
Beck, et al. 2002[60]	Out of scope
Brown, et al. 2018[61]	Out of scope
Chen, et al. 2019[62]	Out of scope
Chowdhury, et al. 2015[63]	Out of scope
Cuijpers, et al. 2005[64]	Out of scope
Dachew, et al. 2020[65]	Out of scope
Dale, et al. 2008[66]	Out of scope
Davenport, et al. 2018[67]	Out of scope
Dipietro, et al. 2019[68]	Out of scope
González-Mesa, et al. 2019[69]	Out of scope
Hofmeyr, et al. 2015[70]	Out of scope
Hösli, et al. 2007[71]	Out of scope
Hutchens, et al. 2020[72]	Out of scope
Luo, et al. 2007[73]	Out of scope
Mersha, et al. 2018[74]	Out of scope
O'Connor, et al. 2016[75]	Out of scope
O'Connor, et al. 2019[76]	Out of scope
Owais, et al. 2020[77]	Out of scope
Park, et al. 2020[78]	Out of scope
Robertson, et al. 2004[79]	Out of scope
Suzuki, et al. 2019[80]	Out of scope
Upadhyay, et al. 2017[81]	Out of scope
Yan, et al. 2020[82]	Out of scope
Yonemoto, et al. 2013[83]	Out of scope
Zhao, et al. 2020[84]	Out of scope
Austin, et al. 2008[85]	Were not meta-analyses conducted with systematic methods
Ayano, et al. 2019[86]	Were not meta-analyses conducted with systematic methods
Bastos, et al. 2015[87]	Were not meta-analyses conducted with systematic methods
Chen, et al. 2019[88]	Were not meta-analyses conducted with systematic methods
Dencker, et al. 2019[89]	Were not meta-analyses conducted with systematic methods
Dennis, et al. 2008[90]	Were not meta-analyses conducted with systematic methods
Dennis, et al. 2008[91]	Were not meta-analyses conducted with systematic methods
Duko, et al. 2020[92]	Were not meta-analyses conducted with systematic methods
Field, et al. 2016[93]	Were not meta-analyses conducted with systematic methods
Gilinsky, et al. 2015[94]	Were not meta-analyses conducted with systematic methods
Giuseppe, et al. 2014[95]	Were not meta-analyses conducted with systematic methods
Gould, et al. 2017[96]	Were not meta-analyses conducted with systematic methods
Hahn-Holbrook, et al. 2017[97]	Were not meta-analyses conducted with systematic methods
Ip, et al. 2007[98]	Were not meta-analyses conducted with systematic methods
Karaçam, et al. 2018[99]	Were not meta-analyses conducted with systematic methods
Middleton, et al. 2018[100]	Were not meta-analyses conducted with systematic methods
Miller, et al. 2013[101]	Were not meta-analyses conducted with systematic methods
Molyneaux, et al. 2018[102]	Were not meta-analyses conducted with systematic methods
Nilaweera, et al. 2014[103]	Were not meta-analyses conducted with systematic methods
Øverland, et al. 2019[104]	Were not meta-analyses conducted with systematic methods
Psarraki, et al. 2020[105]	Were not meta-analyses conducted with systematic methods
Ribamar, et al. 2020[106]	Were not meta-analyses conducted with systematic methods
Rollè, et al. 2020[107]	Were not meta-analyses conducted with systematic methods
Ross, et al. 2006[108]	Were not meta-analyses conducted with systematic methods
Saccone, et al. 2016[109]	Were not meta-analyses conducted with systematic methods
Scope, et al. 2017[110]	Were not meta-analyses conducted with systematic methods
Scott, et al. 1999[111]	Were not meta-analyses conducted with systematic methods
Tobin, et al. 2018[112]	Were not meta-analyses conducted with systematic methods
Villegas, et al. 2011[113]	Were not meta-analyses conducted with systematic methods
Wilson, et al. 1996[114]	Were not meta-analyses conducted with systematic methods

References of the excluded meta-analyses by full text screening

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Table S1. Biomarkers of postpartum depressive symptoms

Biomarker	Author, year	Number of cases / total population	Number of study estimates	Study design	Effect metrics	Random effects summary estimate (95% CI)	Random effects p-value	I^2	95% prediction interval	Large heterogeneity, small study effect, loss of significance under 10% credibility ceiling, or evidential value not found under p-curve analysis	AMSTAR 2	GRADE
Weak (class V)												
Serum 25(OH)D level < 50 nmol/l	Wang 2018	168 / 1432	3	Cohort	OR	4.51 (1.62 to 12.58)	0.004	82%	0 to 966649.84	Large heterogeneity; loss of significance under 10% credibility ceiling; p curve analysis unavailable due to less than three significant studies	Critically low	Very low
High concentration of serum 25(OH)D	Tan 2020	404 / 2375	7	Cohort, case-control, cross-sectional	RR	0.48 (0.26 to 0.87)	0.015	86%	0.06 to 3.62	Large heterogeneity; loss of significance under 10% credibility ceiling	Low	Very low
Omega-6/omega-3 ratio	Lin 2017	200 / 1741	5	Cohort	Hedges' g	0.35 (0.02 to 0.68)	0.037	70%	-0.72 to 1.43	Large heterogeneity; loss of significance under 10% credibility ceiling; p curve analysis unavailable due to less than three significant studies	Critically low	Very low
Not significant (NS)												
Positive anti-thyroperoxidase antibodies	Minaldi 2020	201 / 2348	3	Cohort	RR	1.46 (0.76 to 2.77)	0.25	71%	0 to 2192.8	Large heterogeneity	Critically low	Very low
Total omega-6 acid	Lin 2017	200 / 1741	5	Cohort	Hedges' g	0.13 (-0.02 to 0.27)	0.079	0%	-0.11 to 0.36	None	Critically low	Very low
Arachidonic acid	Lin 2017	200 / 1741	5	Cohort	Hedges' g	0.05 (-0.12 to 0.23)	0.55	19%	-0.34 to 0.45	None	Critically low	Very low
Eicosapentaenoic acid	Lin 2017	215 / 1793	6	Cohort, case-control	Hedges' g	-0.08 (-0.25 to 0.1)	0.39	23%	-0.46 to 0.31	Small study effect	Critically low	Very low
Docosahexaenoic acid	Lin 2017	215 / 1793	6	Cohort, case-control	Hedges' g	-0.2 (-0.49 to 0.08)	0.17	66%	-1.06 to 0.66	Large heterogeneity	Critically low	Low
Total omega-3 acid	Lin 2017	215 / 1793	6	Cohort, case-control	Hedges' g	-0.24 (-0.51 to 0.03)	0.085	63%	-1.04 to 0.56	Large heterogeneity; small study effect	Critically low	Very low

All statistical tests are two-sided.
Abbreviations: AMSTAR 2, A Measurement Tool to Assess Systematic Reviews 2; CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development and Evaluations; OR, odds ratio; RR, relative risk

Table S2. Sensitivity analyses of associations graded as convincing (class I) or highly suggestive (class II)

Exposure	Author, year	Number of cases / total population	Number of study estimates	Effect metrics	Random effects summary estimate (95% CI)	Random effects p-value	I^2	95% prediction interval	Large heterogeneity, small study effect, loss of significance under 10% credibility ceiling, or evidential value not found under p curve analysis	Level of evidence
After excluding individual studies using low cut-off symptom score										
Antenatal anxiety	Grigoriadis 2019	1023 / 11 758	7	OR	2·49 (1·91 to 3·25)	< 0 000001	12%	1·54 to 4·04	None	Convincing retained
Psychological violence	Zhang 2019	1018 / 6067	7	OR	2·05 (1.51 to 2·78)	0·000004	43%	0·95 to 4·43	None	Convincing to suggestive
Intimate partner violence experience	Howard 2013	1055 / 7078	11	OR	2·93 (2.09 to 4·12)	< 0·000001	61%	1·05 to 8·16	Large heterogeneity; small study effect	Highly suggestive retained
Intimate partner violence during pregnancy	Beydoun 2012	4024 / 19 022	15	RR	3·12 (2.26 to 4·31)	< 0·000001	88%	0·85 to 11·4	Large heterogeneity; small study effect	Highly suggestive retained
Smoking during pregnancy	Chen 2019	2466 / 1 424 800	11	OR	2·39 (1.78 to 3·2)	< 0·000001	80%	0·88 to 6·45	Large heterogeneity	Highly suggestive retained
History of premenstrual syndrome	Cao 2020	1400 / 7573	18	OR	2·27 (1.84 to 2·82)	< 0·000001	44%	1·19 to 4·36	Small study effect	Highly suggestive retained
Any type of violence experience	Zhang 2019	11 056 / 122 705	30	OR	2·1 (1.71 to 2·58)	< 0·000001	93%	0·74 to 5·95	Large heterogeneity; small study effect	Highly suggestive retained
Primiparity compared to multiparity	Tokumitsu 2020	316 / 1995	4	RR	1·75 (1.17 to 2·64)	0·0068	62%	0·35 to 8·76	Large heterogeneity; loss of significance under 10% credibility ceiling; p curve analysis unavailable due to less than three significant studies	Highly suggestive to weak
Unintended pregnancy	Qiu 2020	3754 / 42 098	27	OR	1·55 (1.33 to 1·81)	< 0·000001	66%	0·82 to 2·93	Large heterogeneity; small study effect	Highly suggestive retained
Study estimates adjusted for at least one confounder										
Antenatal anxiety	Grigoriadis 2019	959 / 10 446	6	OR	2·48 (1.8 to 3·42)	< 0·000001	20%	1·25 to 4·94	None	Convincing to weak
Psychological violence	Zhang 2019	6720 / 59 060	7	OR	1·98 (1.55 to 2·52)	< 0·000001	54%	1·05 to 3·74	Large heterogeneity	Convincing to highly suggestive
Intimate partner violence during pregnancy	Beydoun 2012	6106 / 21 339	17	RR	2·81 (2.11 to 3·74)	< 0·000001	87%	0·86 to 9·21	Large heterogeneity; small study effect	Highly suggestive retained
Smoking during pregnancy	Chen 2019	73 / 163	1	OR	1·71 (1.01 to 2·89)	0·045	NA	NA	None	Highly suggestive to weak
History of premenstrual syndrome	Cao 2020	660 / 4205	7	OR	2·01 (1.6 to 2·53)	< 0·000001	13%	1·33 to 3·04	Small study effect	Highly suggestive to weak
Any type of violence experience	Zhang 2019	13 556 / 153 756	19	OR	1·79 (1.52 to 2·11)	< 0·000001	72%	1 to 3·2	Large heterogeneity	Highly suggestive retained
Primiparity compared to multiparity	Tokumitsu 2020	14 048 / 102 006	39	RR	1·76 (1.59 to 1·96)	< 0·000001	52%	1·2 to 2·58	Large heterogeneity; small study effect	Highly suggestive retained
Unintended pregnancy	Qiu 2020	4516 / 57534	17	OR	1·37 (1.21 to 1·55)	< 0·000001	71%	0·91 to 2·06	Large heterogeneity; small study effect	Highly suggestive retained
Prospective or retrospective cohort only										
Antenatal anxiety	Grigoriadis 2019	1023 / 11758	7	OR	2·49 (1.91 to 3·25)	< 0·000001	12%	1·54 to 4·04	None	Convincing retained
Psychological violence	Zhang 2019	6734 / 59 132	8	OR	1·93 (1.54 to 2·42)	< 0·000001	48%	1·1 to 3·4	None	Convincing retained

Intimate partner violence experience	Howard 2013	275 / 2482	6	OR	2·87 (2.07 to 3·98)	< 0·000001	0%	1·81 to 4·56	None	Highly suggestive to weak
Smoking during pregnancy	Chen 2019	449 / 4451	5	OR	3·15 (1.41 to 7·02)	0·0051	86%	0·17 to 57·75	Large heterogeneity	Highly suggestive to weak
History of premenstrual syndrome	Cao 2020	452 / 4442	6	OR	2·23 (1.74 to 2·86)	< 0·000001	10%	1·42 to 3·51	None	Highly suggestive to weak
Any type of violence experience	Zhang 2019	16 953 / 177 148	32	OR	2·04 (1.72 to 2·41)	< 0·000001	94%	0·88 to 4·73	Large heterogeneity; small study effect	Highly suggestive retained
Primiparity compared to multiparity	Tokumitsu 2020	12 109 / 88 073	9	RR	1·59 (1.37 to 1·85)	< 0·000001	54%	1·08 to 2·36	Large heterogeneity	Highly suggestive retained
Unintended pregnancy	Qiu 2020	5447 / 62 130	28	OR	1·53 (1.34 to 1·74)	< 0·000001	77%	0·89 to 2·64	Large heterogeneity; small study effect	Highly suggestive retained
Prospective cohort only										
Antenatal anxiety	Grigoriadis 2019	960 / 11 183	6	OR	2·47 (1.98 to 3·09)	< 0·000001	0%	1·8 to 3·39	Small study effect	Convincing to weak
Psychological violence	Zhang 2019	6734 / 59 132	8	OR	1·93 (1.54 to 2·42)	< 0·000001	48%	1·1 to 3·4	None	Convincing retained
Intimate partner violence experience	Howard 2013	275 / 2482	6	OR	2·87 (2.07 to 3·98)	< 0·000001	0%	1·81 to 4·56	None	Highly suggestive to weak
Smoking during pregnancy	Chen 2019	449 / 4451	5	OR	3·15 (1.41 to 7·02)	0·0051	86%	0·17 to 57·75	Large heterogeneity	Highly suggestive to weak
History of premenstrual syndrome	Cao 2020	195 / 1371	3	OR	2·13 (1.52 to 2·97)	0·00001	0%	0·24 to 18·62	P curve analysis unavailable due to less than three significant studies	Highly suggestive to weak
Any type of violence experience	Zhang 2019	16 953 / 177 148	32	OR	2·04 (1.72 to 2·41)	< 0·000001	94%	0·88 to 4·73	Large heterogeneity; small study effect	Highly suggestive retained
Primiparity compared to multiparity	Tokumitsu 2020	12 109 / 88 073	9	RR	1·59 (1.37 to 1·85)	< 0·000001	54%	1·08 to 2·36	Large heterogeneity	Highly suggestive retained
Unintended pregnancy	Qiu 2020	3662 / 33 348	25	OR	1·63 (1.38 to 1·93)	< 0·000001	79%	0·8 to 3·31	Large heterogeneity; small study effect	Highly suggestive retained

All statistical tests are two-sided.
Abbreviations: CI, confidence interval; OR, odds ratio; RR, relative risk

Table S3. Supplementary analyses result of environmental risk and protective factors

Exposure	Author, year	Number of study estimates	Effect metrics	Fixed effects summary estimate (95% CI)	Fixed effects p-value	Effect estimate of the largest study (95% CI)	Egger p value	Summary estimate (95% CI) under 5/10/15/20% credibility ceilings	I^2 under 0/5/10/15/20% credibility ceilings	Right-skewness test of p curve analysis, p value for half curve / p value for full curve
Antenatal anxiety	Grigoriadis 2019	7	OR	2·39 (1·92 to 2·96)	< 0·000001	2·1 (1·6 to 2·76)	0·21	2·34 (1·48 to 3·7)/2·16 (1·25 to 3·72)/1·99 (1·07 to 3·7)/1·83 (0·92 to 3·64)	12/0/0/0/0%	< 0·001 / < 0·001
Psychological violence	Zhang 2019	8	OR	1·75 (1·62 to 1·89)	< 0·000001	1·7 (1·56 to 1·85)	0·38	1·65 (1·26 to 2·17)/1·62 (1·16 to 2·27)/1·59 (1·07 to 2·37)/1·56 (0·98 to 2·47)	48/0/0/0/0%	< 0·001 / < 0·001
Intimate partner violence experience	Howard 2013	12	OR	2·43 (2·04 to 2·9)	< 0·000001	1·44 (1 to 2·07)	0·021	2·02 (1·52 to 2·69)/2·02 (1·4 to 2·91)/2·02 (1·3 to 3·15)/2·02 (1·18 to 3·47)	58/0/0/0/0%	< 0·001 / < 0·001
Intimate partner violence during pregnancy	Beydoun 2012	17	RR	2·01 (1·84 to 2·21)	< 0·000001	1·4 (1·21 to 1·62)	< 0·001	1·7 (1·42 to 2·04)/1·7 (1·35 to 2·14)/1·7 (1·28 to 2·26)/1·7 (1·19 to 2·42)	87/0/0/0/0%	< 0·001 / < 0·001
Smoking during pregnancy	Chen 2019	11	OR	2·14 (1·9 to 2·41)	< 0·000001	2·21 (1·75 to 2·79)	0·33	1·77 (1·39 to 2·26)/1·72 (1·29 to 2·3)/1·69 (1·2 to 2·39)/1·7 (1·12 to 2·58)	80/0/0/0/0%	< 0·001 / < 0·001
History of premenstrual syndrome	Cao 2020	19	OR	2·01 (1·76 to 2·31)	< 0·000001	1·5 (1·09 to 2·07)	< 0·001	1·86 (1·52 to 2·28)/1·81 (1·41 to 2·31)/1·76 (1·32 to 2·33)/1·71 (1·23 to 2·39)	42/0/0/0/0%	< 0·001 / < 0·001
Any type of violence experience	Zhang 2019	32	OR	1·45 (1·4 to 1·49)	< 0·000001	1·11 (1·06 to 1·16)	0·013	1·43 (1·25 to 1·64)/1·24 (1·12 to 1·37)/1·23 (1·09 to 1·39)/1·22 (1·06 to 1·41)	94/31/0/0/0%	< 0·001 / < 0·001
Primiparity compared to multiparity	Tokumitsu 2020	39	RR	1·52 (1·47 to 1·56)	< 0·000001	1·46 (1·41 to 1·51)	0·002	1·59 (1·42 to 1·78)/1·53 (1·34 to 1·75)/1·48 (1·28 to 1·72)/1·43 (1·21 to 1·7)	52/0/0/0/0%	< 0·001 / < 0·001
Unintended pregnancy	Qiu 2020	30	OR	1·21 (1·17 to 1·26)	< 0·000001	1·11 (1·06 to 1·17)	< 0·001	1·24 (1·15 to 1·33)/1·23 (1·13 to 1·34)/1·22 (1·11 to 1·35)/1·21 (1·07 to 1·36)	77/0/0/0/0%	< 0·001 / < 0·001
Intimate partner violence in the past year	Bacchus 2018	7	OR	1·74 (1·47 to 2·06)	< 0·000001	1·29 (1·02 to 1·63)	0·17	1·66 (1·06 to 2·61)/1·42 (0·94 to 2·14)/1·26 (0·88 to 1·81)/1·18 (0·78 to 1·79)	80/41/17/0/0%	< 0·001 / < 0·001
Preterm birth	de Paula Eduardo 2019	12	OR	1·79 (1·44 to 2·23)	< 0·000001	1·29 (0·9 to 1·85)	0·21	1·42 (1·11 to 1·81)/1·36 (1·05 to 1·76)/1·32 (0·98 to 1·77)/1·28 (0·92 to 1·78)	66/1/0/0/0%	< 0·001 / < 0·001
Perinatal anemia	Kang 2020	6	RR	2·04 (1·76 to 2·37)	< 0·000001	2·01 (1·7 to 2·38)	0·87	1·88 (1·22 to 2·89)/1·76 (1·06 to 2·93)/1·64 (0·89 to 3·02)/1·64 (0·77 to 3·48)	44/7/0/0/0%	< 0·001 / < 0·001
Domestic violence	Zhang 2019	16	OR	2·15 (1·92 to 2·39)	< 0·000001	1·29 (1·02 to 1·63)	0·83	1·5 (1·16 to 1·93)/1·36 (1·09 to 1·69)/1·31 (1·02 to 1·68)/1·26 (0·94 to 1·67)	85/31/0/0/0%	< 0·001 / < 0·001
Physical violence	Zhang 2019	8	OR	1·75 (1·47 to 2·08)	< 0·000001	1·4 (1·09 to 1·79)	0·65	1·58 (1·2 to 2·08)/1·54 (1·1 to 2·16)/1·5 (1·01 to 2·23)/1·46 (0·93 to 2·29)	59/0/0/0/0%	0·004 / 0·001

Immigration	Falah-Hassani 2015	5	OR	1·42 (1·28 to 1·56)	< 0·000001	1·3 (1·16 to 1·45)	0·016	1·56 (1·16 to 2·09)/1·51 (1·08 to 2·13)/1·51 (0·99 to 2·3)/1·51 (0·9 to 2·54)	71/5/0/0/0%	< 0·001 / < 0·001
Sexual violence	Zhang 2019	6	OR	1·56 (1·35 to 1·81)	< 0·000001	1·6 (1·34 to 1·91)	0·93	1·41 (1·09 to 1·82)/1·35 (1·02 to 1·78)/1·29 (0·96 to 1·74)/1·27 (0·89 to 1·82)	17/0/0/0/0%	< 0·001 / 0·006
Cesarean section	Moameri 2019	38	OR	1·27 (1·19 to 1·36)	< 0·000001	1·32 (1·14 to 1·53)	0·19	1·17 (1·08 to 1·27)/1·14 (1·04 to 1·24)/1·11 (1·01 to 1·22)/1·09 (0·98 to 1·21)	54/0/0/0/0%	0·001 / < 0·001
Pre-pregnancy obesity	Molyneaux 2014	14	OR	1·34 (1·27 to 1·41)	< 0·000001	1·43 (1·32 to 1·55)	0·79	1·25 (1·07 to 1·46)/1·2 (1·02 to 1·41)/1·16 (0·96 to 1·39)/1·11 (0·91 to 1·36)	48/7/0/0/0%	< 0·001 / < 0·001
Elective cesarean section	Moameri 2019	28	OR	1·26 (1·16 to 1·36)	< 0·000001	1·32 (1·14 to 1·53)	0·75	1·18 (1·06 to 1·31)/1·11 (0·99 to 1·24)/1·08 (0·96 to 1·21)/1·05 (0·93 to 1·19)	48/3/0/0/0%	0·06 / 0·002
Poor social support	Tolossa 2020	5	OR	3·97 (3·33 to 4·72)	< 0·000001	1·83 (1·43 to 2·34)	0·043	2·89 (1·42 to 5·88)/2·63 (1·18 to 5·84)/2·63 (0·98 to 7·05)/2·63 (0·78 to 8·86)	96/6/0/0/0%	< 0·001 / < 0·001
History of depression	Tolossa 2020	6	OR	4·99 (3·95 to 6·31)	< 0·000001	6·32 (3·96 to 10·09)	0·11	2·34 (1·42 to 3·86)/2·2 (1·23 to 3·95)/2·2 (1·07 to 4·54)/2·2 (0·9 to 5·37)	79/0/0/0/0%	< 0·001 / < 0·001
History of postpartum depression	Desta 2021	3	OR	4·82 (3·35 to 6·93)	< 0·000001	7·81 (4·47 to 13·65)	0·22	3·36 (1·4 to 8·05)/3·36 (1·1 to 10·31)/3·36 (0·84 to 13·45)/3·36 (0·61 to 18·53)	65/0/0/0/0%	< 0·001 / < 0·001
Poor sleep quality	Yang 2020	4	OR	4·04 (3·04 to 5·37)	< 0·000001	3·34 (2·04 to 5·47)	0·95	2·41 (1·35 to 4·3)/2·41 (1·14 to 5·08)/2·41 (0·96 to 6·05)/2·41 (0·77 to 7·5)	87/0/0/0/0%	< 0·001 / < 0·001
History of substance abuse	Desta 2021	3	OR	3·57 (2·64 to 4·84)	< 0·000001	5·42 (3·35 to 8·76)	0·72	2·39 (1·22 to 4·66)/2·39 (1·01 to 5·64)/2·39 (0·82 to 6·91)/2·39 (0·64 to 8·84)	82/0/0/0/0%	< 0·001 / < 0·001
History of infant death	Tolossa 2020	5	OR	3·63 (2·75 to 4·79)	< 0·000001	2·26 (1·45 to 3·52)	0·84	2·44 (1·36 to 4·41)/2·26 (1·13 to 4·51)/2·1 (0·97 to 4·55)/1·95 (0·84 to 4·56)	83/0/0/0/0%	< 0·001 / < 0·001
Poor marital relationship	Necho 2020	6	OR	3·84 (3·76 to 3·92)	< 0·000001	6 (5·79 to 6·21)	0·25	2·96 (1·72 to 5·09)/2·96 (1·48 to 5·94)/2·96 (1·25 to 7)/2·96 (1·03 to 8·54)	100/0/0/0/0%	< 0·001 / < 0·001
History of stressful life event	Necho 2020	2	OR	2·72 (2·15 to 3·43)	< 0·000001	2·4 (1·85 to 3·11)	NA	2·81 (1·14 to 6·93)/2·81 (0·88 to 8·95)/2·81 (0·67 to 11·77)/2·81 (0·48 to 16·39)	77/0/0/0/0%	NA / NA
Exposure to different types of intimate partner violence	Dadi 2020	10	OR	2·91 (2·42 to 3·51)	< 0·000001	3·1 (2·11 to 4·55)	0·7	2·45 (1·72 to 3·49)/2·45 (1·55 to 3·85)/2·45 (1·4 to 4·29)/2·45 (1·23 to 4·89)	17/0/0/0/0%	< 0·001 / < 0·001
History of mental disorders	Dadi 2020	5	OR	3·39 (2·95 to 3·9)	< 0·000001	4·42 (3·67 to 5·33)	0·3	2·03 (1·09 to 3·8)/1·66 (0·89 to 3·1)/1·43 (0·74 to 2·77)/1·28 (0·63 to 2·6)	85/25/4/0/0%	< 0·001 / < 0·001
Low income	Necho 2020	3	OR	2·51 (1·75 to 3·59)	< 0·000001	2·3 (1·31 to 4·03)	0·14	2·38 (1·29 to 4·4)/2·38 (1·08 to 5·25)/2·38 (0·9 to 6·32)/2·38 (0·71 to 7·93)	4/0/0/0/0%	0·028 / 0·004
Adverse birth and infant health conditions	Dadi 2020	5	OR	2·06 (1·7 to 2·5)	< 0·000001	1·4 (1·04 to 1·88)	0·25	1·69 (1·22 to 2·35)/1·69 (1·11 to 2·58)/1·69 (1·01	75/0/0/0/0%	< 0·001 / < 0·001

								to 2·84)/1·69 (0·89 to 3·21)		
Postpartum anemia	Azami 2019	10	RR	1·54 (1·28 to 1·87)	0·000008	1 (0·65 to 1·55)	0·048	1·41 (1·01 to 1·96)/1·22 (0·92 to 1·61)/1·1 (0·86 to 1·41)/1·08 (0·82 to 1·42)	75/39/15/0/0%	0·007 / 0·003
Poor obstetric conditions	Dadi 2020	8	OR	1·5 (1·35 to 1·66)	< 0·000001	1·35 (1·12 to 1·62)	0·064	1·37 (1·17 to 1·61)/1·37 (1·12 to 1·69)/1·37 (1·07 to 1·77)/1·37 (1 to 1·88)	71/0/0/0/0%	0·024 / 0·002
Pre-pregnancy underweight	Dachew 2021	5	OR	1·58 (1·38 to 1·82)	< 0·000001	1·52 (1·3 to 1·78)	0·54	1·55 (1·12 to 2·14)/1·5 (1·02 to 2·21)/1·46 (0·95 to 2·26)/1·42 (0·88 to 2·3)	45/0/0/0/0%	< 0·001 / < 0·001
Gestational diabetes	Azami 2019	14	RR	1·67 (1·53 to 1·81)	< 0·000001	1·44 (1·26 to 1·65)	0·87	1·31 (1·07 to 1·61)/1·25 (1·03 to 1·52)/1·23 (0·98 to 1·53)/1·2 (0·93 to 1·54)	89/26/0/0/0%	< 0·001 / < 0·001
Emergency cesarean section	Moameri 2019	10	OR	1·29 (1·14 to 1·46)	0·000039	1·13 (0·97 to 1·32)	0·083	1·19 (1·05 to 1·35)/1·18 (1·02 to 1·37)/1·18 (0·99 to 1·4)/1·18 (0·97 to 1·43)	68/0/0/0/0%	< 0·001 / 0·001
Childhood abuse	Zhang 2019	5	OR	1·59 (1·34 to 1·88)	< 0·000001	1·41 (1·1 to 1·81)	0·65	1·46 (1·15 to 1·85)/1·42 (1·07 to 1·88)/1·39 (1·01 to 1·9)/1·36 (0·95 to 1·95)	44/0/0/0/0%	0·02 / 0·002
HIV infection	Zhu 2019	10	OR	1·37 (1·11 to 1·68)	0·0034	0·93 (0·63 to 1·37)	0·11	1·28 (0·96 to 1·72)/1·16 (0·9 to 1·5)/1·08 (0·85 to 1·38)/1·03 (0·8 to 1·33)	65/28/8/0/0%	0·067 / 0·007
Anemia during pregnancy	Azami 2019	8	RR	1·25 (1·07 to 1·47)	0·0063	1·35 (0·98 to 1·87)	0·93	1·19 (0·97 to 1·45)/1·14 (0·94 to 1·38)/1·13 (0·91 to 1·41)/1·12 (0·88 to 1·43)	39/19/1/0/0%	NA / NA
Female infant compared to male infant	Ye 2020	29	OR	1 (0·97 to 1·04)	0·99	0·97 (0·93 to 1·01)	0·068	1 (0·93 to 1·08)/0·98 (0·94 to 1·02)/0·98 (0·93 to 1·03)/0·98 (0·93 to 1·04)	75/19/0/0/0%	< 0·001 / 0·001
Pre-pregnancy overweight	Dachew 2021	6	OR	1·08 (1·01 to 1·15)	0·018	1·05 (0·98 to 1·13)	0·19	1·07 (1 to 1·14)/1·06 (0·99 to 1·14)/1·07 (0·98 to 1·16)/1·07 (0·96 to 1·18)	27/0/0/0/0%	NA / NA
Active husband participation in maternal healthcare/services during pregnancy	Yargawa 2015	2	OR	0·36 (0·23 to 0·56)	0·000005	0·27 (0·15 to 0·49)	NA	0·45 (0·22 to 0·91)/0·45 (0·18 to 1·12)/0·45 (0·14 to 1·39)/0·45 (0·11 to 1·8)	48/0/0/0/0%	NA / NA
Active husband participation in maternal healthcare/services postpartum	Yargawa 2015	5	OR	0·38 (0·27 to 0·52)	< 0·000001	0·53 (0·34 to 0·83)	0·49	0·43 (0·24 to 0·75)/0·42 (0·21 to 0·84)/0·46 (0·2 to 1·08)/0·48 (0·18 to 1·3)	57/0/0/0/0%	0·001 / 0·002
Family history of mental illness	Necho 2020	2	OR	1·55 (0·99 to 2·43)	0·057	1·2 (0·72 to 2·01)	NA	1·63 (0·62 to 4·27)/1·36 (0·69 to 2·7)/1·26 (0·76 to 2·08)/1·24 (0·75 to 2·06)	75/44/12/0/0%	NA / NA
Labor epidural analgesia	Kountanis 2020	10	OR	1·03 (0·89 to 1·19)	0·73	0·86 (0·69 to 1·07)	0·85	1·1 (0·8 to 1·51)/1·09 (0·81 to 1·45)/0·99 (0·8 to 1·24)/1 (0·77 to 1·31)	79/48/26/0/0%	0·011 / 0·001
All statistical tests are two-sided. Abbreviations: CI, confidence interval; HIV, human immunodeficiency virus; NA, not available; OR,odds ratio; RR, relative risk										

Table S4. Grading of Recommendations, Assessment, Development and Evaluations appraisal for environmental risk and protective factors

Environmental risk/protective factor	Author, year	k	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Other considerations	Certainty
Antenatal anxiety	Grigoriadis 2019	7	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely	Large effect	Moderate
Psychological violence	Zhang 2019	8	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Intimate partner violence experience	Howard 2013	12	Cohort, cross-sectional	Not Serious	Serious	Not serious	Not serious	Likely	Large effect	Very low
Intimate partner violence during pregnancy	Beydoun 2012	17	Cross-sectional	Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Smoking during pregnancy	Chen 2019	11	Cohort, case-control, cross-sectional	Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
History of premenstrual syndrome	Cao 2020	19	Cohort, case-control, cross-sectional	Very serious	Not serious	Not serious	Not serious	Not likely	Large effect	Very low
Any type of violence experience	Zhang 2019	32	Cohort	Not Serious	Very Serious	Not serious	Not serious	Likely	Large effect	Very low
Primiparity compared to multiparity	Tokumitsu 2020	39	Cohort, case-control, cross-sectional	Serious	Serious	Not serious	Not serious	Likely		Very low
Unintended pregnancy	Qiu 2020	30	Cohort, case-control	Not Serious	Very Serious	Not serious	Not serious	Not likely		Very low
History of mental disorders	Dadi 2020	5	Cohort, cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Intimate partner violence in the past year	Bacchus 2018	7	Cohort	Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Preterm birth	de Paula Eduardo 2019	12	Cohort, case-control, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely	Large effect	Low
Perinatal anemia	Kang 2020	6	Cohort, case-control	Serious	Not serious	Not serious	Not serious	Not likely	Large effect	Low
Domestic violence	Zhang 2019	16	Cohort	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Physical violence	Zhang 2019	8	Cohort	Not Serious	Serious	Not serious	Not serious	Likely		Very low
Immigration	Falah-Hassani 2015	5	Cohort, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Pre-pregnancy underweight	Dachew 2021	5	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Sexual violence	Zhang 2019	6	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Cesarean section	Moameri 2019	38	Cohort, case-control	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Pre-pregnancy obesity	Molyneaux 2014	14	Cohort, cross-sectional	Not Serious	Not serious	Not serious	Not serious	Likely		Very low
Elective cesarean section	Moameri 2019	28	Cohort, case-control	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Poor social support	Tolossa 2020	5	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Very large effect	Low
History of depression	Tolossa 2020	6	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
History of postpartum depression	Desta 2021	3	Cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely	Large effect	Low
Poor sleep quality	Yang 2020	4	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
History of substance abuse	Desta 2021	3	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
History of infant death	Tolossa 2020	5	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Poor marital relationship	Necho 2020	6	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
History of stressful life event	Necho 2020	2	Cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely	Large effect	Very low
Exposure to different types of intimate partner violence	Dadi 2020	10	Cohort, cross-sectional	Not Serious	Not serious	Not serious	Not serious	Not likely	Large effect	Moderate
Low income	Necho 2020	3	Cross-sectional	Not Serious	Not serious	Not serious	Not serious	Not likely	Large effect	Moderate

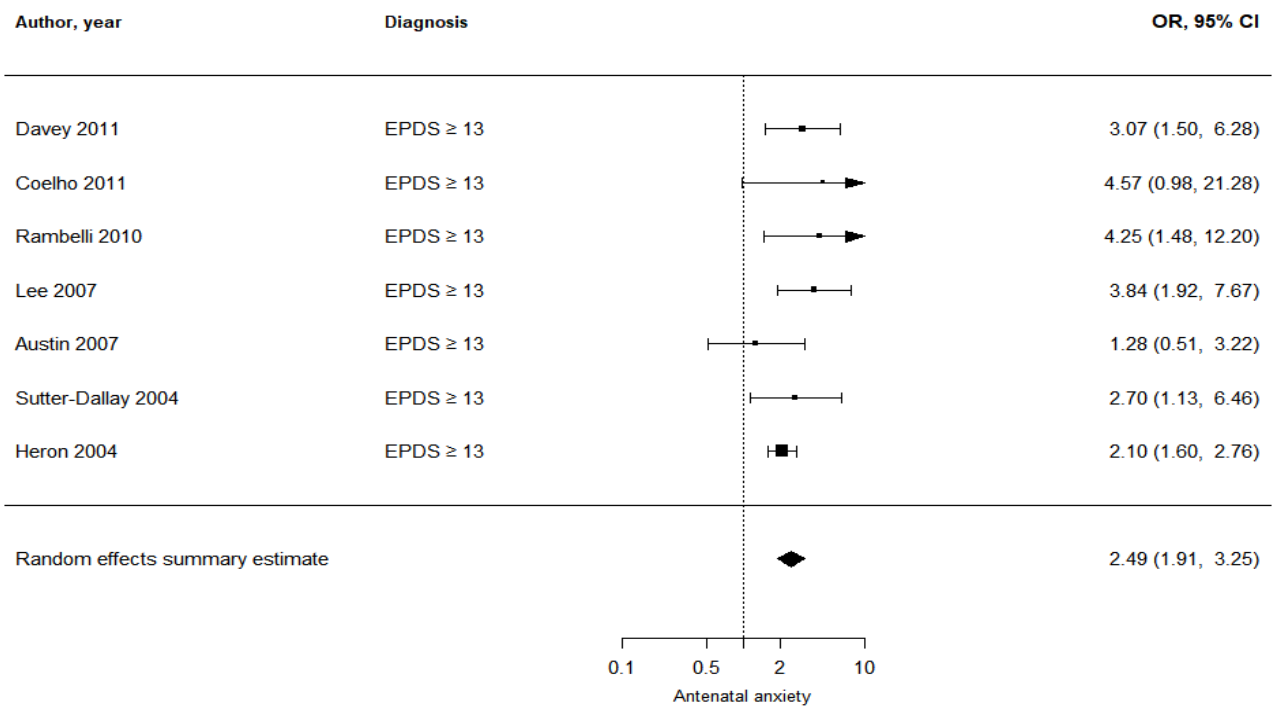
Adverse birth and infant health conditions	Dadi 2020	5	Cohort, cross-sectional	Not Serious	Serious	Not serious	Not serious	Likely	Large effect	Very low
Postpartum anemia	Azami 2019	10	Cohort, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Poor obstetric conditions	Dadi 2020	8	Cohort, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Gestational diabetes	Azami 2019	14	Cohort, case-control, cross-sectional	Not Serious	Very Serious	Not serious	Not serious	Not likely		Very low
Emergency cesarean section	Moameri 2019	10	Cohort, case-control	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Childhood abuse	Zhang 2019	5	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
HIV infection	Zhu 2019	10	Cohort, case-control, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Anemia during pregnancy	Azami 2019	8	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Female infant compared to male infant	Ye 2020	29	Cohort, case-control	Not Serious	Serious	Not serious	Not serious	Not likely		Very low
Pre-pregnancy overweight	Dachew 2021	6	Cohort	Not Serious	Not serious	Not serious	Not serious	Not likely		Low
Active husband participation in maternal healthcare/services during pregnancy	Yargawa 2015	2	Cohort, cross-sectional	Not Serious	Not serious	Not serious	Not serious	Likely	Large effect	Low
Active husband participation in maternal healthcare/services postpartum	Yargawa 2015	5	Cohort, case-control, cross-sectional	Not Serious	Serious	Not serious	Not serious	Not likely	Large effect	Low
Family history of mental illness	Necho 2020	2	Cross-sectional	Not Serious	Serious	Not serious	Serious	Not likely		Very low
Labor epidural analgesia	Kountanis 2020	10	Cohort, case-control	Serious	Very Serious	Not serious	Serious	Not likely		Very low
Abbreviations: HIV, human immunodeficiency virus; k, number of study estimates										

Table S5. Grading of Recommendations, Assessment, Development and Evaluations appraisal for biomarkers s

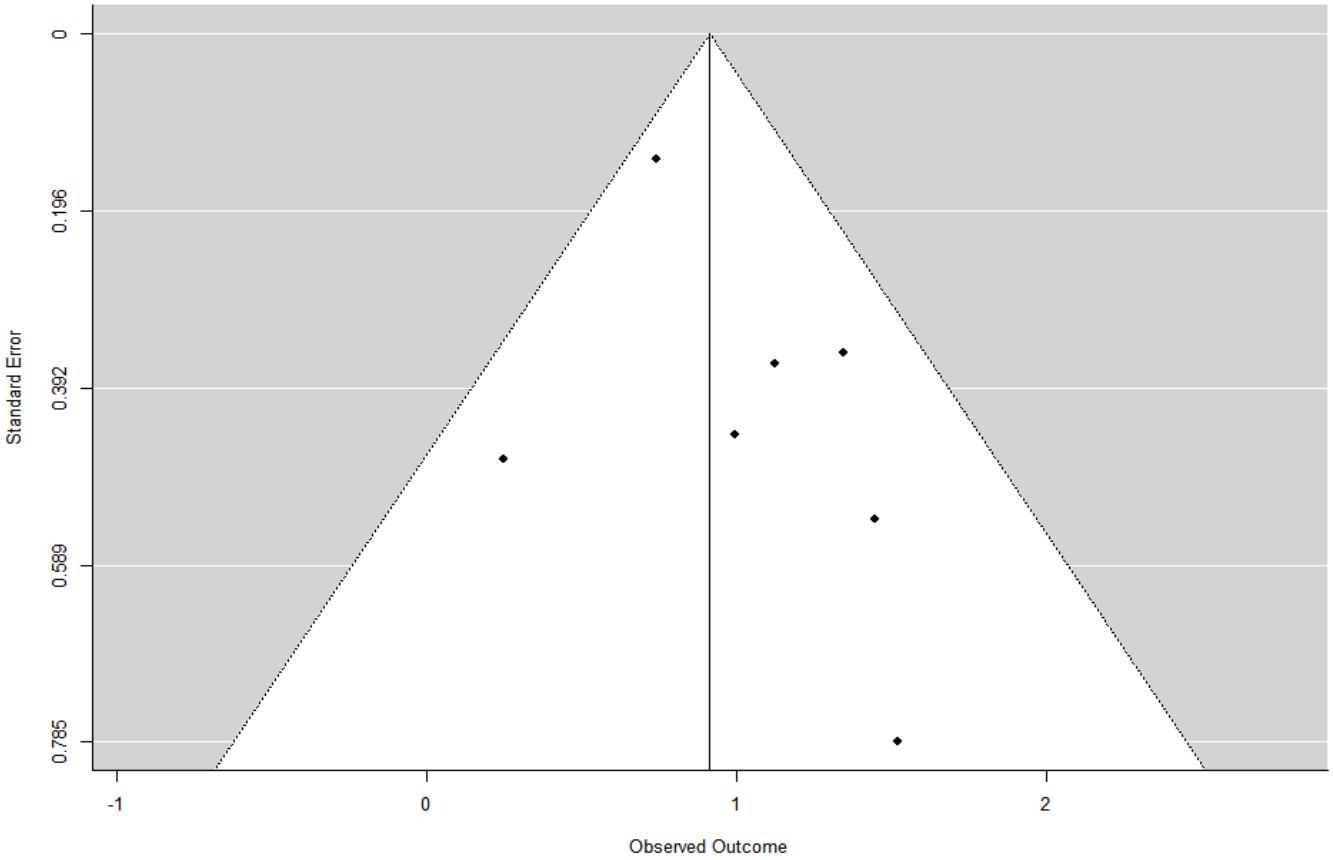
Biomarkers	Author, year	k	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Other considerations	Certainty
Serum 25(OH)D level < 50 nmol/l	Wang 2018	3	Cohort	Not serious	Very serious	Not serious	Not serious	Not likely	Large effect	Very low
High concentration of serum 25(OH)D	Tan 2020	7	Cohort, case-control, cross-sectional	Not serious	Very serious	Not serious	Not serious	Not likely		Very low
Omega-6/omega-3 ratio	Lin 2017	5	Cohort	Not serious	Serious	Not serious	Not serious	Not likely		Very low
Positive anti-thyroperoxidase antibodies	Minaldi 2020	3	Cohort	Not serious	Serious	Not serious	Serious	Not likely		Very low
Total omega-6 acid	Lin 2017	5	Cohort	Not serious	Not serious	Not serious	Serious	Not likely		Very low
Arachidonic acid	Lin 2017	5	Cohort	Not serious	Not serious	Not serious	Serious	Not likely		Very low
Eicosapentaenoic acid	Lin 2017	6	Cohort, case-control	Not serious	Not serious	Not serious	Serious	Likely		Very low
Docosahexaenoic acid	Lin 2017	6	Cohort, case-control	Not serious	Serious	Not serious	Serious	Not likely	Large effect	Low
Total omega-3 acid	Lin 2017	6	Cohort, case-control	Not serious	Serious	Not serious	Serious	Likely	Large effect	Very low
Abbreviations: k, number of study estimates										

Figure S1. Antenatal anxiety (Forest plot, funnel plot, p curve analysis plot)

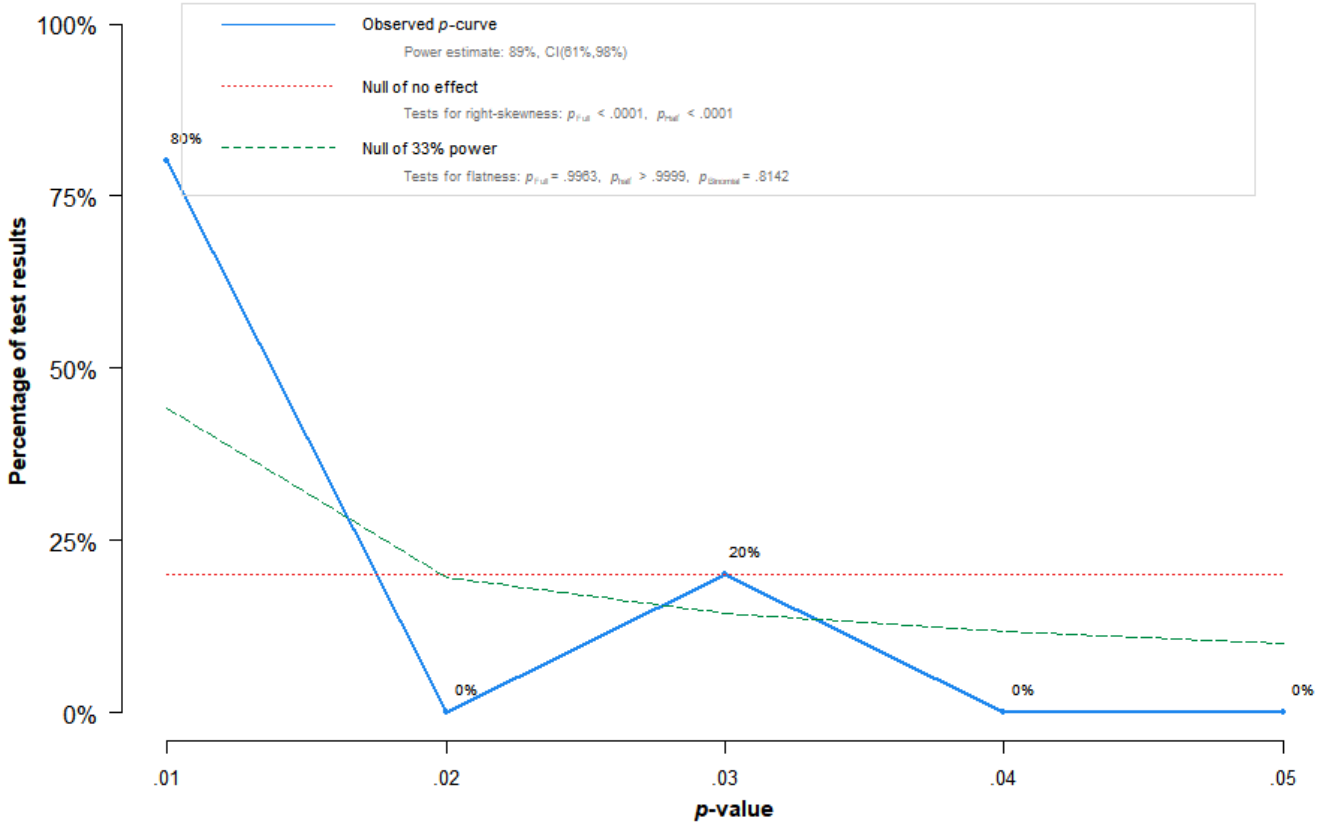
1) Forest plot



2) Funnel plot


Standard Error
0
0.196
0.392
0.589
0.785
-1
0
1
2
Observed Outcome

3) P curve analysis plot



Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 2 additional results entered but excluded from *p*-curve because they were $p > .05$.

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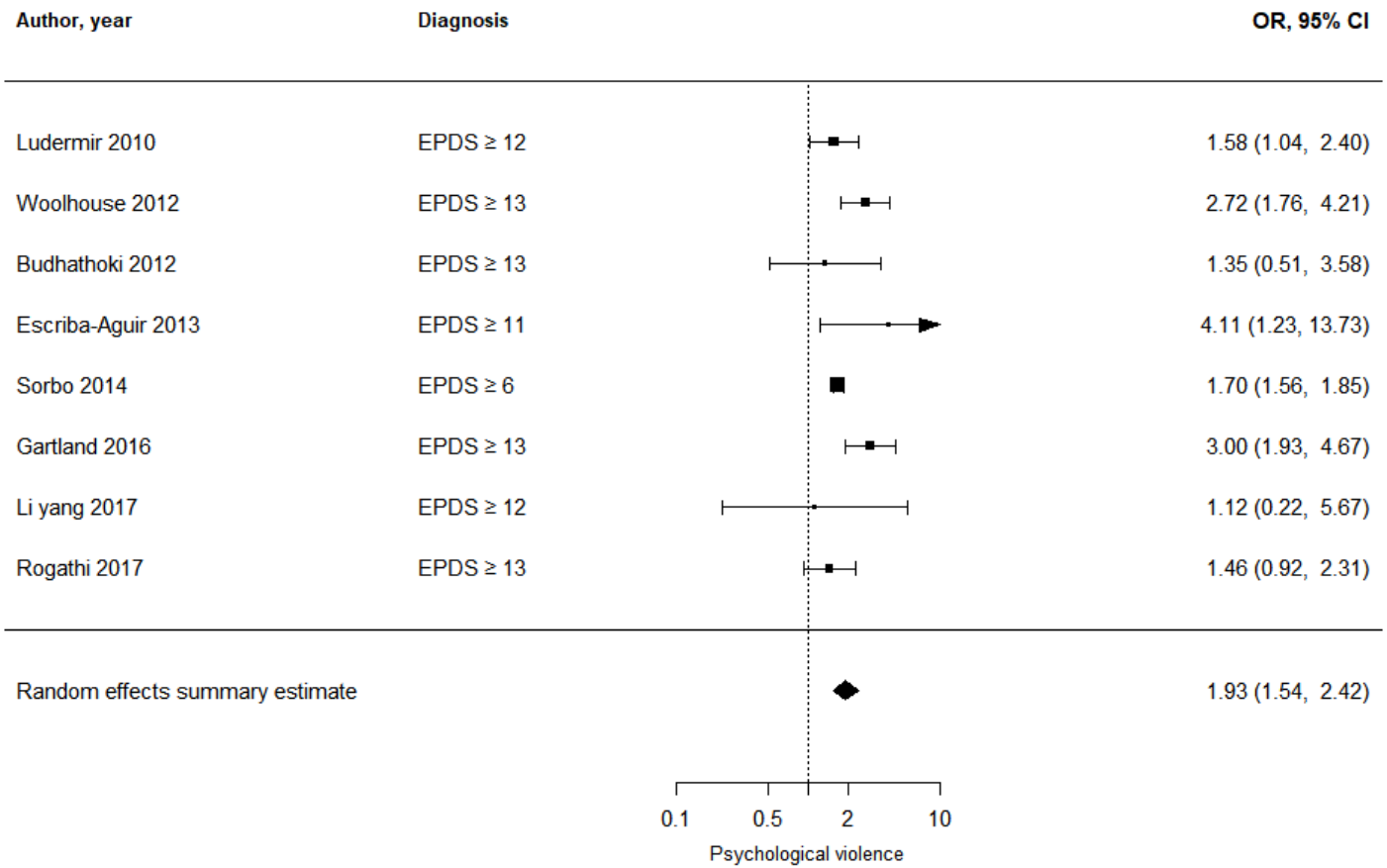
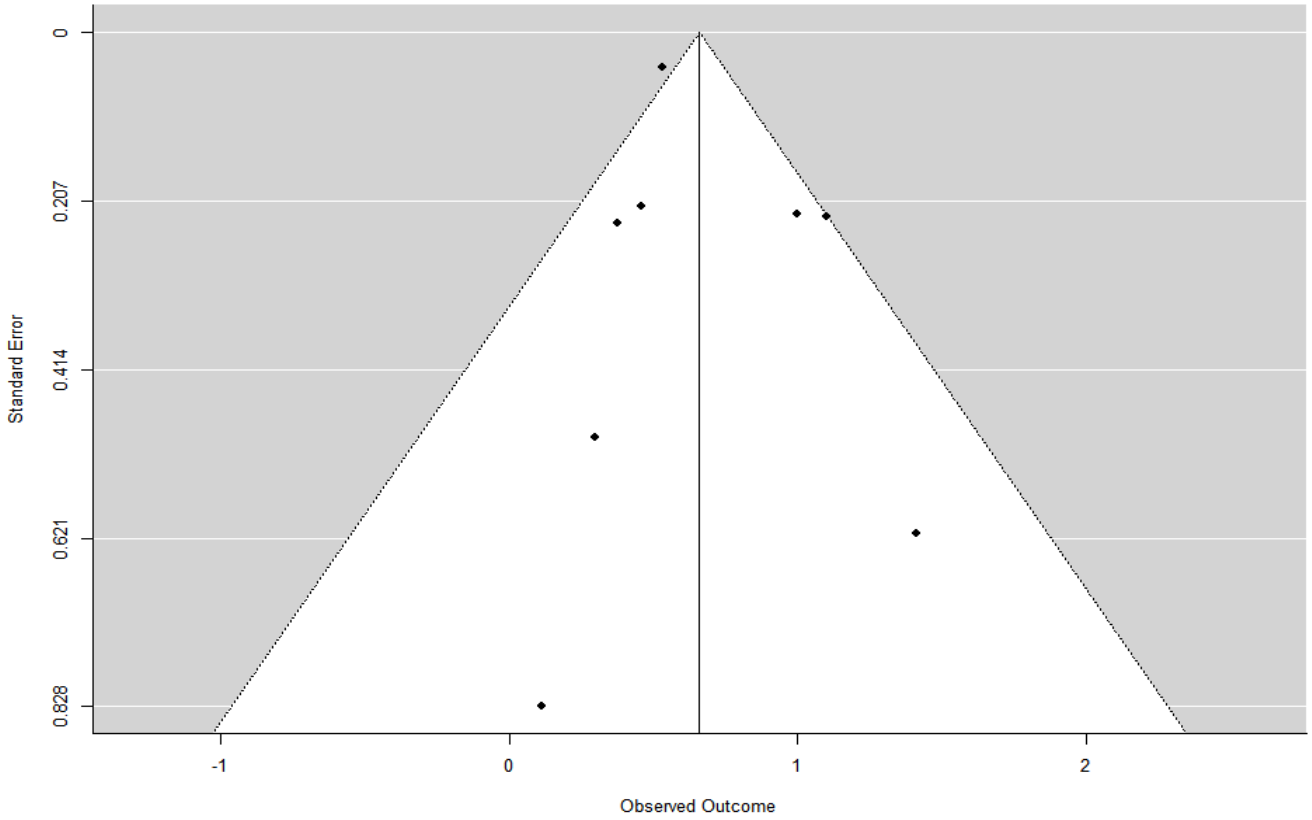
Figure S2. Psychological violence (Forest plot, funnel plot, p curve analysis plot)

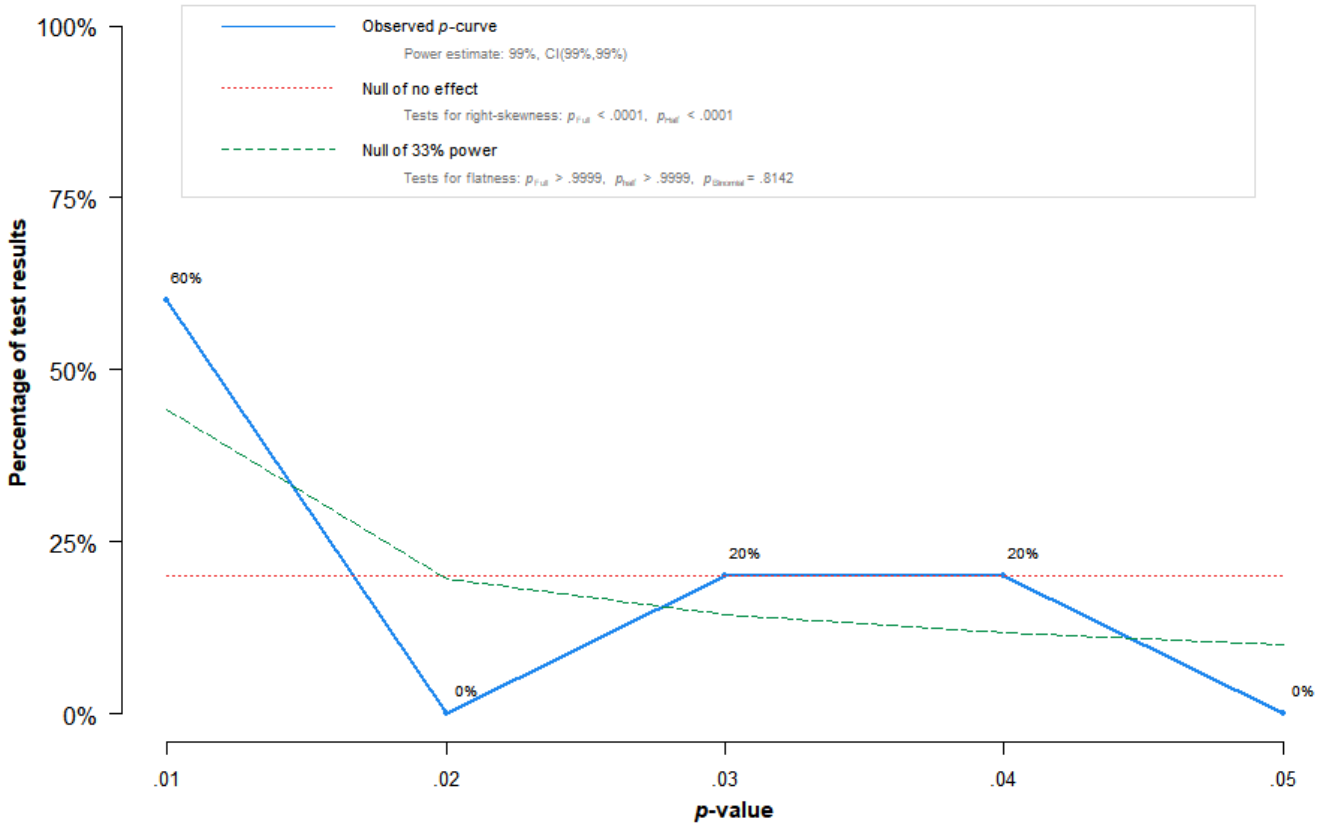
1) Forest plot



2) Funnel plot



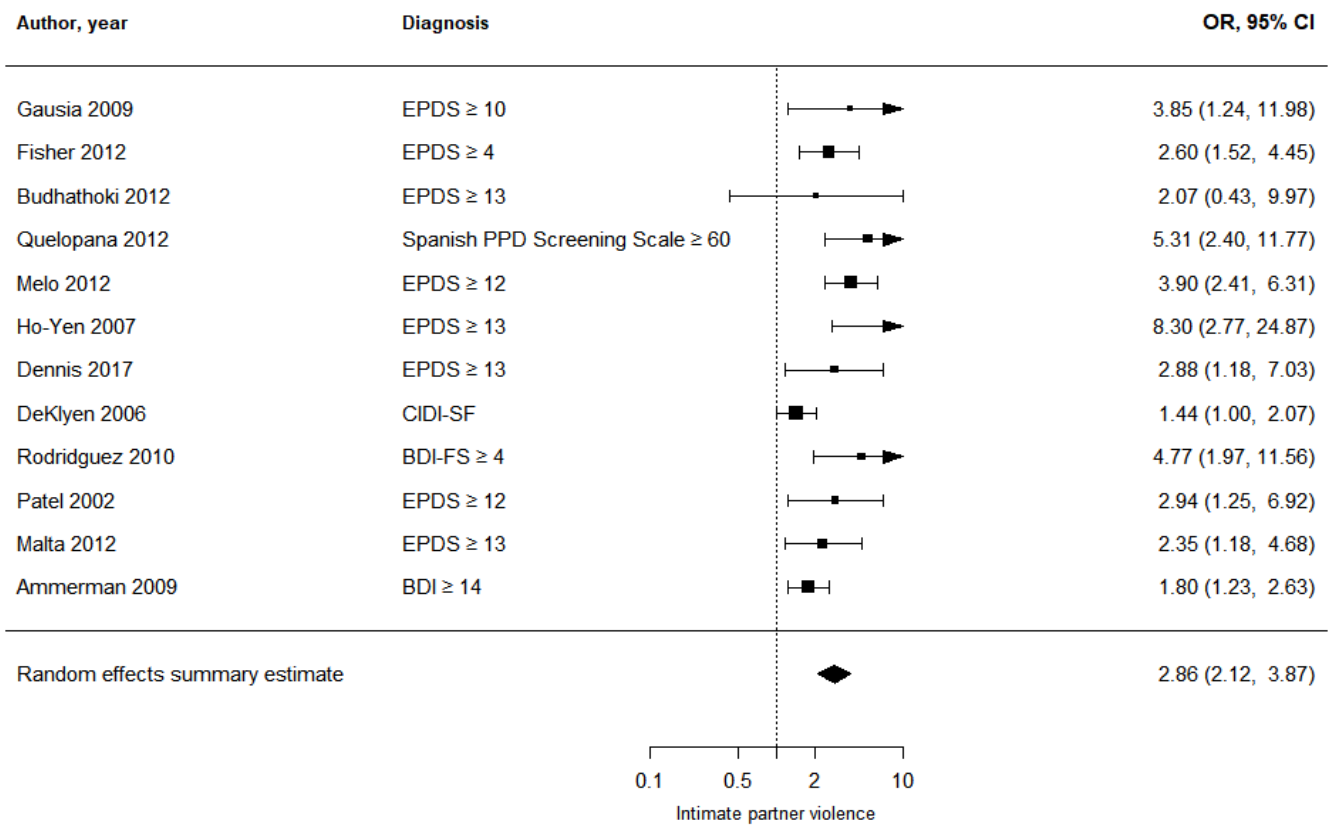
3) P curve analysis plot



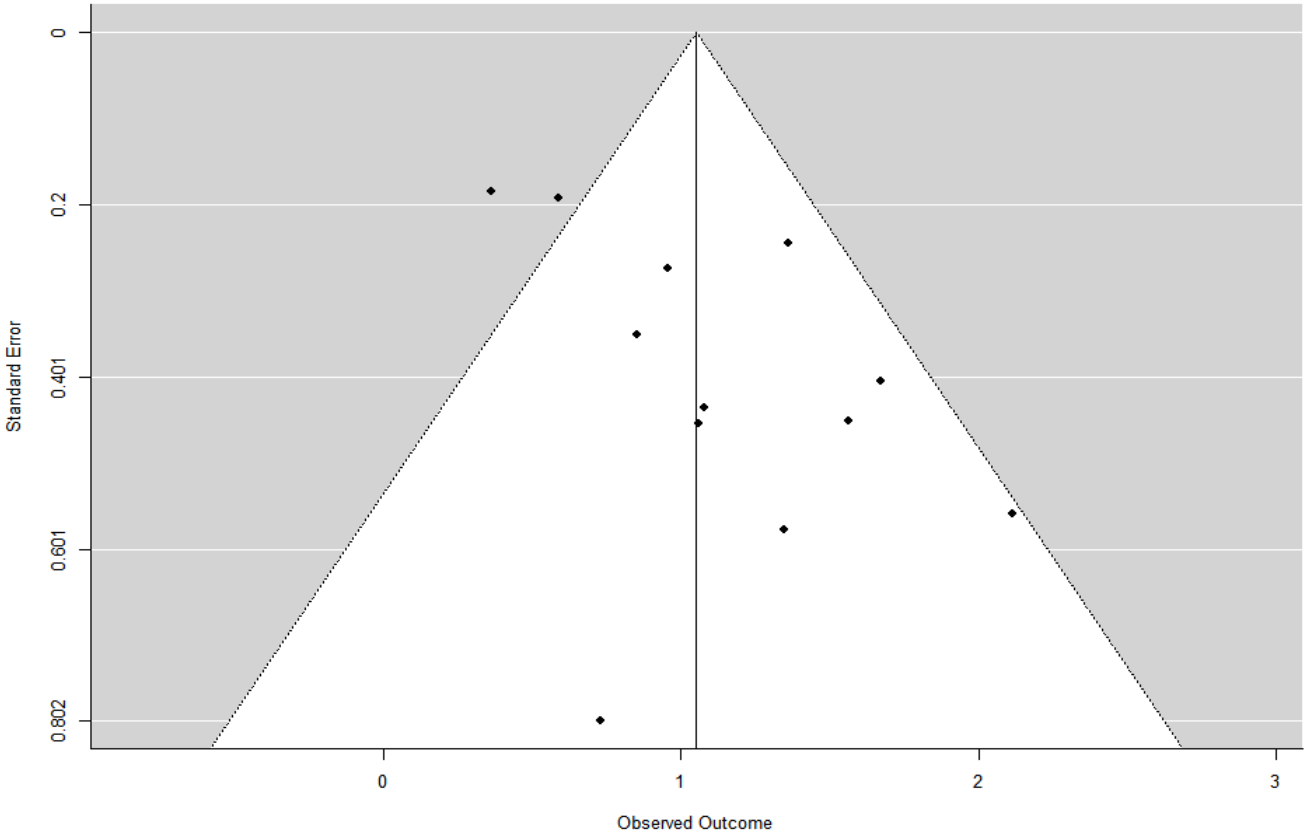
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 3 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S3. Intimate partner violence experience (Forest plot, funnel plot, p curve analysis plot)

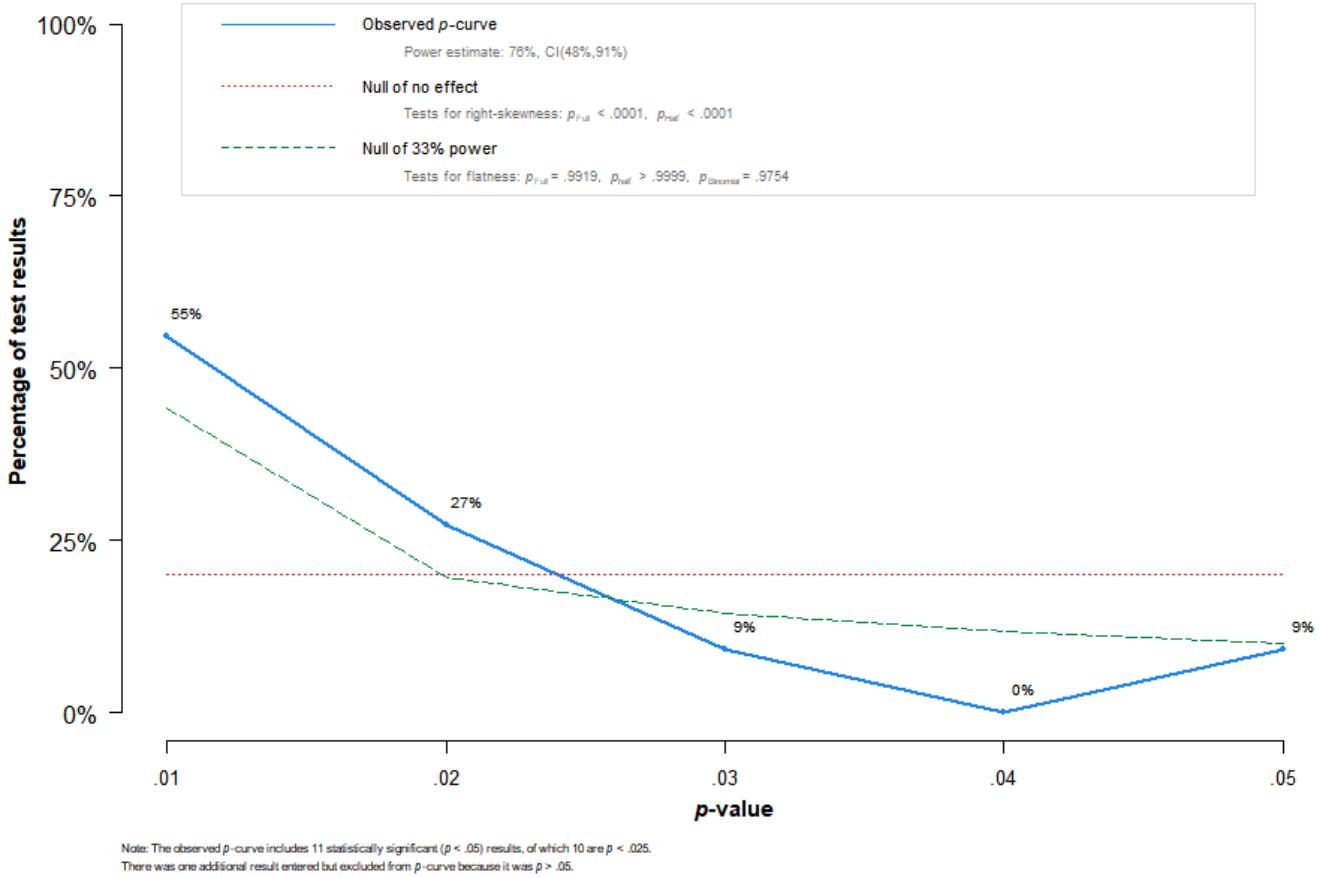
1) Forest plot



2) Funnel plot


Standard Error
0
0.2
0.401
0.601
0.802
0
1
2
3
Observed Outcome

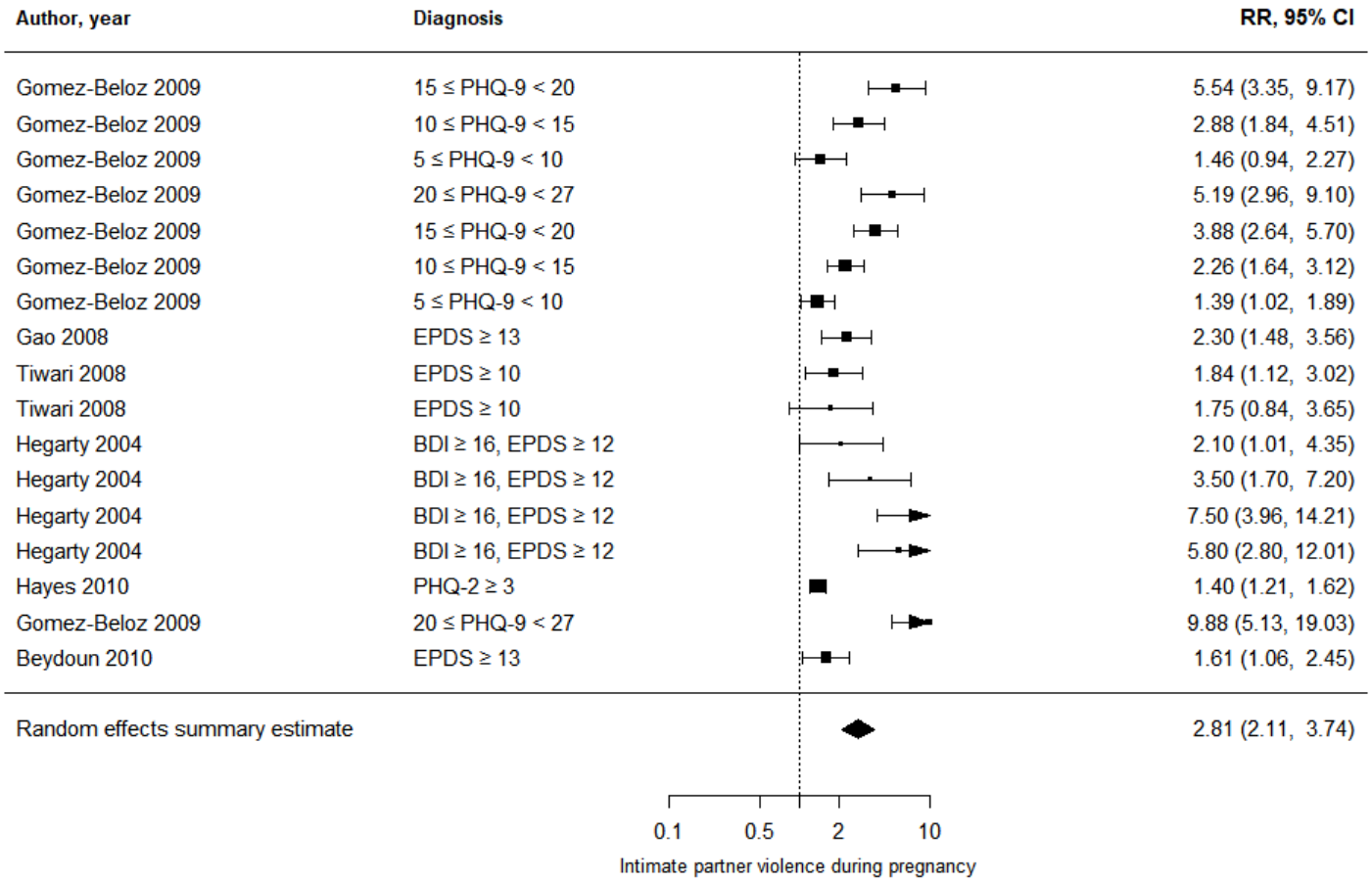
3) P curve analysis plot



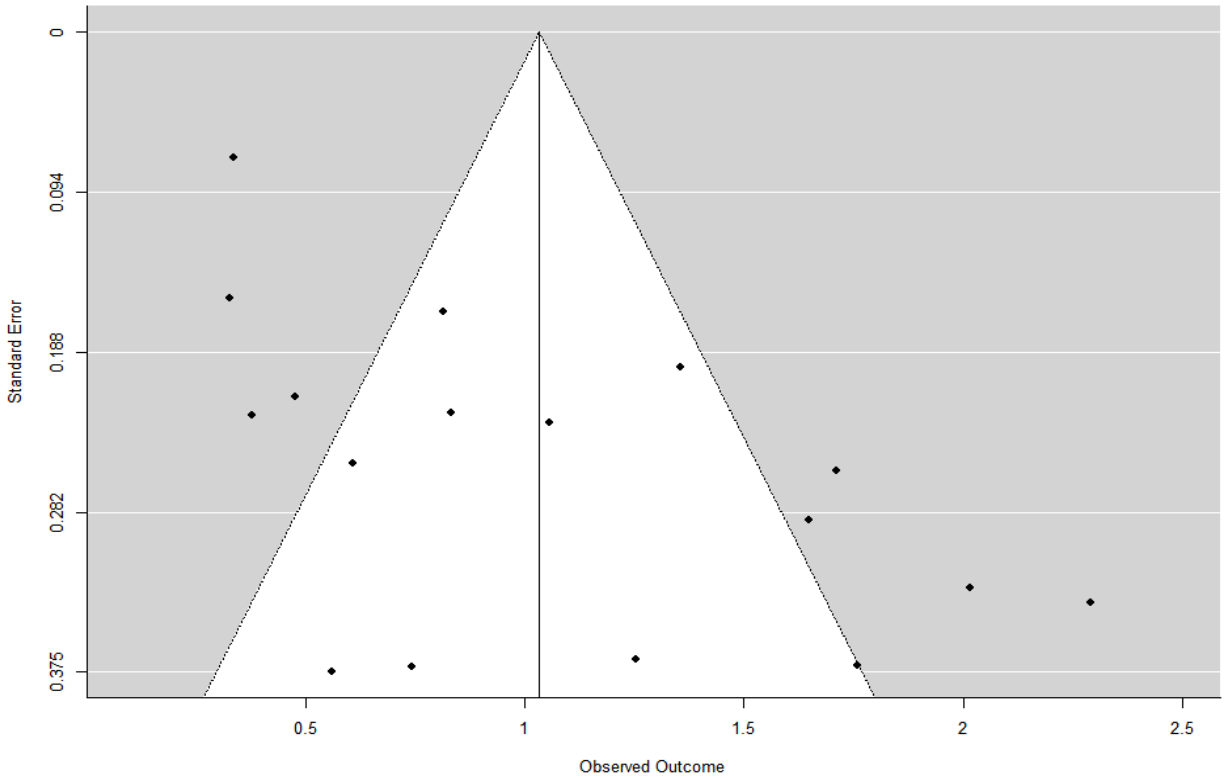
Note: The observed *p*-curve includes 11 statistically significant ($p < .05$) results, of which 10 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S4. Intimate partner violence during pregnancy (Forest plot, funnel plot, p curve analysis plot)

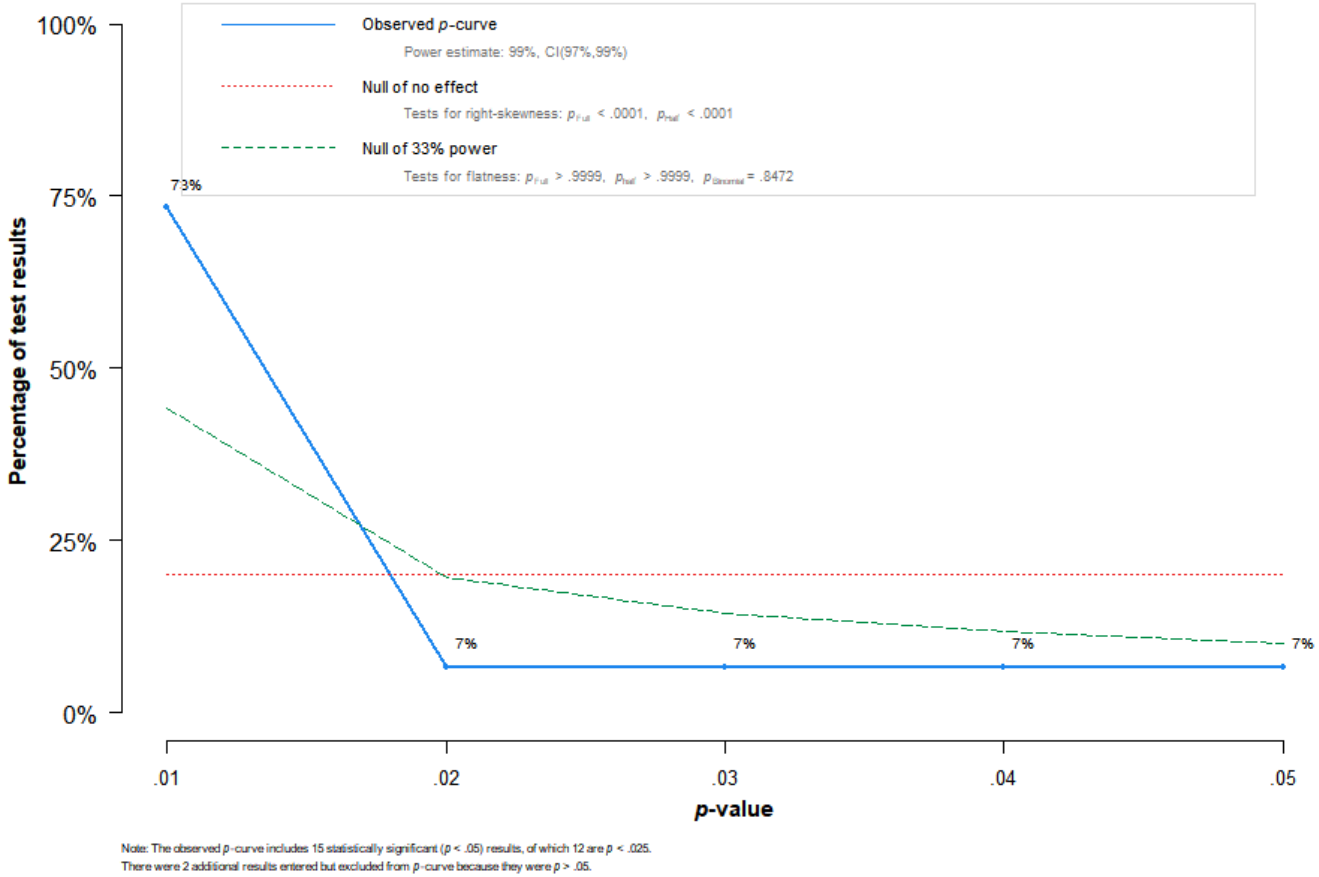
1) Forest plot



2) Funnel plot


Standard Error
0
0.094
0.188
0.282
0.375
0.5
1
1.5
2
2.5
Observed Outcome

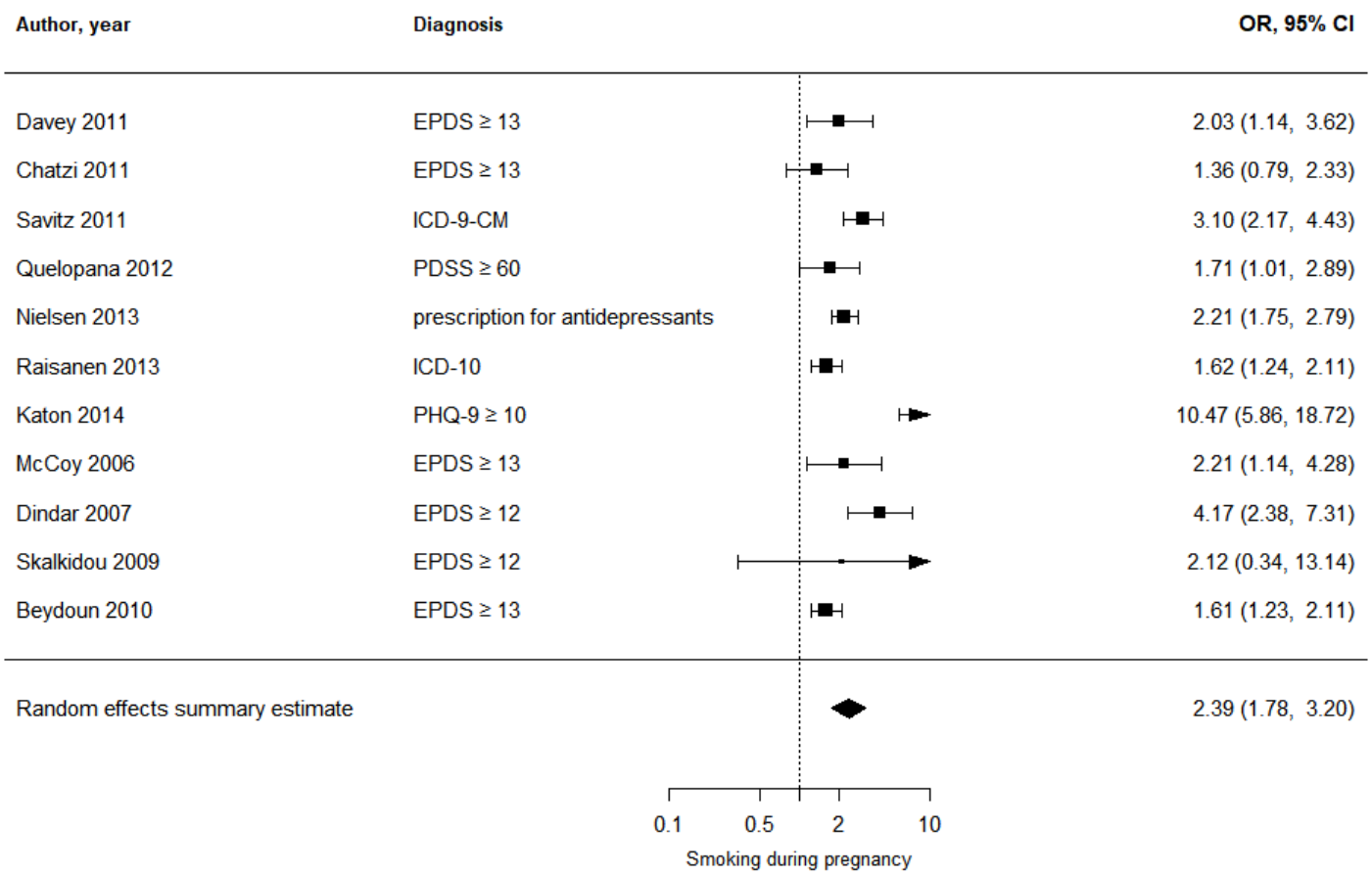
3) P curve analysis plot



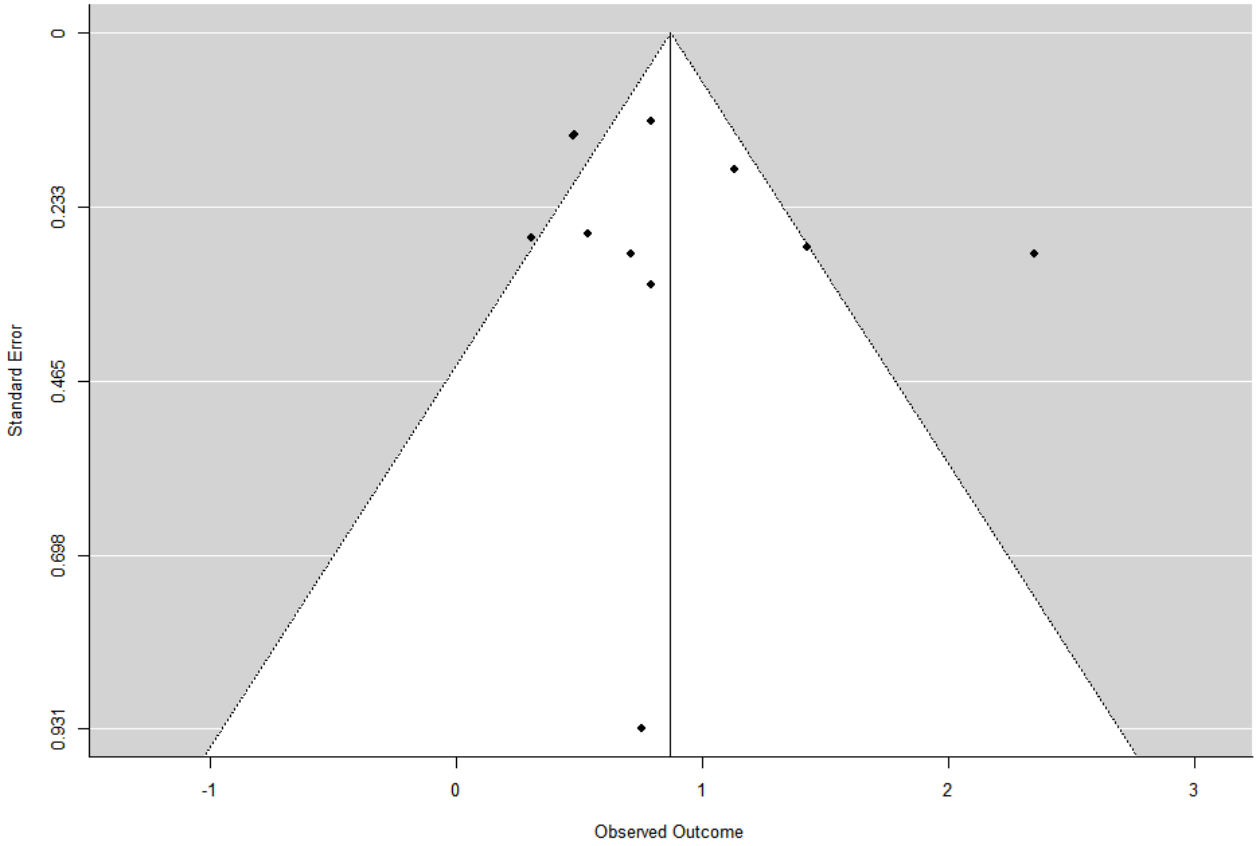
Note: The observed *p*-curve includes 15 statistically significant ($p < .05$) results, of which 12 are $p < .025$.
There were 2 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S5. Smoking during pregnancy (Forest plot, funnel plot, p curve analysis plot)

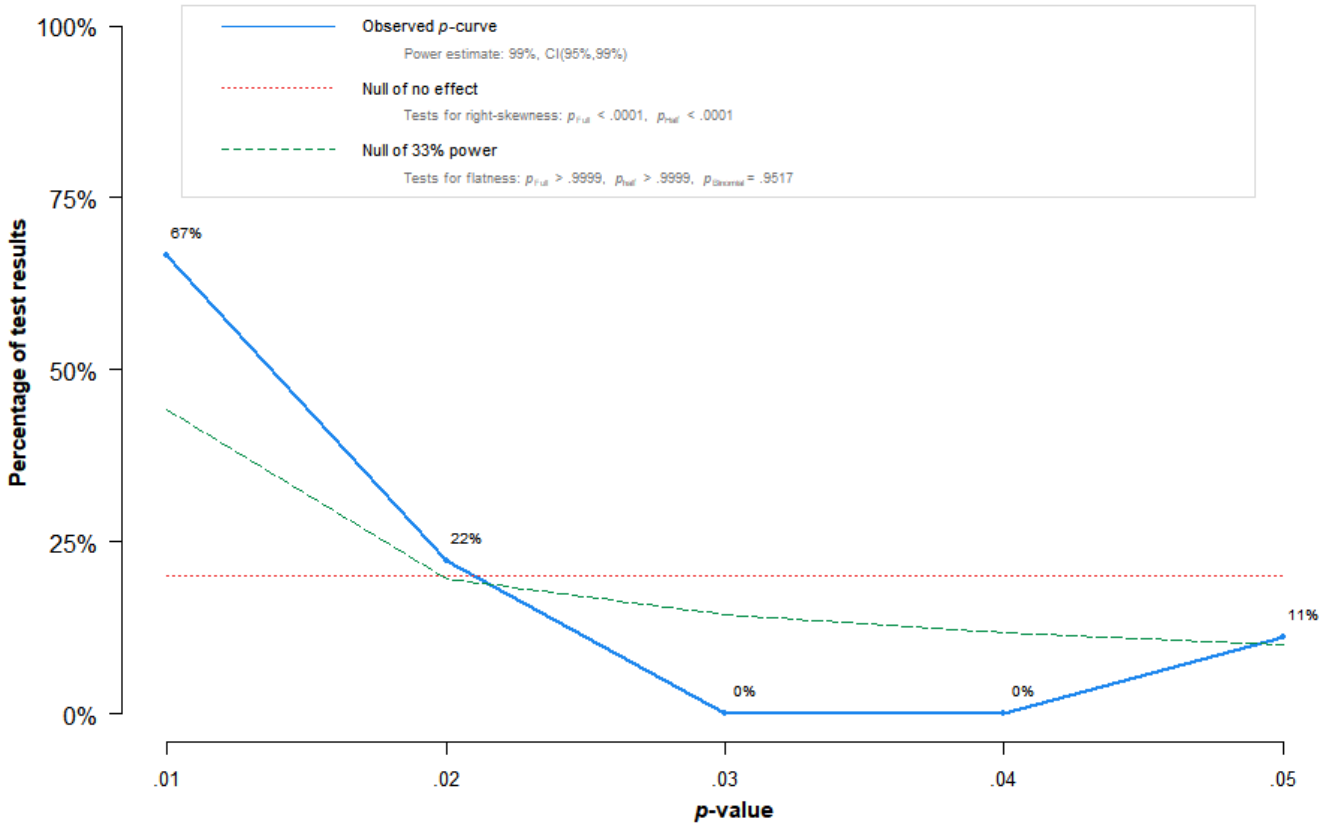
1) Forest plot



2) Funnel plot



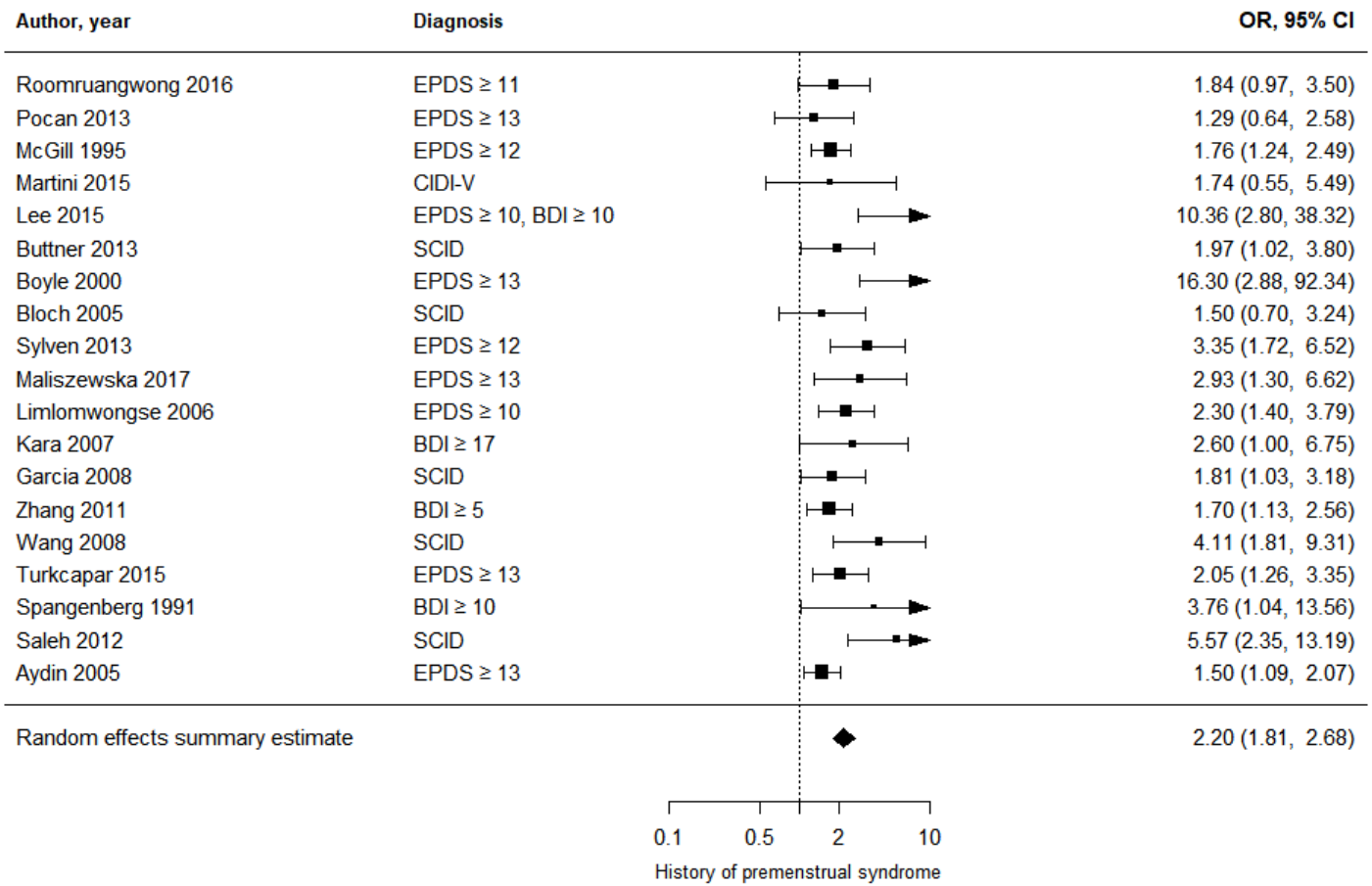
3) P curve analysis plot



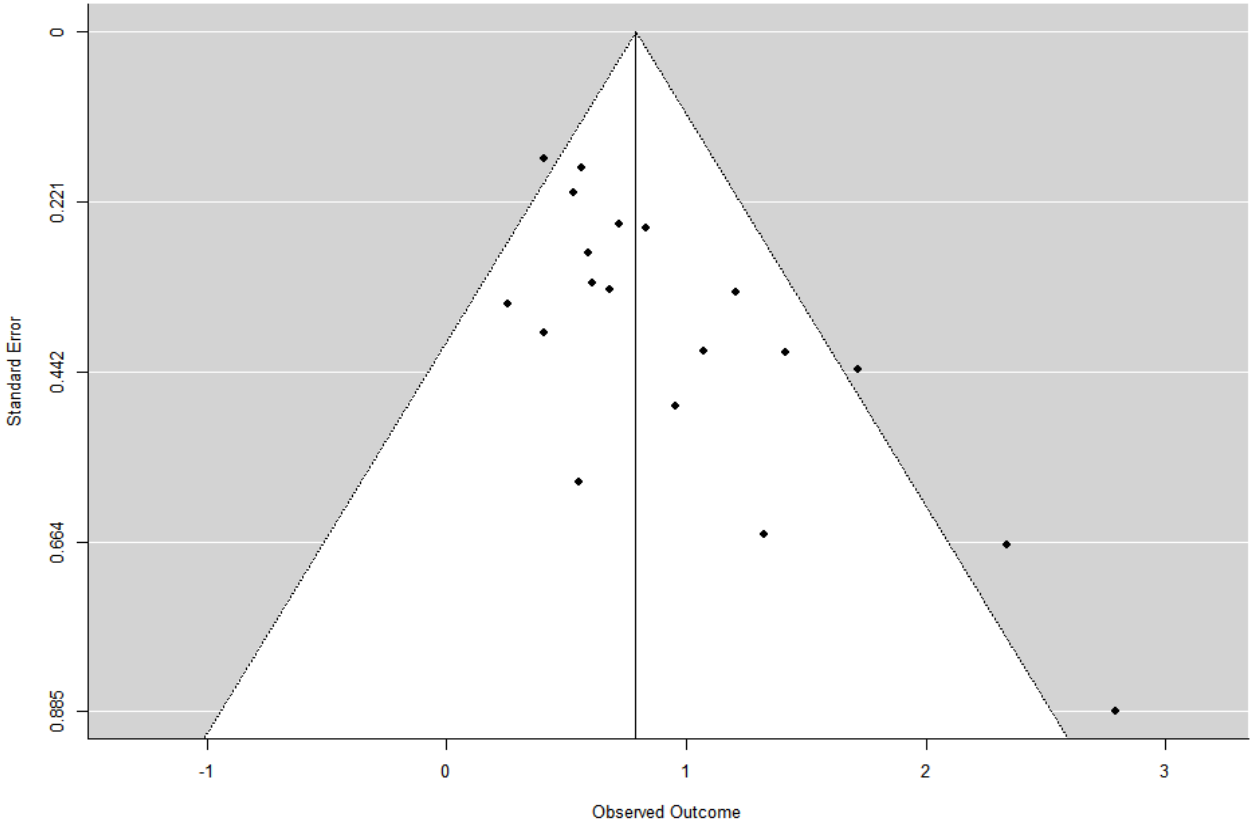
Note: The observed *p*-curve includes 9 statistically significant ($p < .05$) results, of which 8 are $p < .025$.
There were 2 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S6. History of premenstrual syndrome (Forest plot, funnel plot, p curve analysis plot)

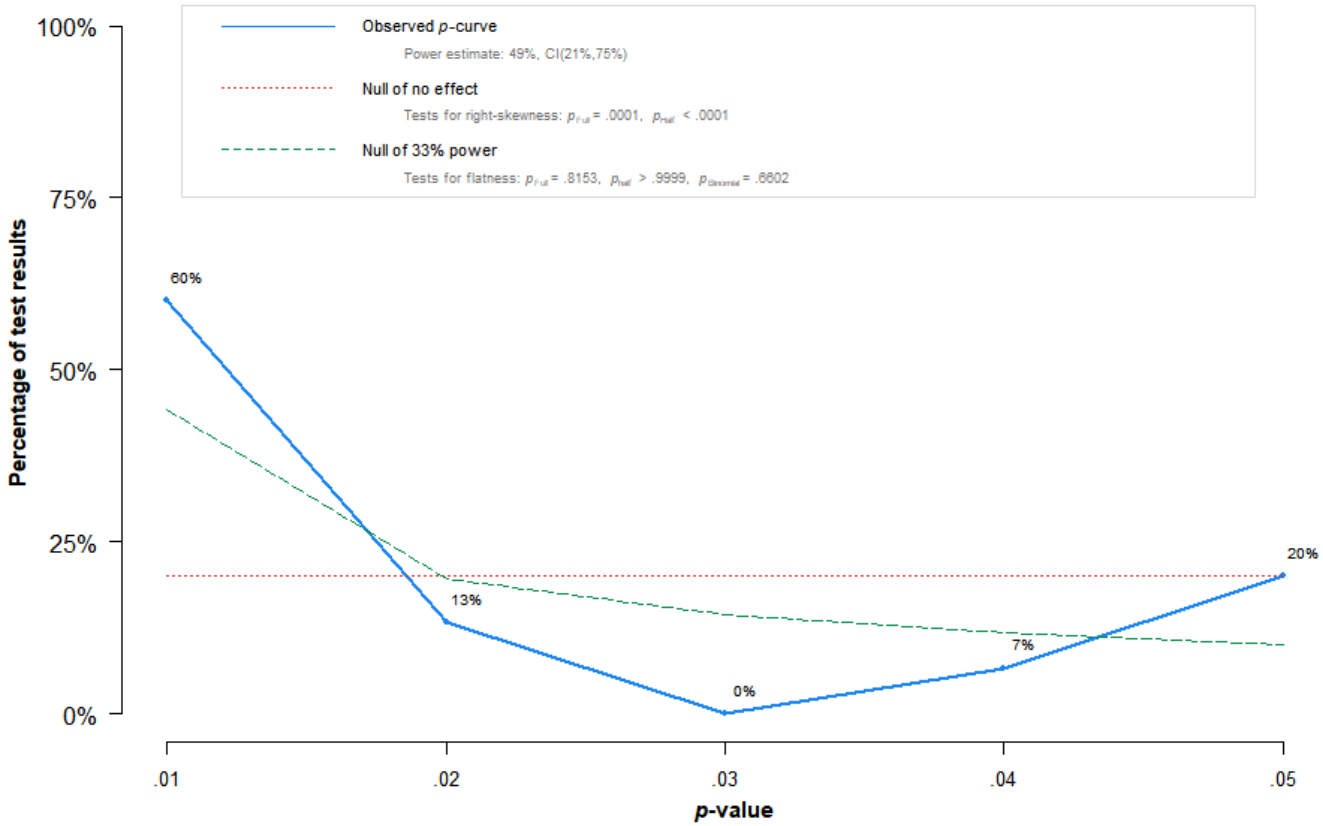
1) Forest plot



2) Funnel plot



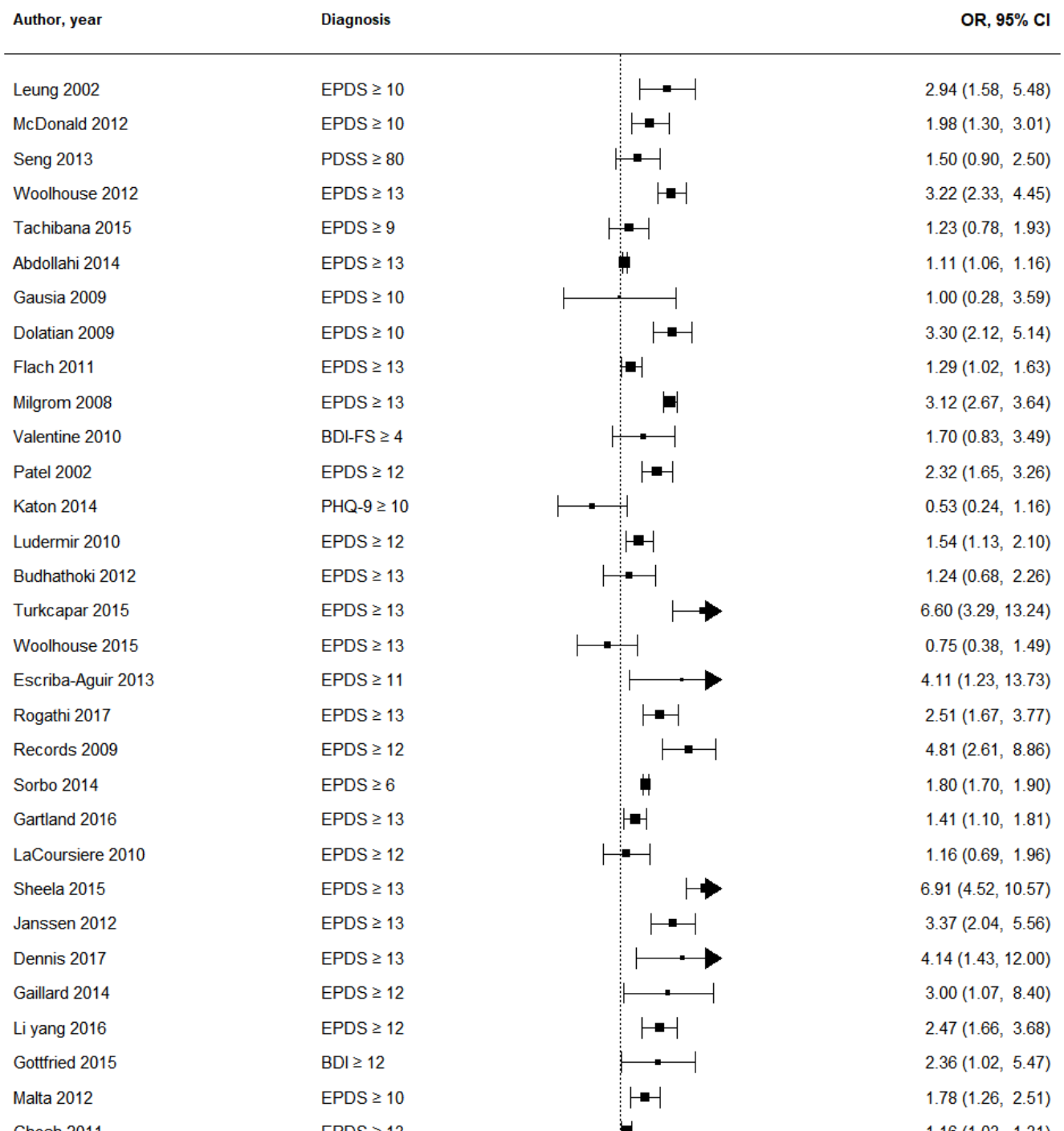
3) P curve analysis plot



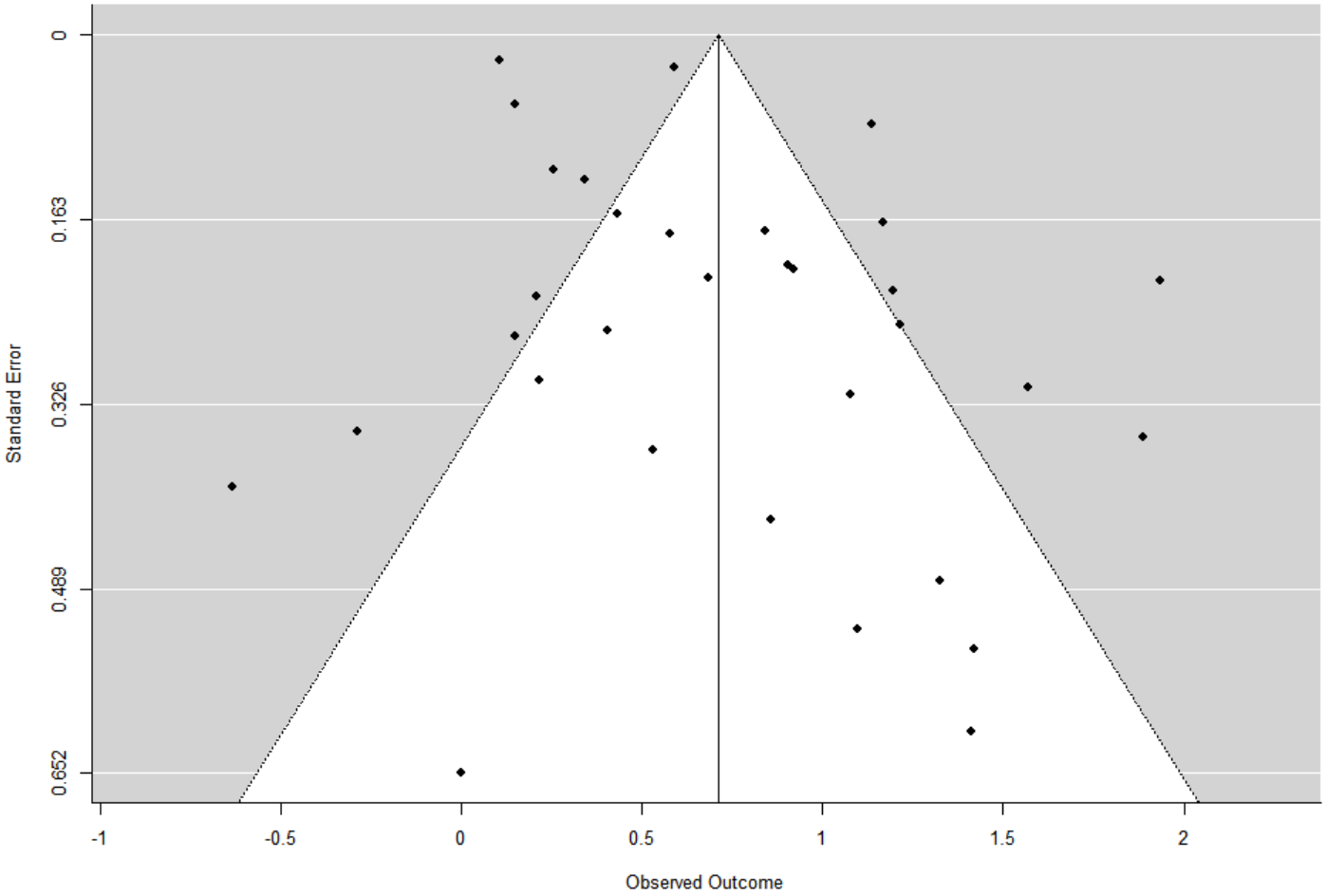
Note: The observed *p*-curve includes 15 statistically significant ($p < .05$) results, of which 11 are $p < .025$.
There were 4 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S7. Any type of violence (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot


Author, year
Diagnosis
OR, 95% CI
Leung 2002
EPDS ≥ 10
2.94 (1.58, 5.48)
McDonald 2012
EPDS ≥ 10
1.98 (1.30, 3.01)
Seng 2013
PDSS ≥ 80
1.50 (0.90, 2.50)
Woolhouse 2012
EPDS ≥ 13
3.22 (2.33, 4.45)
Tachibana 2015
EPDS ≥ 9
1.23 (0.78, 1.93)
Abdollahi 2014
EPDS ≥ 13
1.11 (1.06, 1.16)
Gausia 2009
EPDS ≥ 10
1.00 (0.28, 3.59)
Dolatian 2009
EPDS ≥ 10
3.30 (2.12, 5.14)
Flach 2011
EPDS ≥ 13
1.29 (1.02, 1.63)
Milgrom 2008
EPDS ≥ 13
3.12 (2.67, 3.64)
Valentine 2010
BDI-FS ≥ 4
1.70 (0.83, 3.49)
Patel 2002
EPDS ≥ 12
2.32 (1.65, 3.26)
Katon 2014
PHQ-9 ≥ 10
0.53 (0.24, 1.16)
Ludermir 2010
EPDS ≥ 12
1.54 (1.13, 2.10)
Budhathoki 2012
EPDS ≥ 13
1.24 (0.68, 2.26)
Turkcapar 2015
EPDS ≥ 13
6.60 (3.29, 13.24)
Woolhouse 2015
EPDS ≥ 13
0.75 (0.38, 1.49)
Escriba-Aguir 2013
EPDS ≥ 11
4.11 (1.23, 13.73)
Rogathi 2017
EPDS ≥ 13
2.51 (1.67, 3.77)
Records 2009
EPDS ≥ 12
4.81 (2.61, 8.86)
Sorbo 2014
EPDS ≥ 6
1.80 (1.70, 1.90)
Gartland 2016
EPDS ≥ 13
1.41 (1.10, 1.81)
LaCoursiere 2010
EPDS ≥ 12
1.16 (0.69, 1.96)
Sheela 2015
EPDS ≥ 13
6.91 (4.52, 10.57)
Janssen 2012
EPDS ≥ 13
3.37 (2.04, 5.56)
Dennis 2017
EPDS ≥ 13
4.14 (1.43, 12.00)
Gaillard 2014
EPDS ≥ 12
3.00 (1.07, 8.40)
Li yang 2016
EPDS ≥ 12
2.47 (1.66, 3.68)
Gottfried 2015
BDI ≥ 12
2.36 (1.02, 5.47)
Malta 2012
EPDS ≥ 10
1.78 (1.26, 2.51)

2) Funnel plot



3) P curve analysis plot

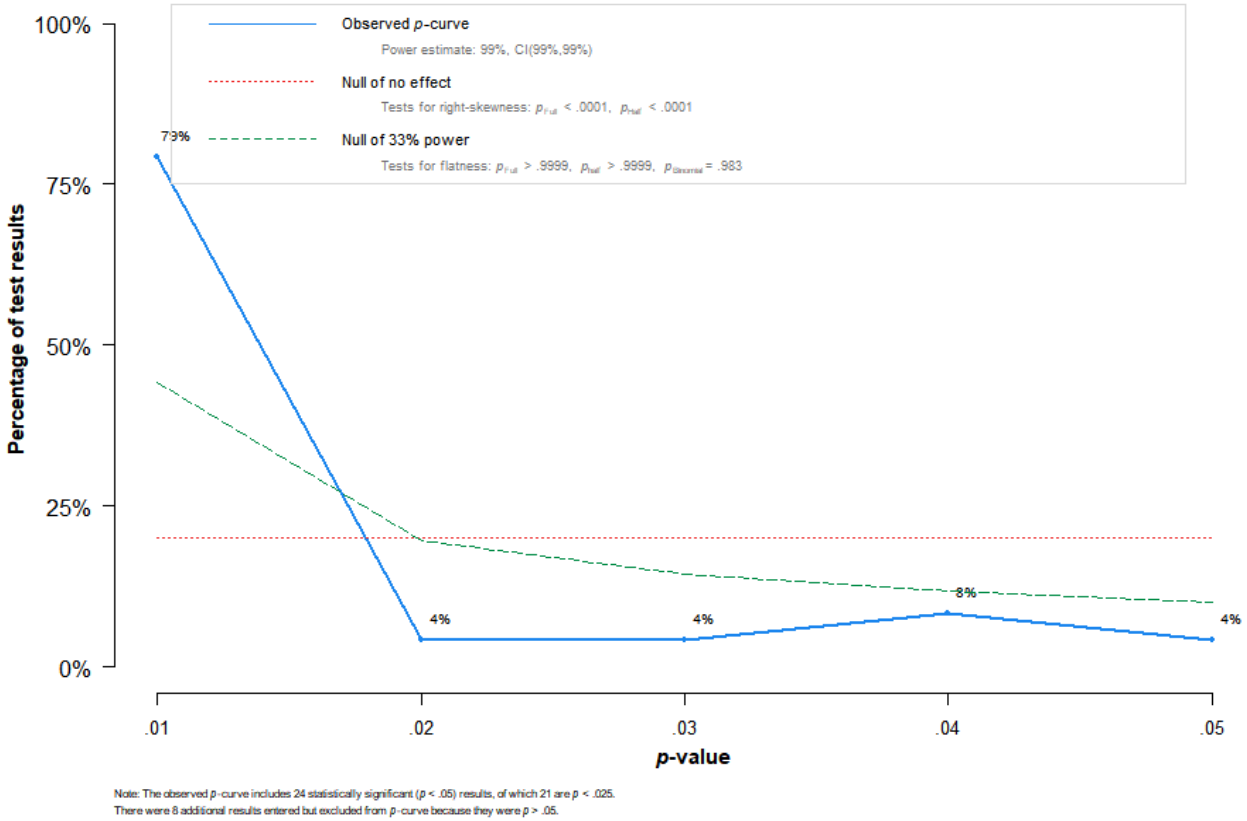
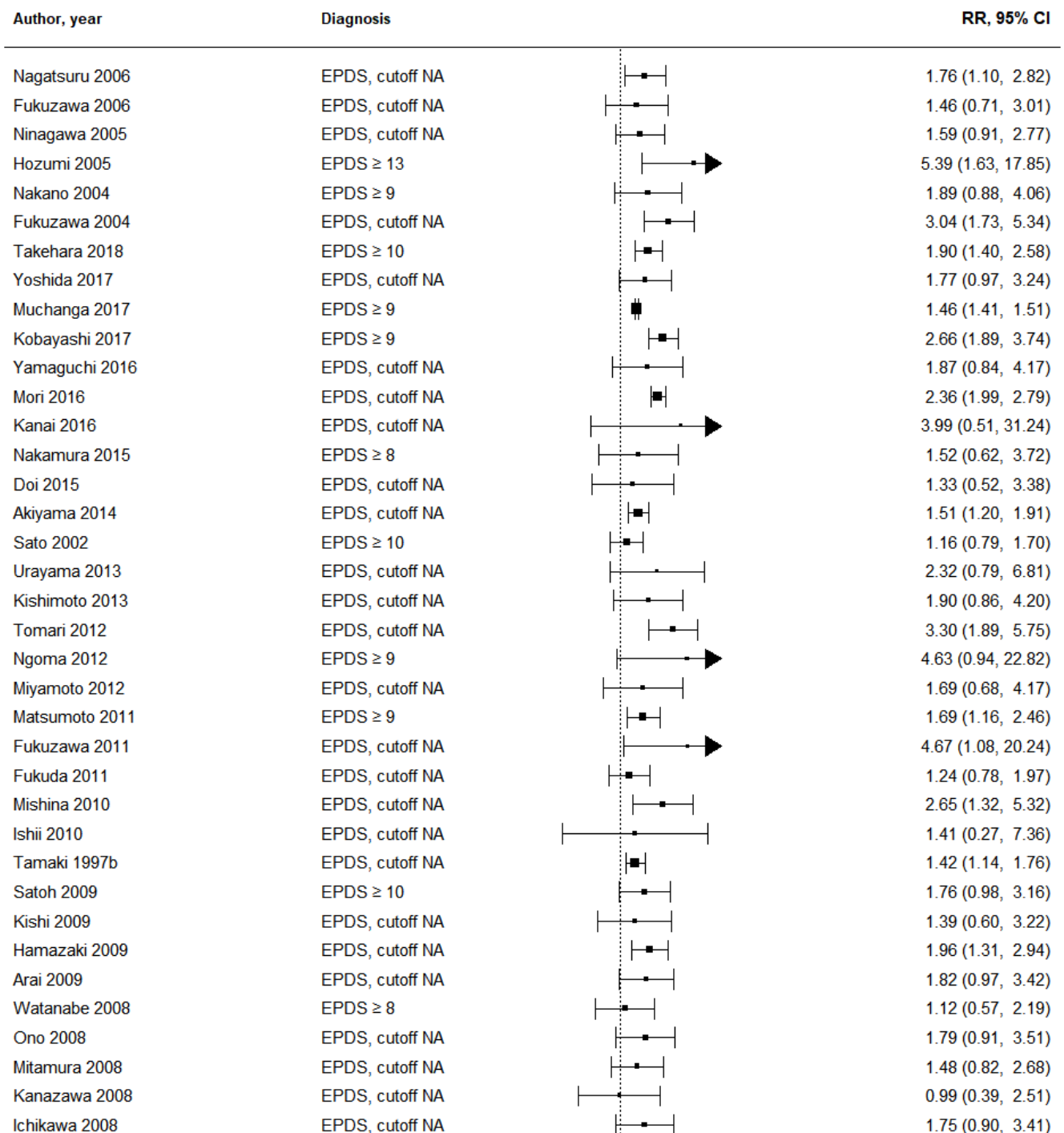
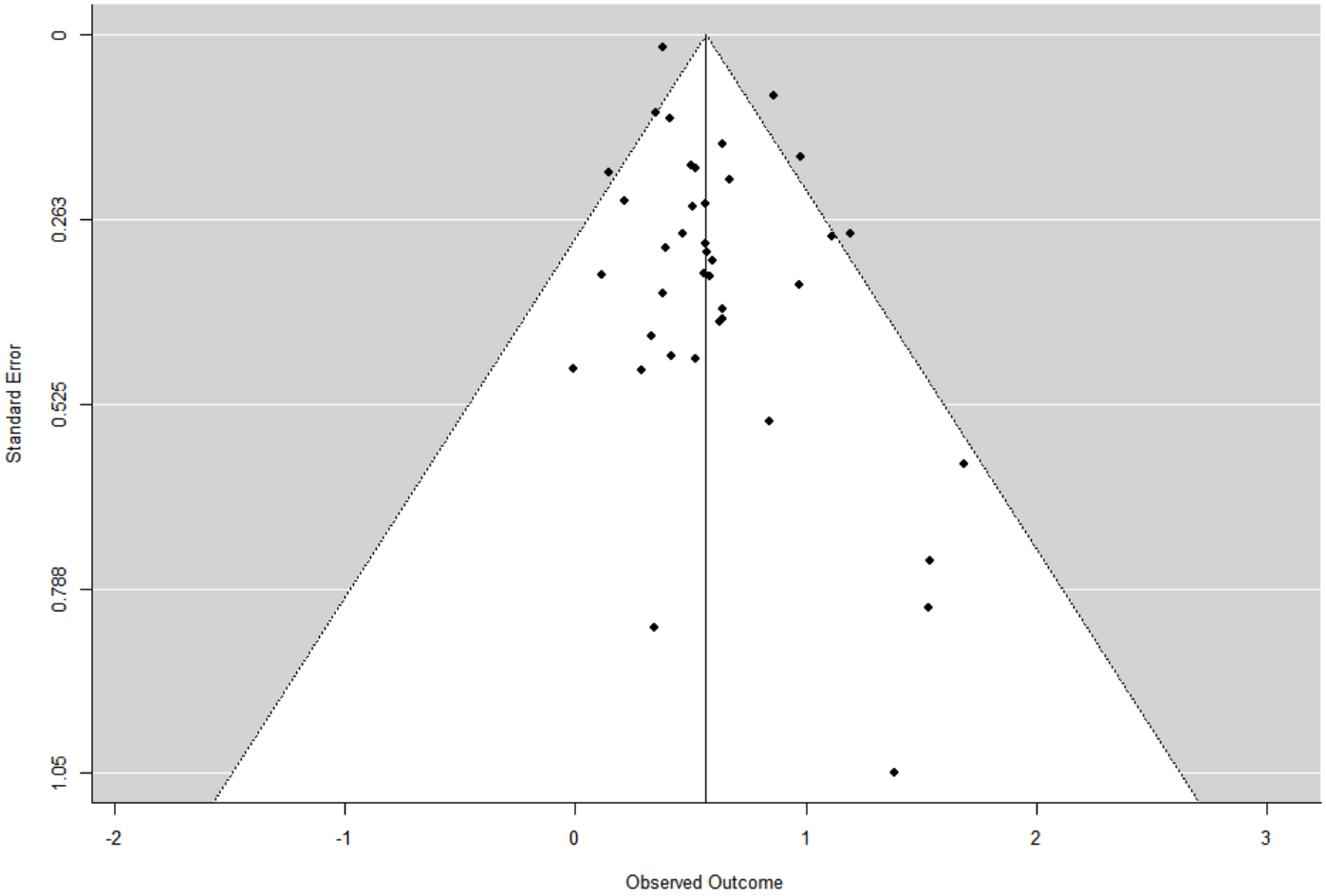


Figure S8. Primiparity compared to multiparity (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot


Author, year
Diagnosis
RR, 95% CI
Nagatsuru 2006 EPDS, cutoff NA 1.76 (1.10, 2.82)
Fukuzawa 2006 EPDS, cutoff NA 1.46 (0.71, 3.01)
Ninagawa 2005 EPDS, cutoff NA 1.59 (0.91, 2.77)
Hozumi 2005 EPDS ≥ 13 5.39 (1.63, 17.85)
Nakano 2004 EPDS ≥ 9 1.89 (0.88, 4.06)
Fukuzawa 2004 EPDS, cutoff NA 3.04 (1.73, 5.34)
Takehara 2018 EPDS ≥ 10 1.90 (1.40, 2.58)
Yoshida 2017 EPDS, cutoff NA 1.77 (0.97, 3.24)
Muchanga 2017 EPDS ≥ 9 1.46 (1.41, 1.51)
Kobayashi 2017 EPDS ≥ 9 2.66 (1.89, 3.74)
Yamaguchi 2016 EPDS, cutoff NA 1.87 (0.84, 4.17)
Mori 2016 EPDS, cutoff NA 2.36 (1.99, 2.79)
Kanai 2016 EPDS, cutoff NA 3.99 (0.51, 31.24)
Nakamura 2015 EPDS ≥ 8 1.52 (0.62, 3.72)
Doi 2015 EPDS, cutoff NA 1.33 (0.52, 3.38)
Akiyama 2014 EPDS, cutoff NA 1.51 (1.20, 1.91)
Sato 2002 EPDS ≥ 10 1.16 (0.79, 1.70)
Urayama 2013 EPDS, cutoff NA 2.32 (0.79, 6.81)
Kishimoto 2013 EPDS, cutoff NA 1.90 (0.86, 4.20)
Tomari 2012 EPDS, cutoff NA 3.30 (1.89, 5.75)
Ngoma 2012 EPDS ≥ 9 4.63 (0.94, 22.82)
Miyamoto 2012 EPDS, cutoff NA 1.69 (0.68, 4.17)
Matsumoto 2011 EPDS ≥ 9 1.69 (1.16, 2.46)
Fukuzawa 2011 EPDS, cutoff NA 4.67 (1.08, 20.24)
Fukuda 2011 EPDS, cutoff NA 1.24 (0.78, 1.97)
Mishina 2010 EPDS, cutoff NA 2.65 (1.32, 5.32)
Ishii 2010 EPDS, cutoff NA 1.41 (0.27, 7.36)
Tamaki 1997b EPDS, cutoff NA 1.42 (1.14, 1.76)
Satoh 2009 EPDS ≥ 10 1.76 (0.98, 3.16)
Kishi 2009 EPDS, cutoff NA 1.39 (0.60, 3.22)
Hamazaki 2009 EPDS, cutoff NA 1.96 (1.31, 2.94)
Arai 2009 EPDS, cutoff NA 1.82 (0.97, 3.42)
Watanabe 2008 EPDS ≥ 8 1.12 (0.57, 2.19)
Ono 2008 EPDS, cutoff NA 1.79 (0.91, 3.51)
Mitamura 2008 EPDS, cutoff NA 1.48 (0.82, 2.68)
Kanazawa 2008 EPDS, cutoff NA 0.99 (0.39, 2.51)
Ichikawa 2008 EPDS, cutoff NA 1.75 (0.90, 3.41)

2) Funnel plot



3) P curve analysis plot

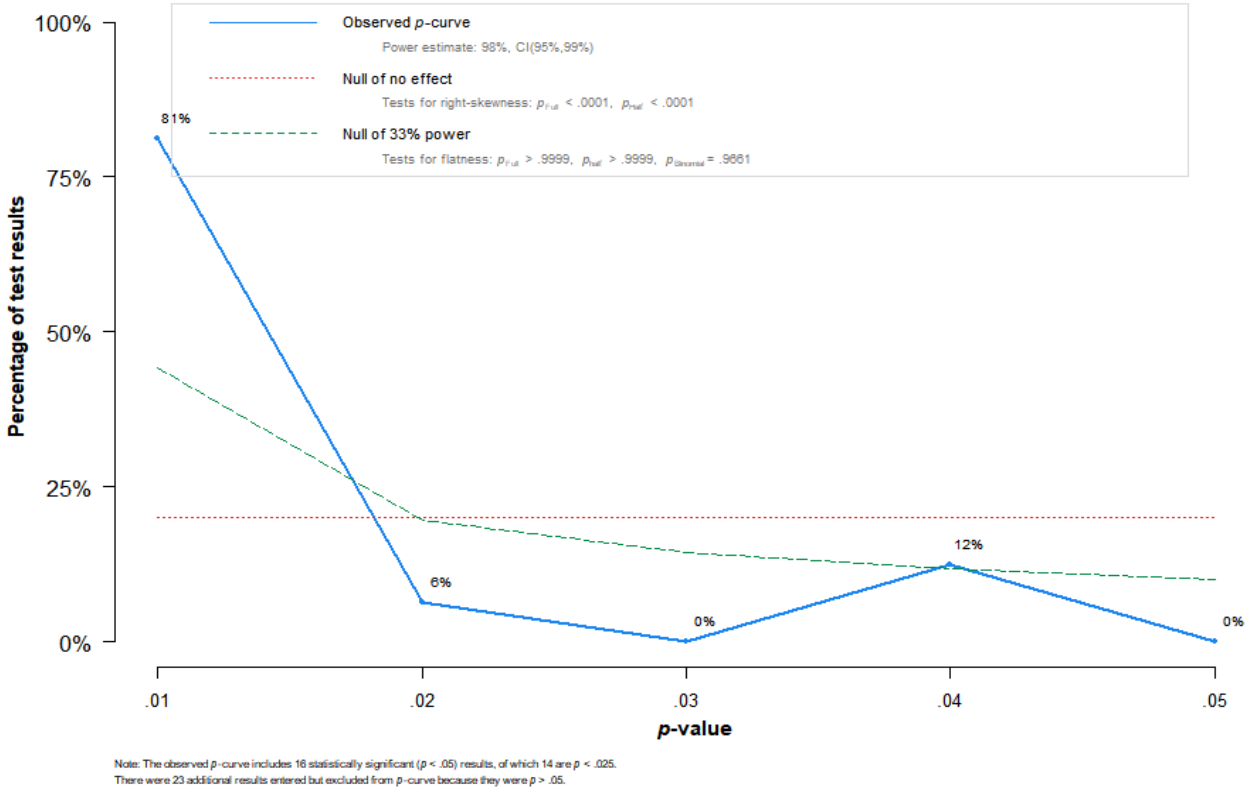
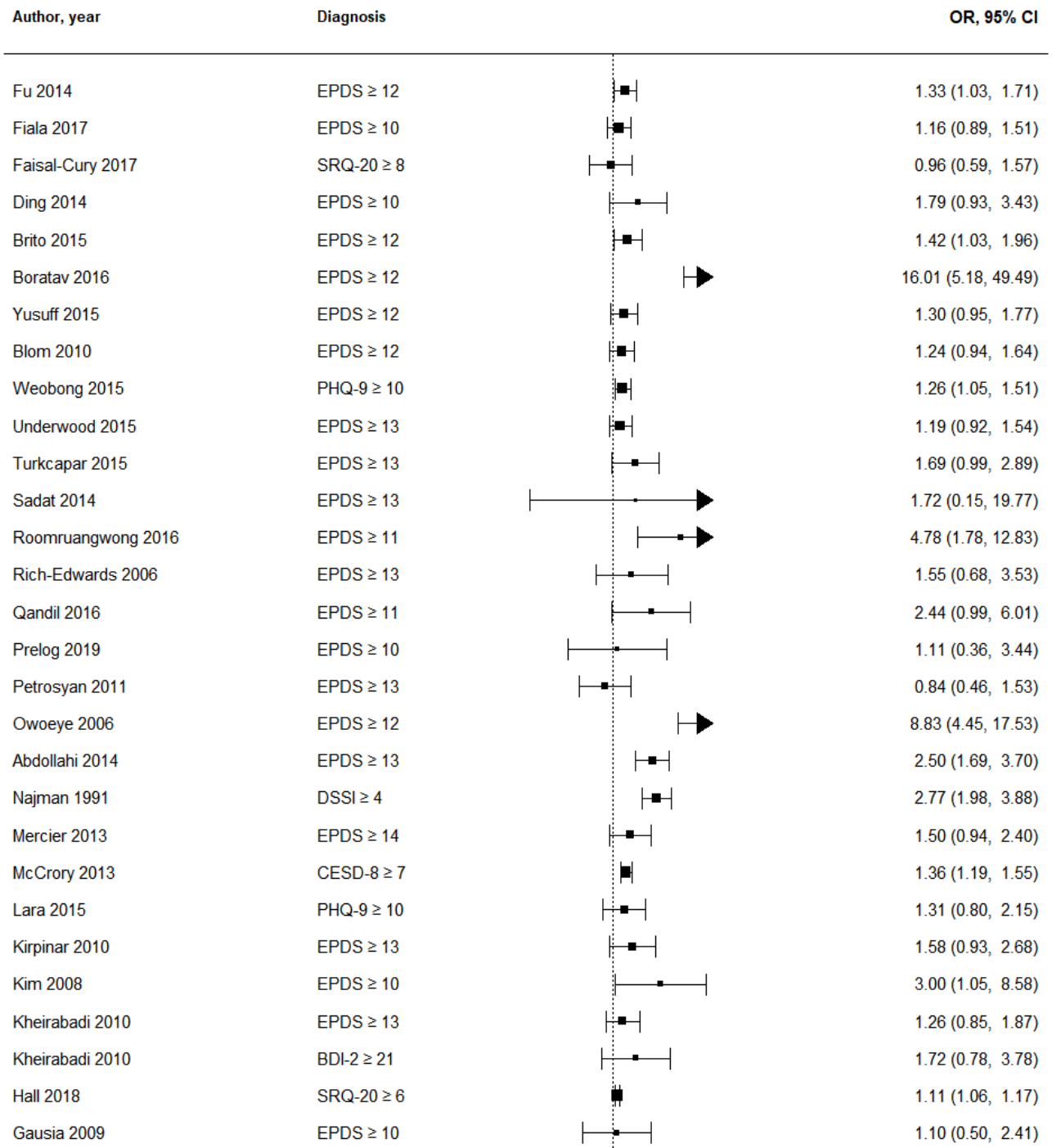
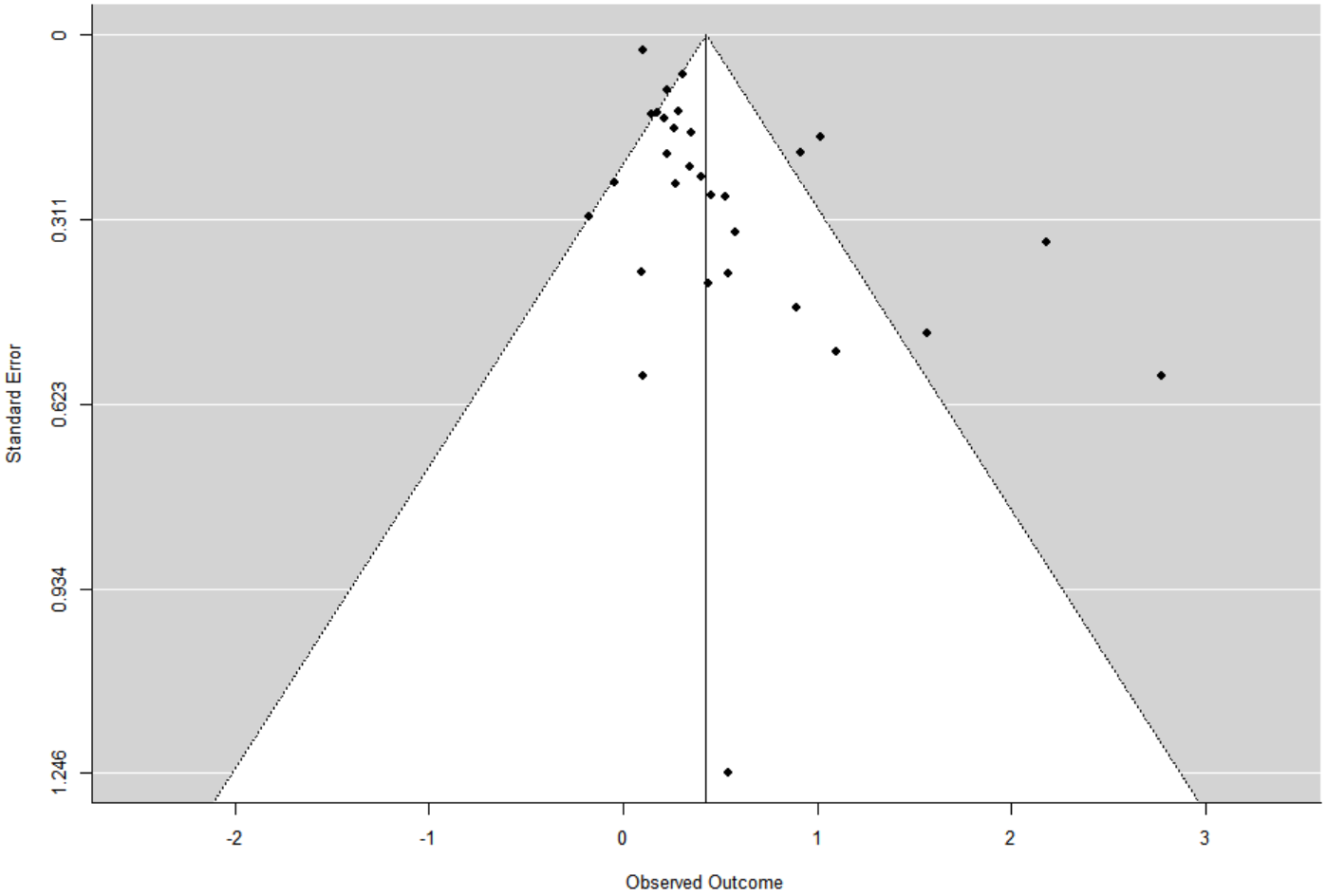


Figure S9. Unintended pregnancy (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot


Author, year
Diagnosis
OR, 95% CI
Fu 2014
EPDS ≥ 12
1.33 (1.03, 1.71)
Fiala 2017
EPDS ≥ 10
1.16 (0.89, 1.51)
Faisal-Cury 2017
SRQ-20 ≥ 8
0.96 (0.59, 1.57)
Ding 2014
EPDS ≥ 10
1.79 (0.93, 3.43)
Brito 2015
EPDS ≥ 12
1.42 (1.03, 1.96)
Boratav 2016
EPDS ≥ 12
16.01 (5.18, 49.49)
Yusuff 2015
EPDS ≥ 12
1.30 (0.95, 1.77)
Blom 2010
EPDS ≥ 12
1.24 (0.94, 1.64)
Weobong 2015
PHQ-9 ≥ 10
1.26 (1.05, 1.51)
Underwood 2015
EPDS ≥ 13
1.19 (0.92, 1.54)
Turkcapar 2015
EPDS ≥ 13
1.69 (0.99, 2.89)
Sadat 2014
EPDS ≥ 13
1.72 (0.15, 19.77)
Roomruangwong 2016
EPDS ≥ 11
4.78 (1.78, 12.83)
Rich-Edwards 2006
EPDS ≥ 13
1.55 (0.68, 3.53)
Qandil 2016
EPDS ≥ 11
2.44 (0.99, 6.01)
Prelog 2019
EPDS ≥ 10
1.11 (0.36, 3.44)
Petrosyan 2011
EPDS ≥ 13
0.84 (0.46, 1.53)
Owoeye 2006
EPDS ≥ 12
8.83 (4.45, 17.53)
Abdollahi 2014
EPDS ≥ 13
2.50 (1.69, 3.70)
Najman 1991
DSSI ≥ 4
2.77 (1.98, 3.88)
Mercier 2013
EPDS ≥ 14
1.50 (0.94, 2.40)
McCrory 2013
CESD-8 ≥ 7
1.36 (1.19, 1.55)
Lara 2015
PHQ-9 ≥ 10
1.31 (0.80, 2.15)
Kirpinar 2010
EPDS ≥ 13
1.58 (0.93, 2.68)
Kim 2008
EPDS ≥ 10
3.00 (1.05, 8.58)
Kheirabadi 2010
EPDS ≥ 13
1.26 (0.85, 1.87)
Kheirabadi 2010
BDI-2 ≥ 21
1.72 (0.78, 3.78)
Hall 2018
SRQ-20 ≥ 6
1.11 (1.06, 1.17)
Gausia 2009
EPDS ≥ 10
1.10 (0.50, 2.41)

2) Funnel plot



3) P curve analysis plot

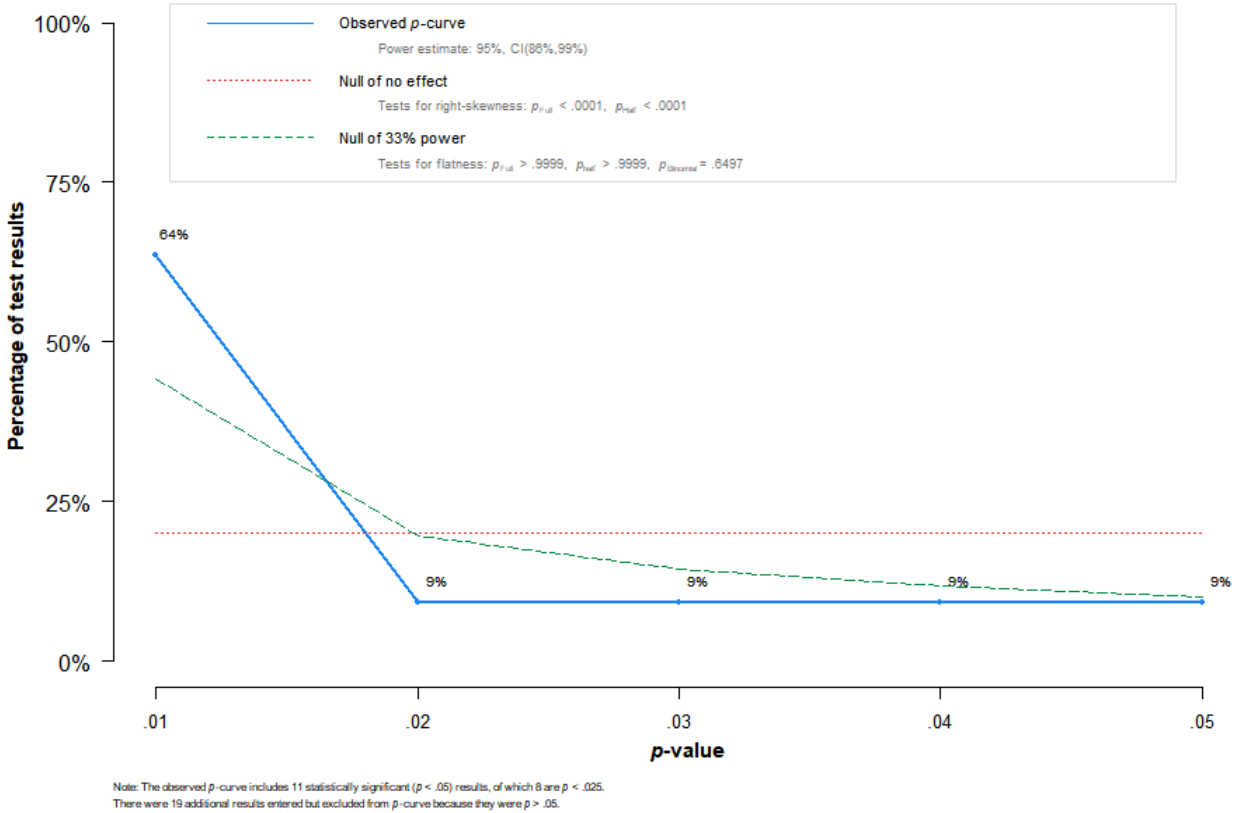
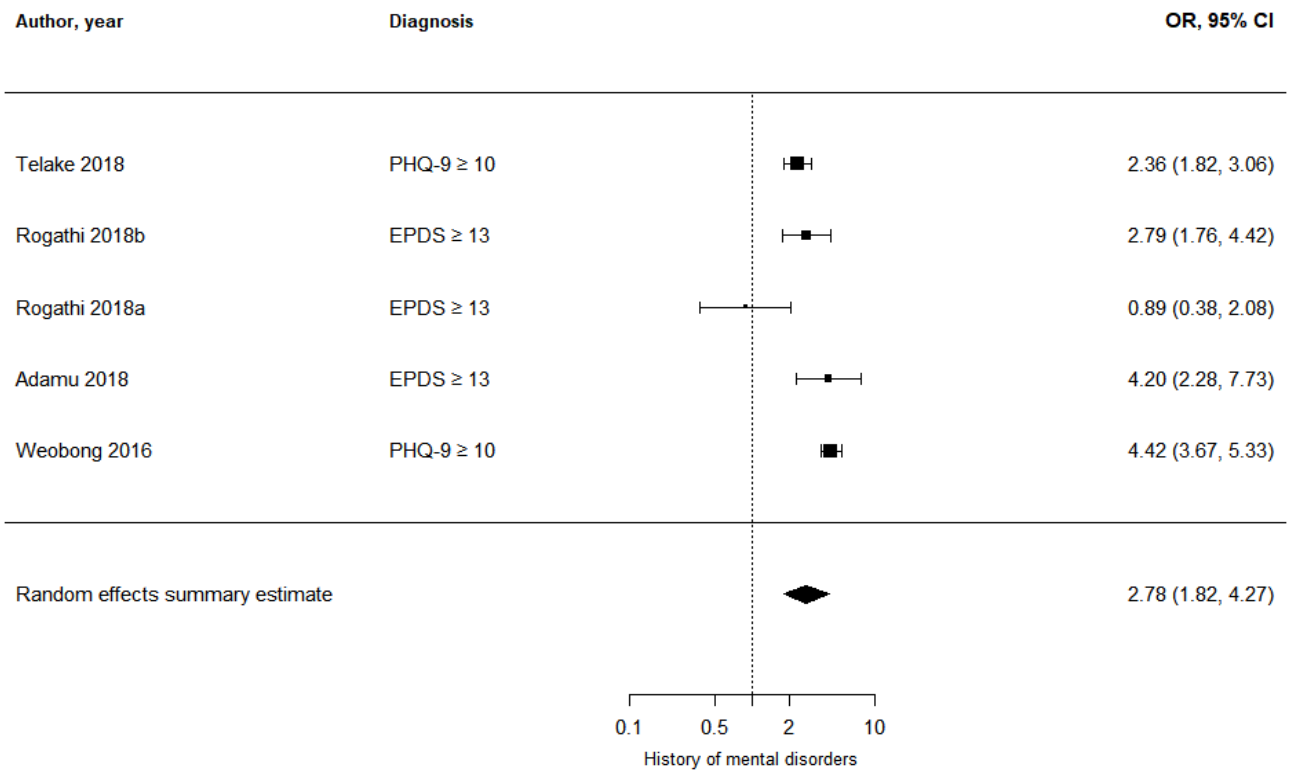
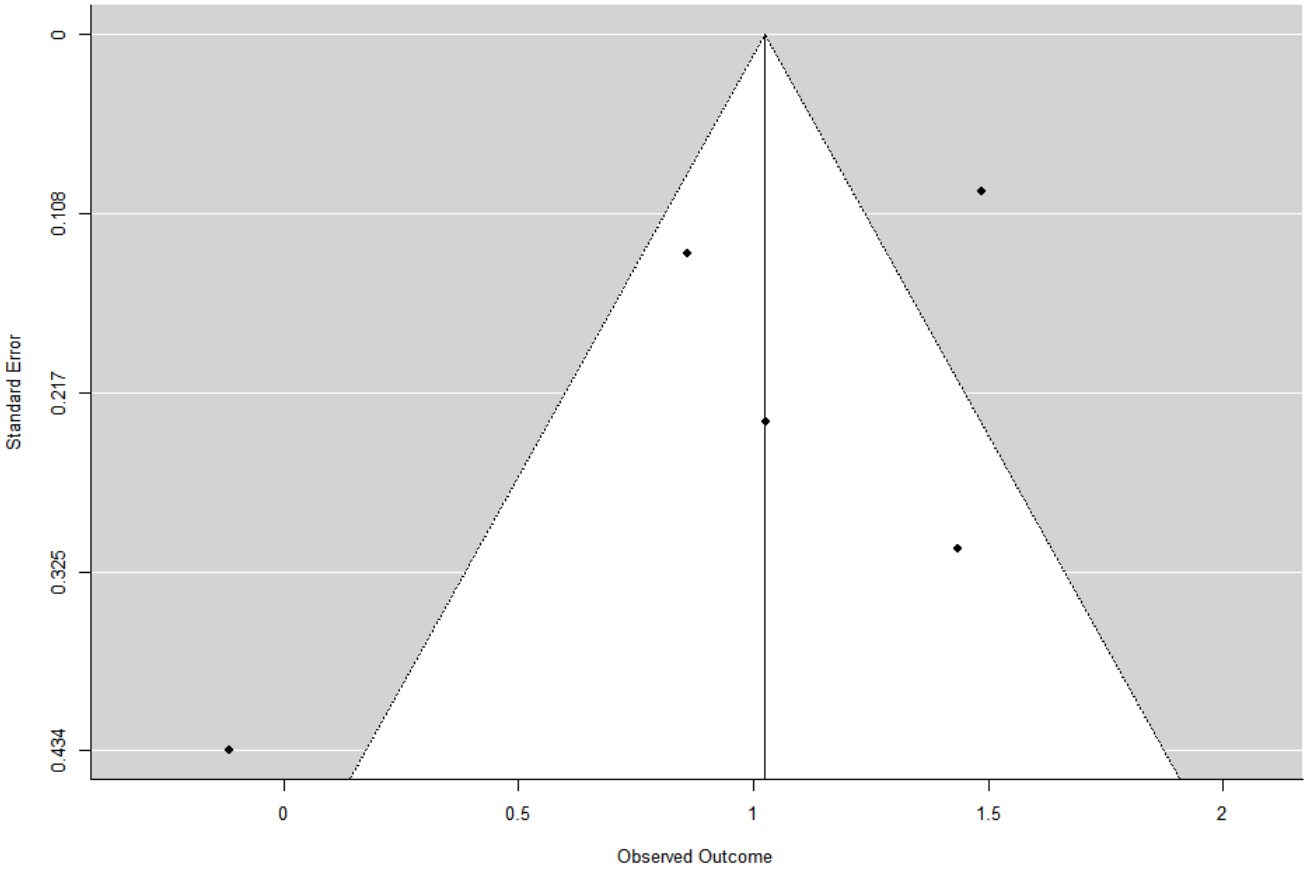


Figure S10. History of mental disorders (Forest plot, funnel plot, p curve analysis plot)

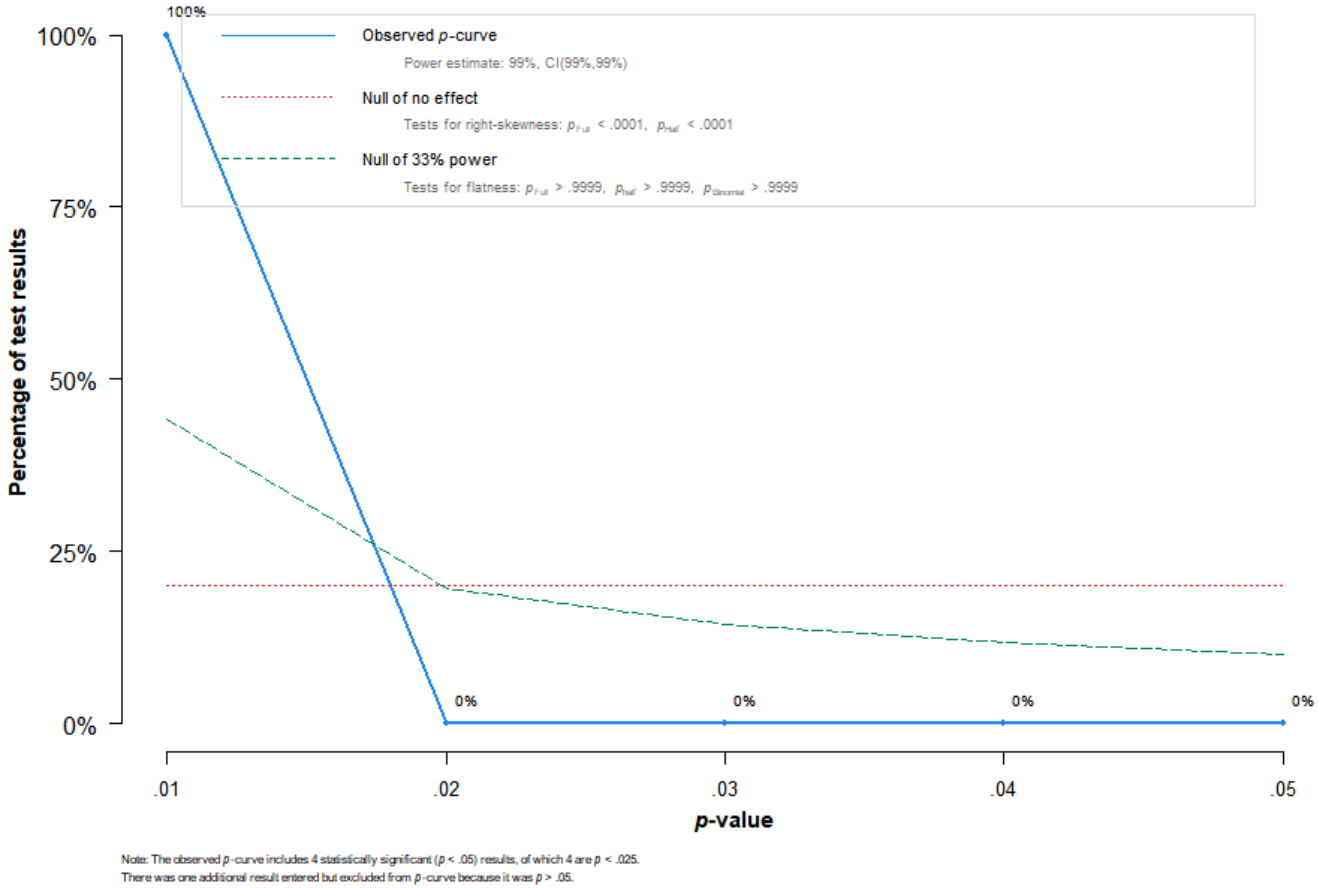
1) Forest plot



2) Funnel plot


Standard Error
0
0.108
0.217
0.325
0.434
0
0.5
1
1.5
2
Observed Outcome

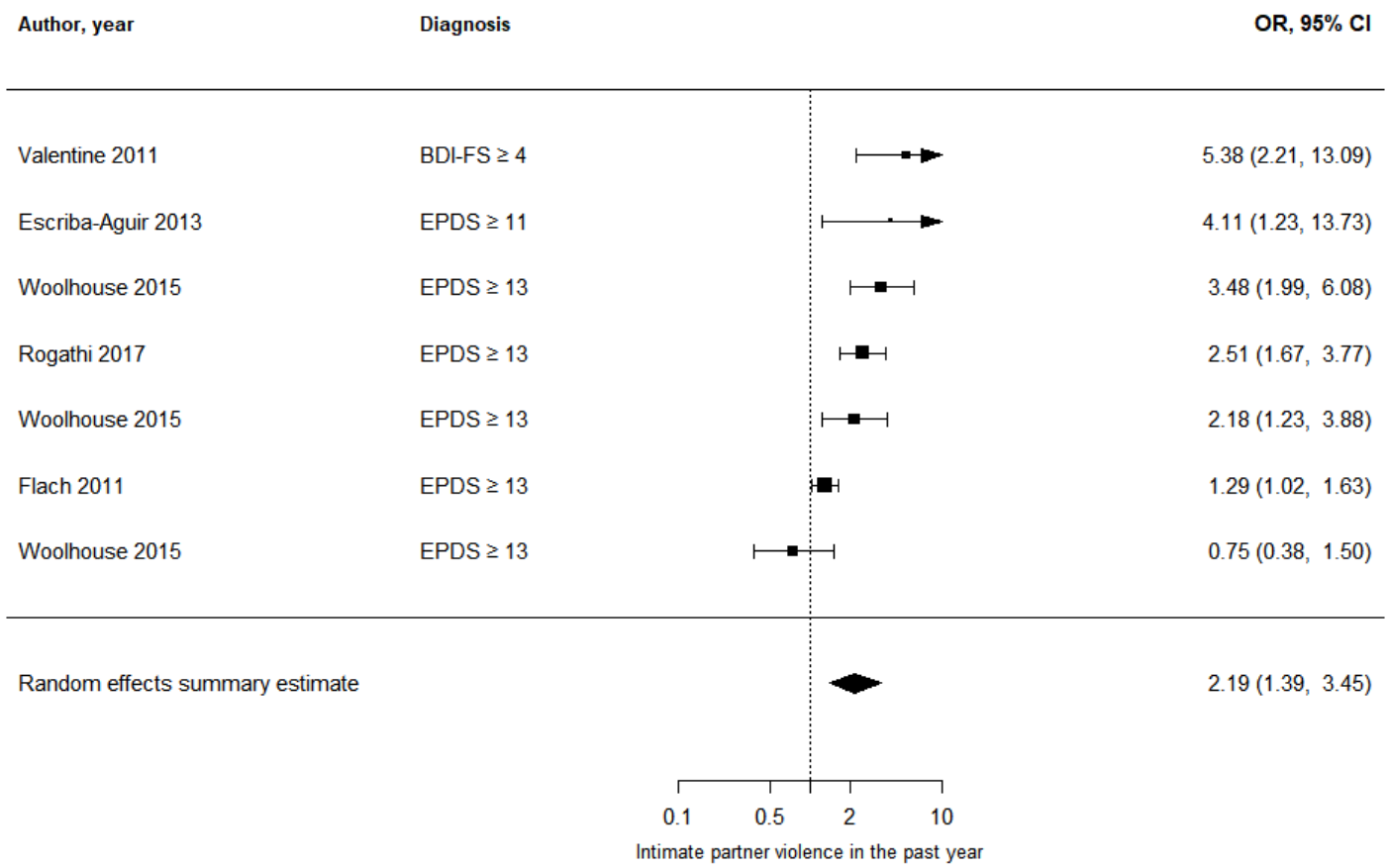
3) P curve analysis plot



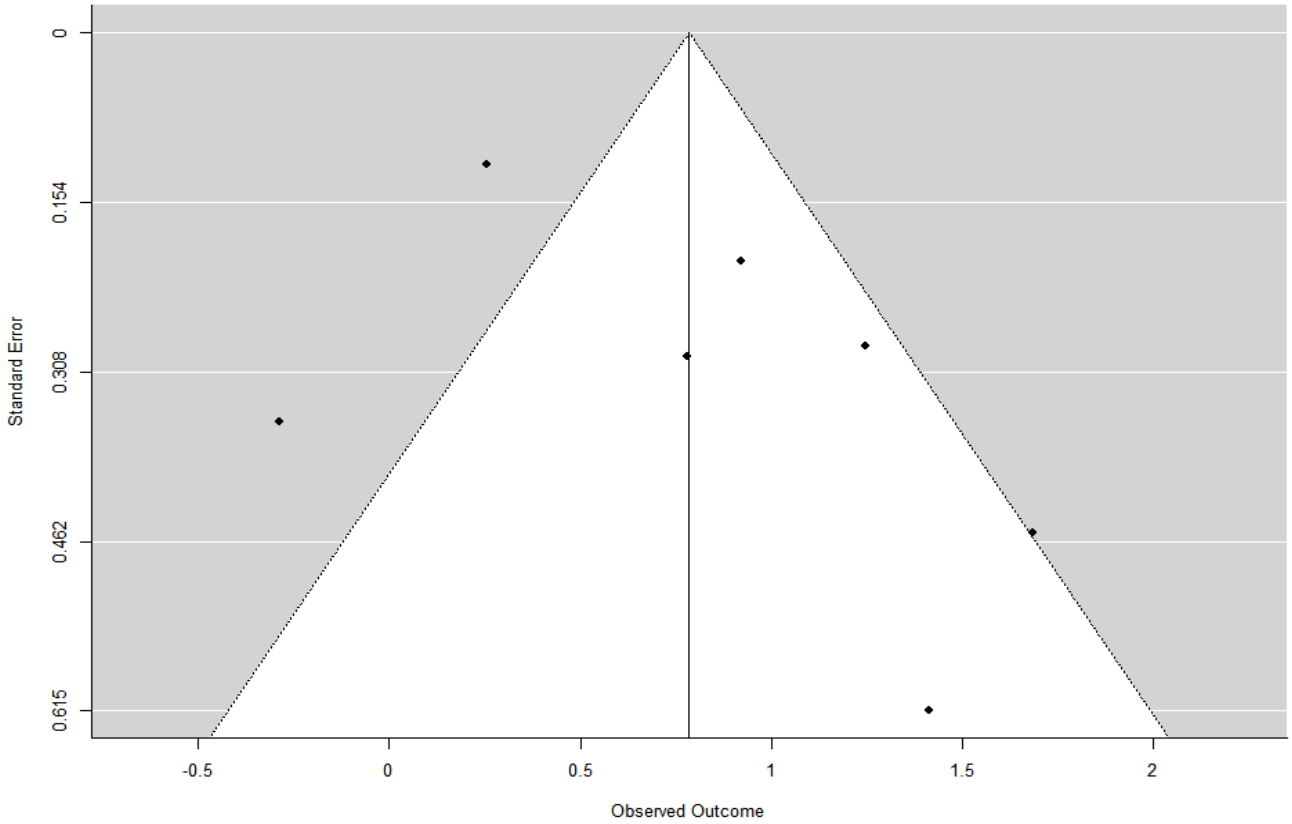
Note: The observed p-curve includes 4 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There was one additional result entered but excluded from p-curve because it was $p > .05$.

Figure S11. Intimate partner violence in the past year (Forest plot, funnel plot, p curve analysis plot)

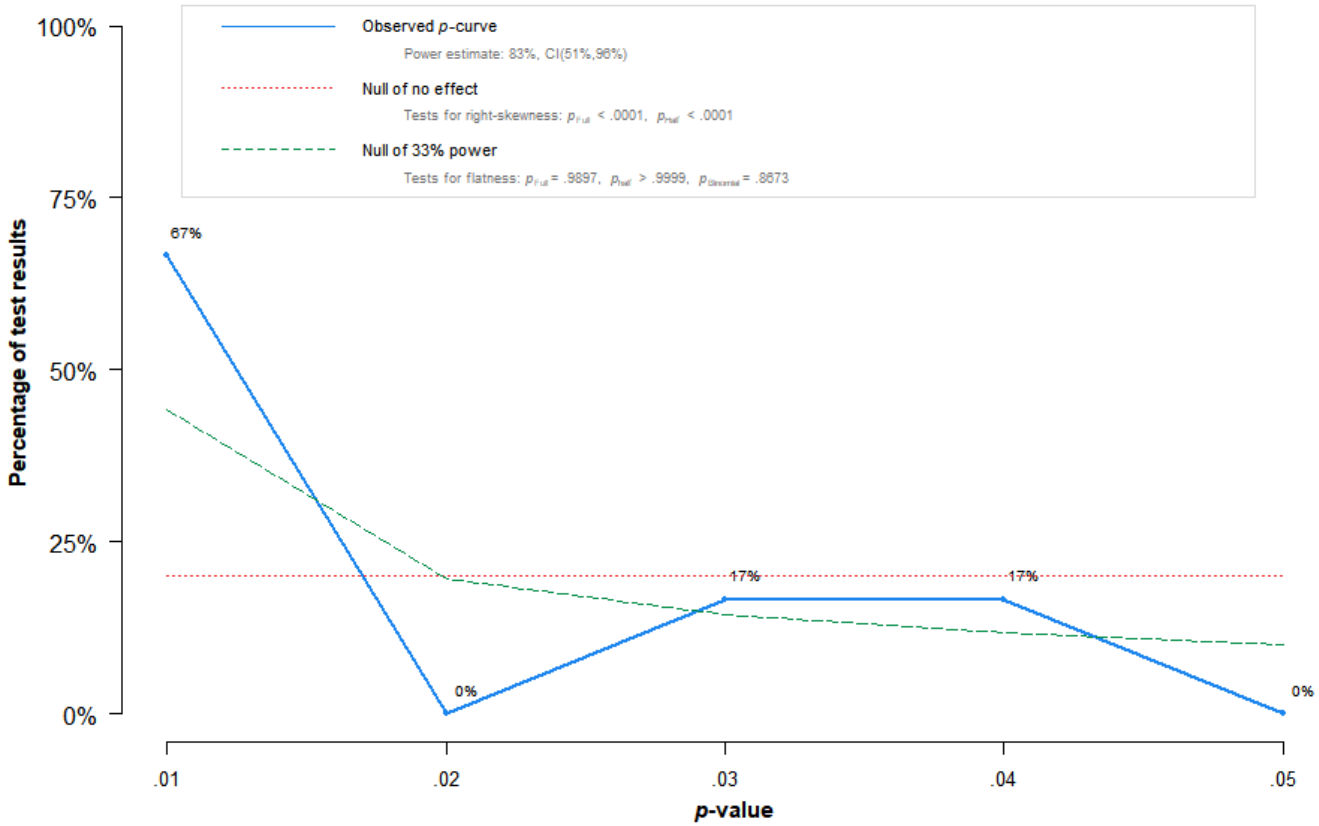
1) Forest plot



2) Funnel plot



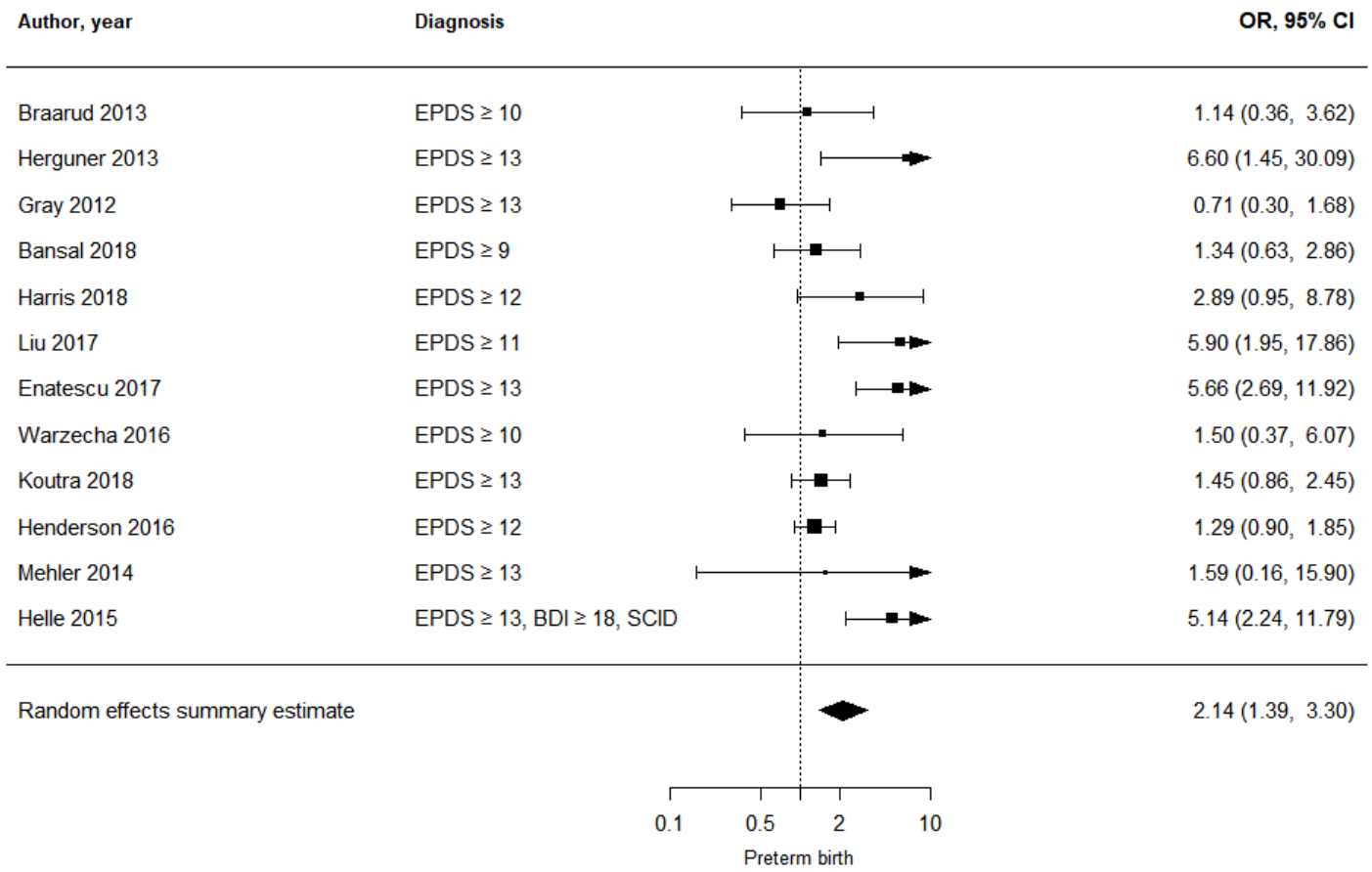
3) P curve analysis plot



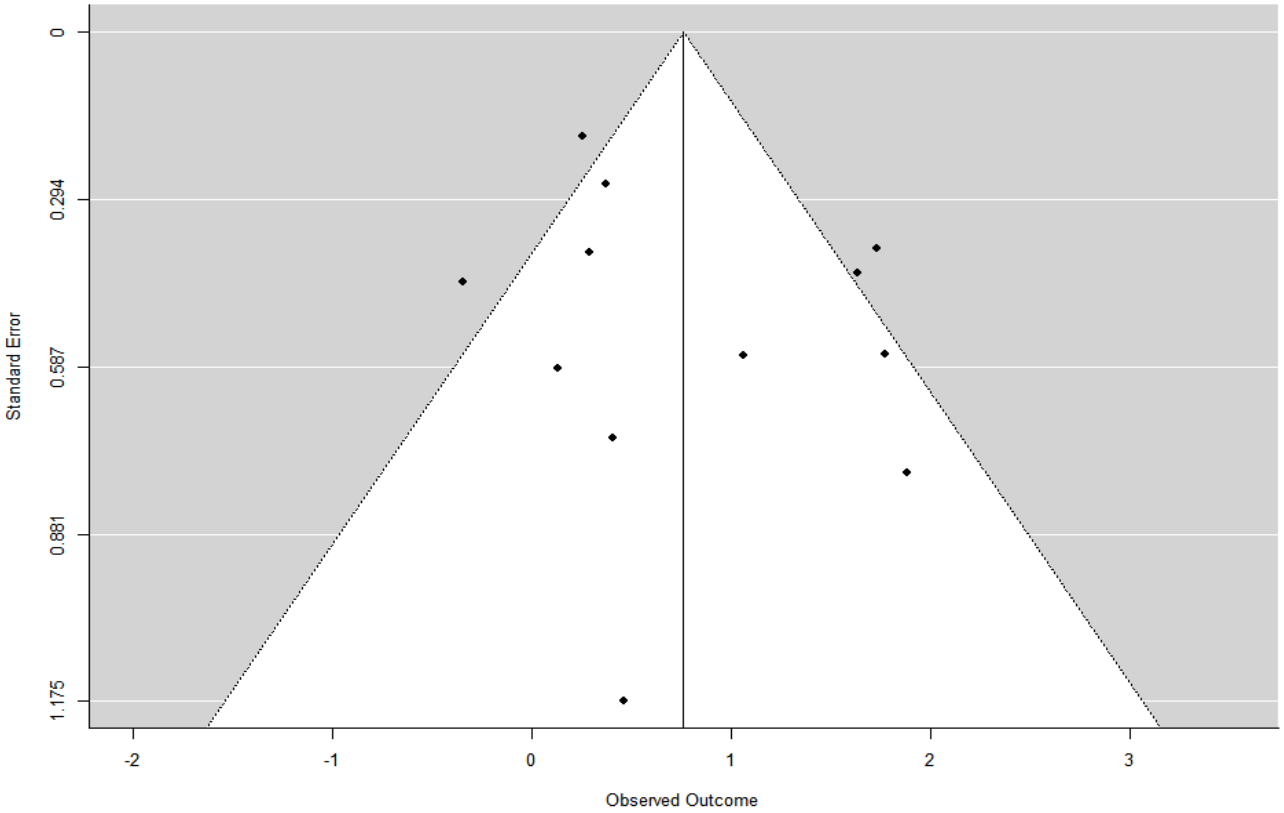
Note: The observed *p*-curve includes 6 statistically significant ($p < .05$) results, of which 5 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S12. Preterm birth (Forest plot, funnel plot, p curve analysis plot)

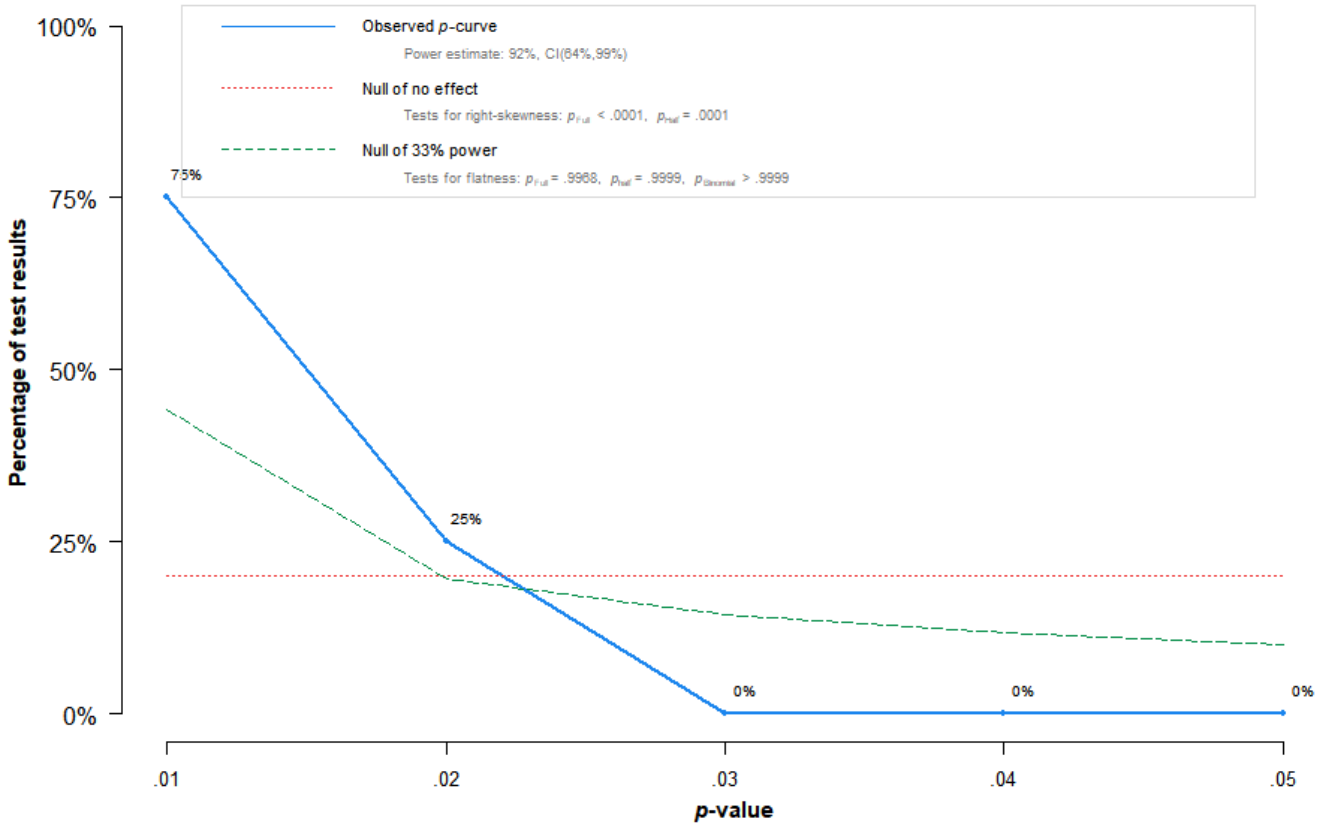
1) Forest plot



2) Funnel plot



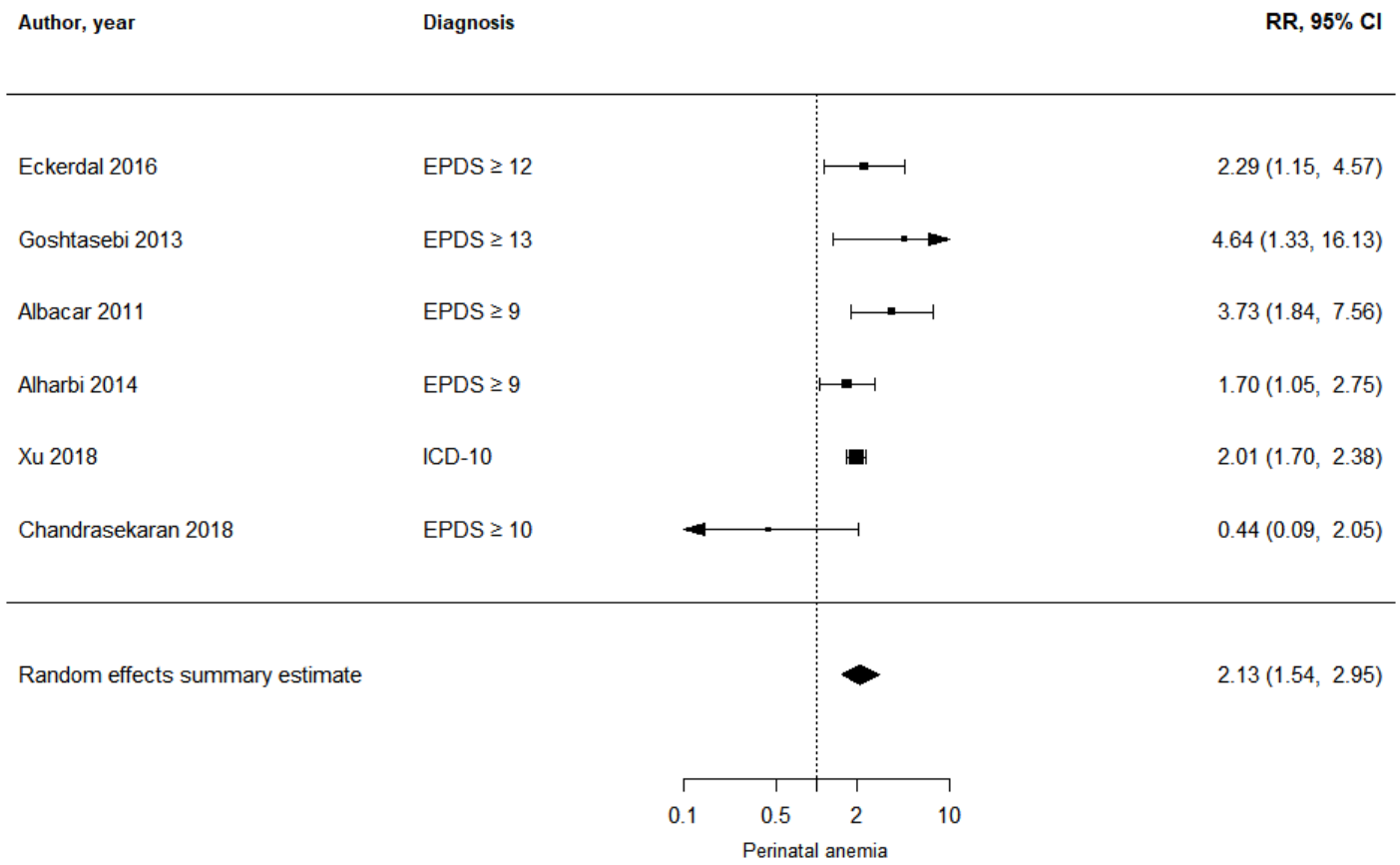
3) P curve analysis plot



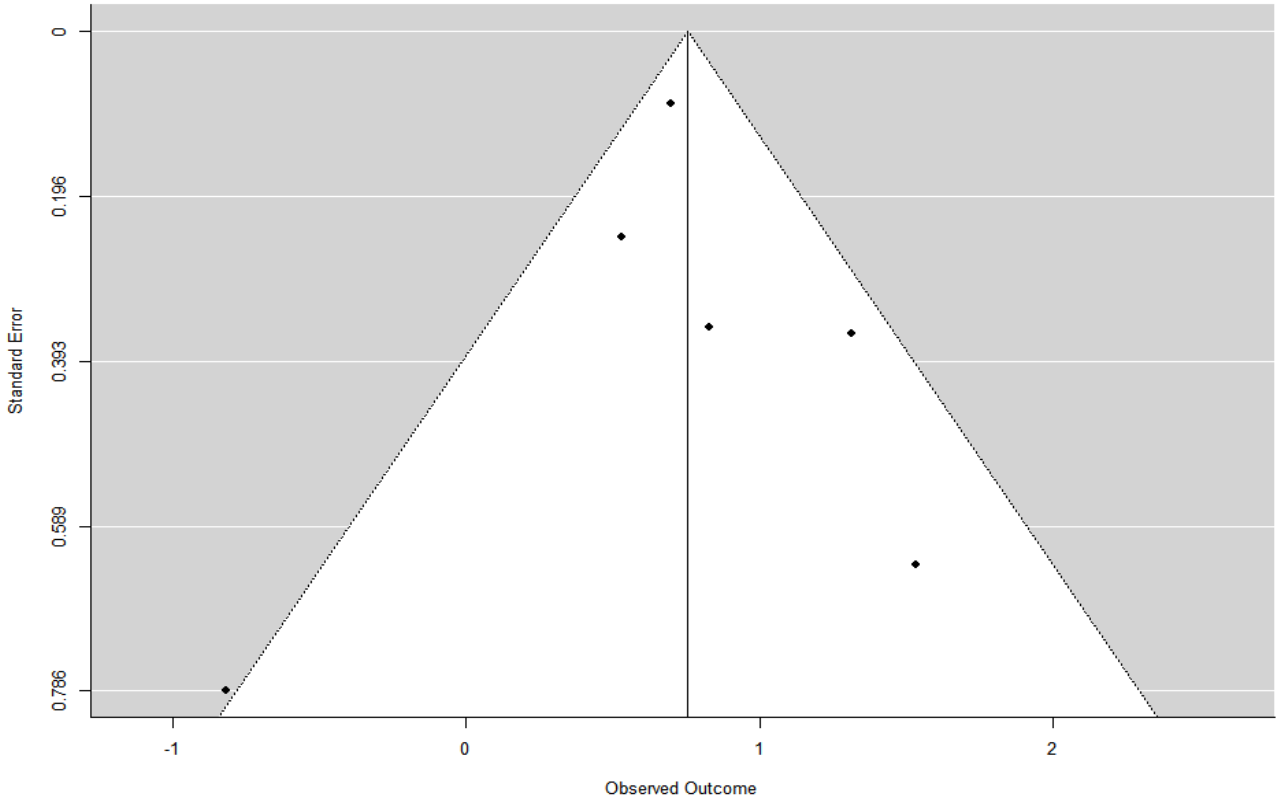
Note: The observed *p*-curve includes 4 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 8 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S13. Perinatal anemia (Forest plot, funnel plot, p curve analysis plot)

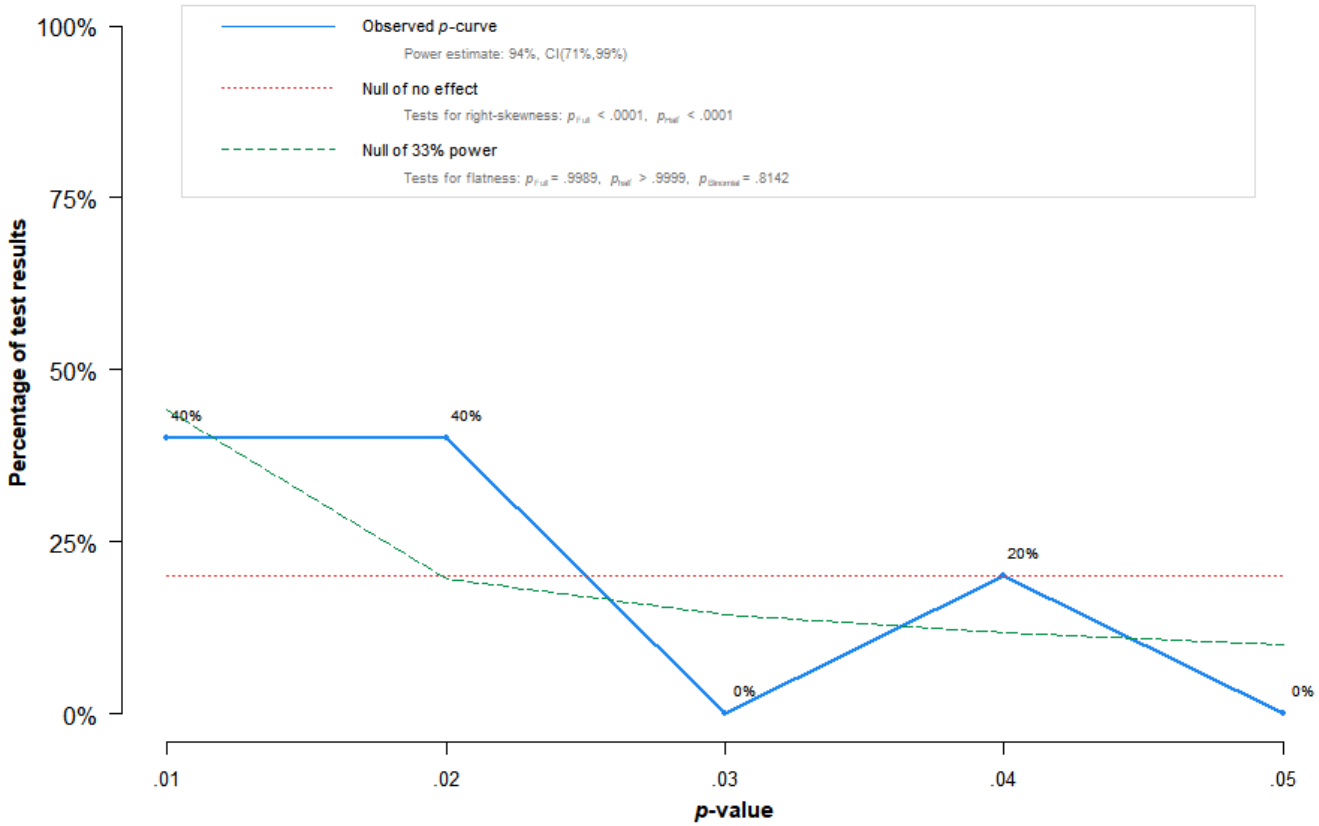
1) Forest plot



2) Funnel plot



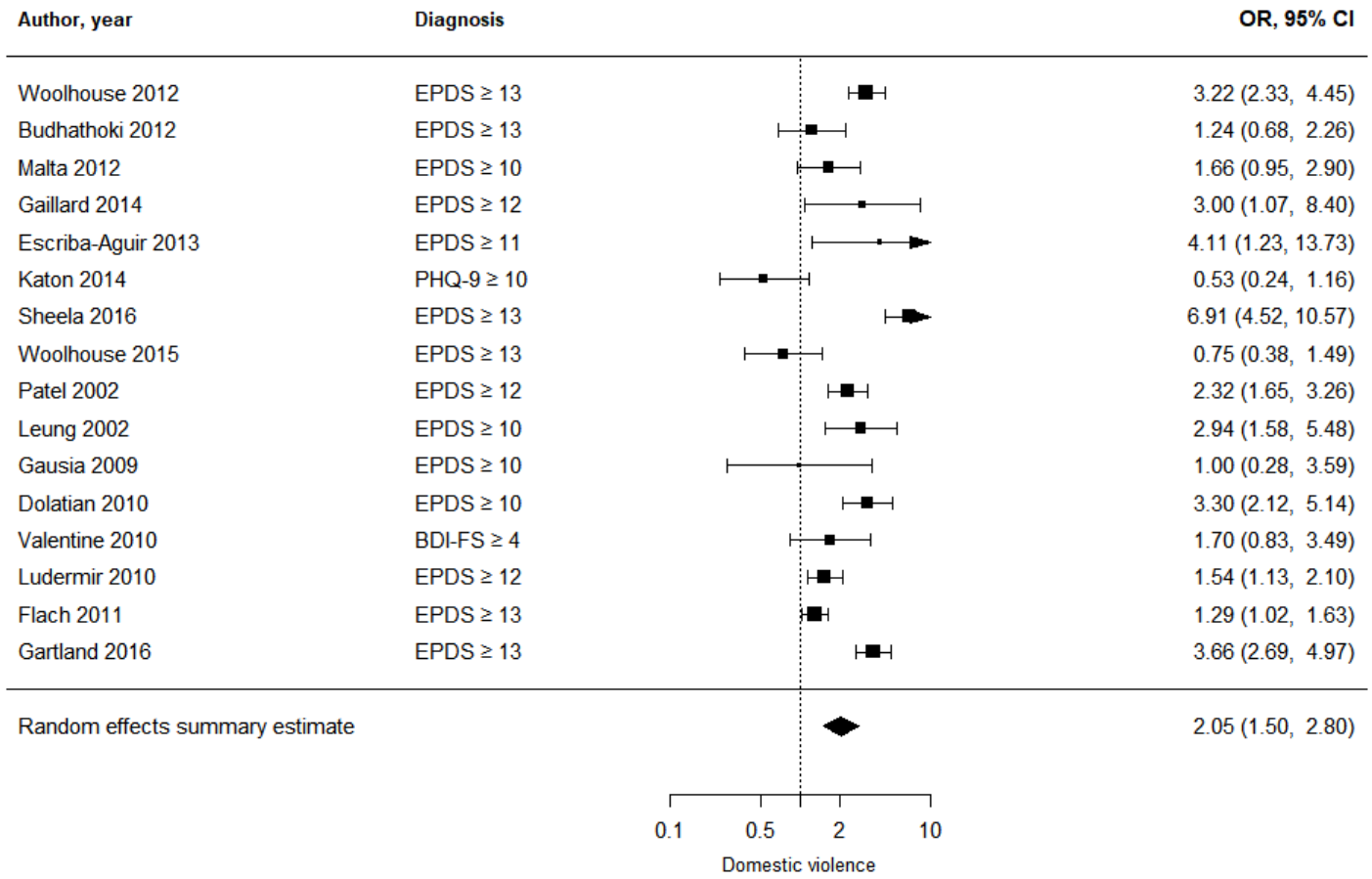
3) P curve analysis plot



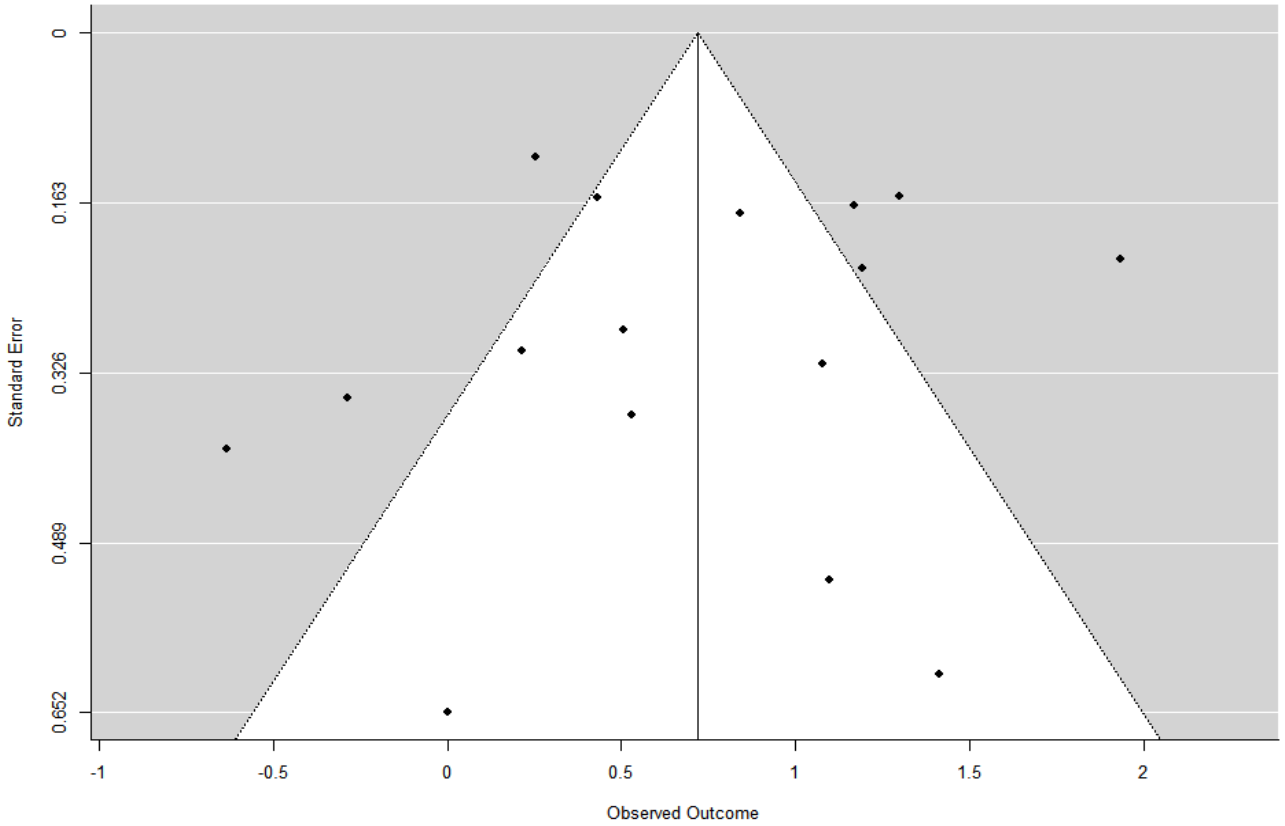
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S14. Domestic violence (Forest plot, funnel plot, p curve analysis plot)

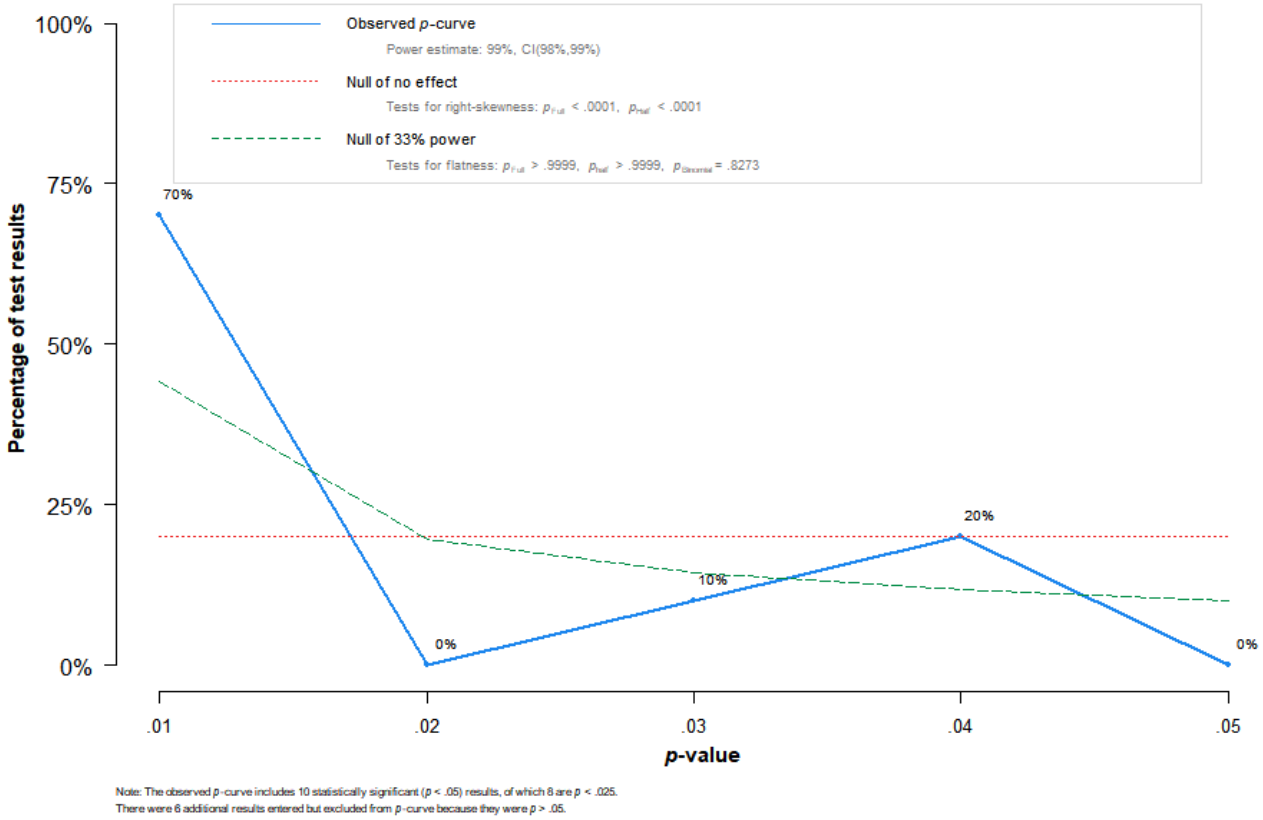
1) Forest plot



2) Funnel plot



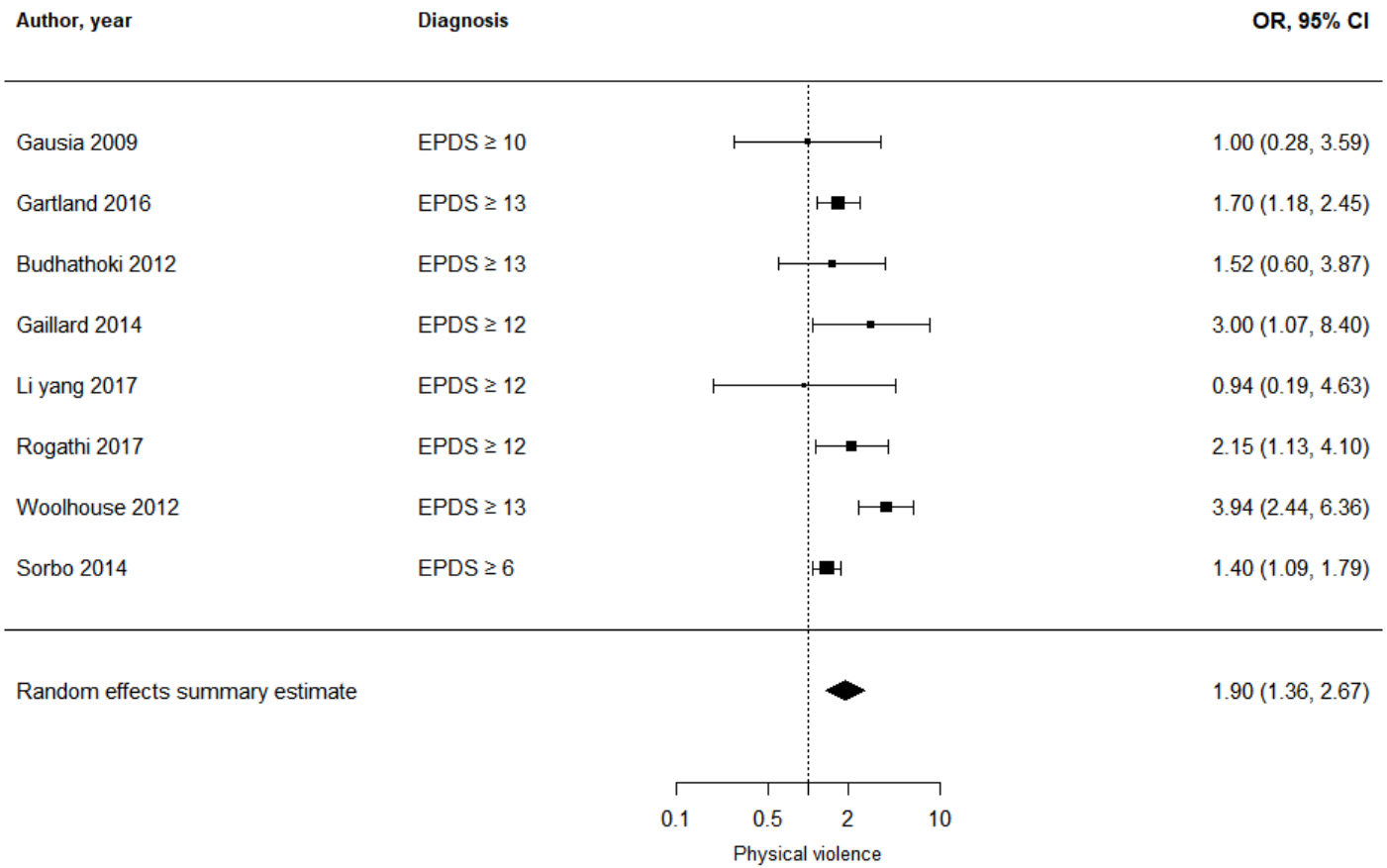
3) P curve analysis plot



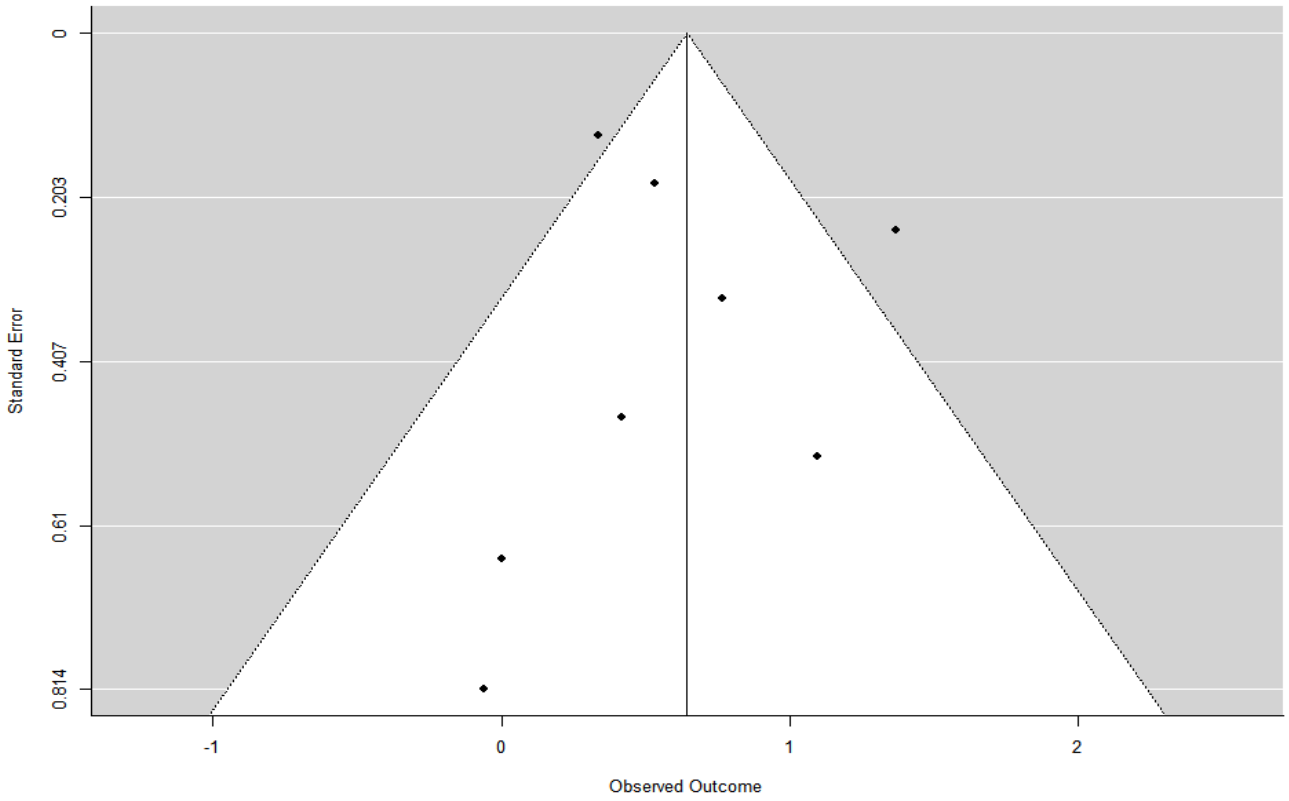
Note: The observed *p*-curve includes 10 statistically significant ($p < .05$) results, of which 8 are $p < .025$.
There were 6 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S15. Physical violence (Forest plot, funnel plot, p curve analysis plot)

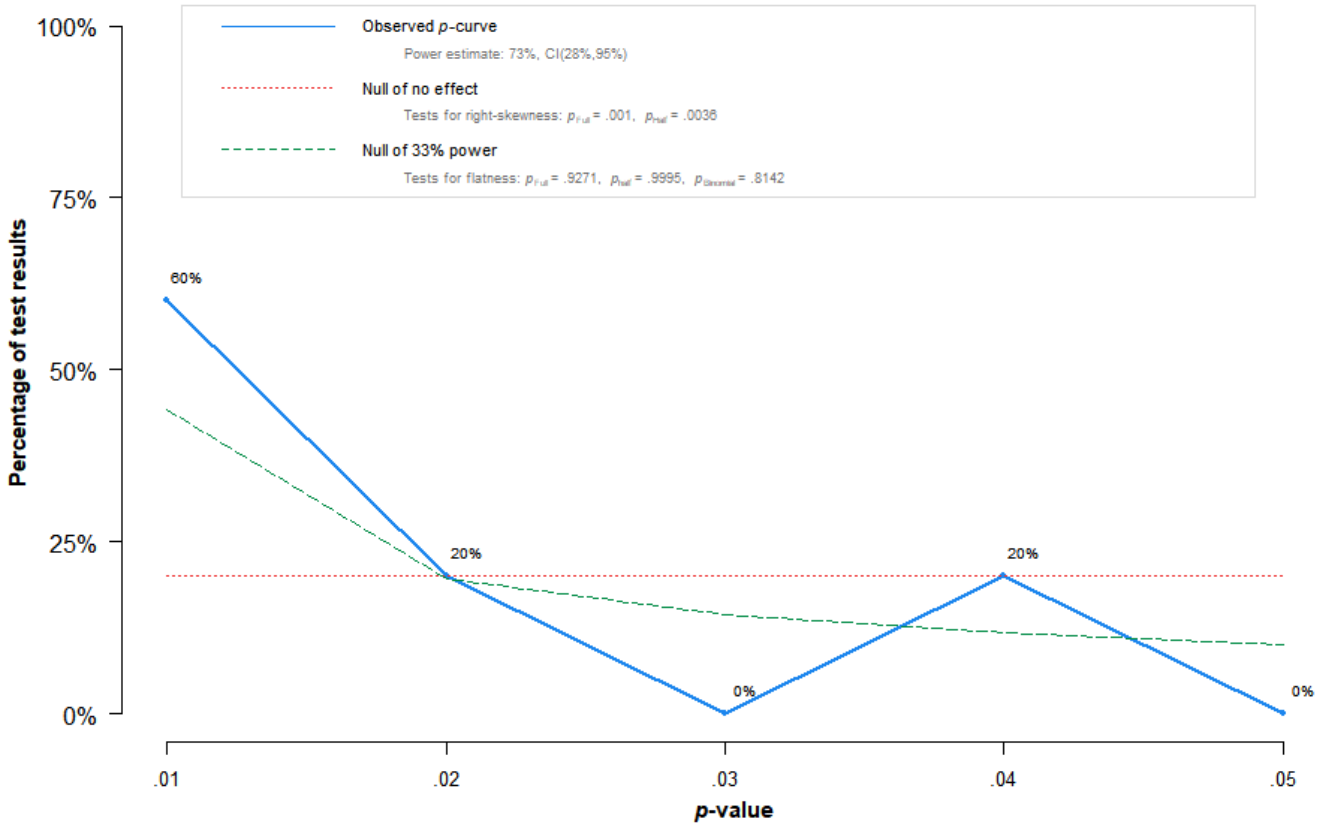
1) Forest plot



2) Funnel plot



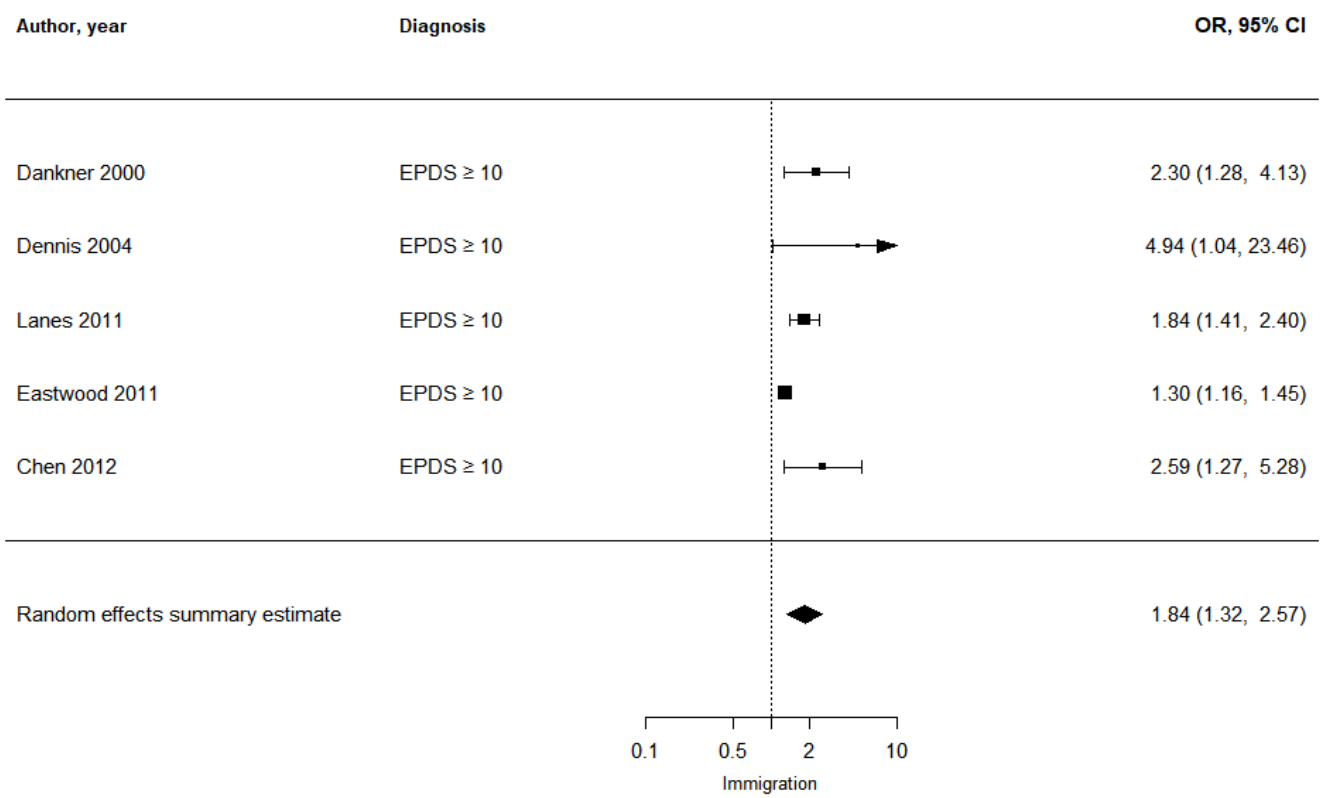
3) P curve analysis plot



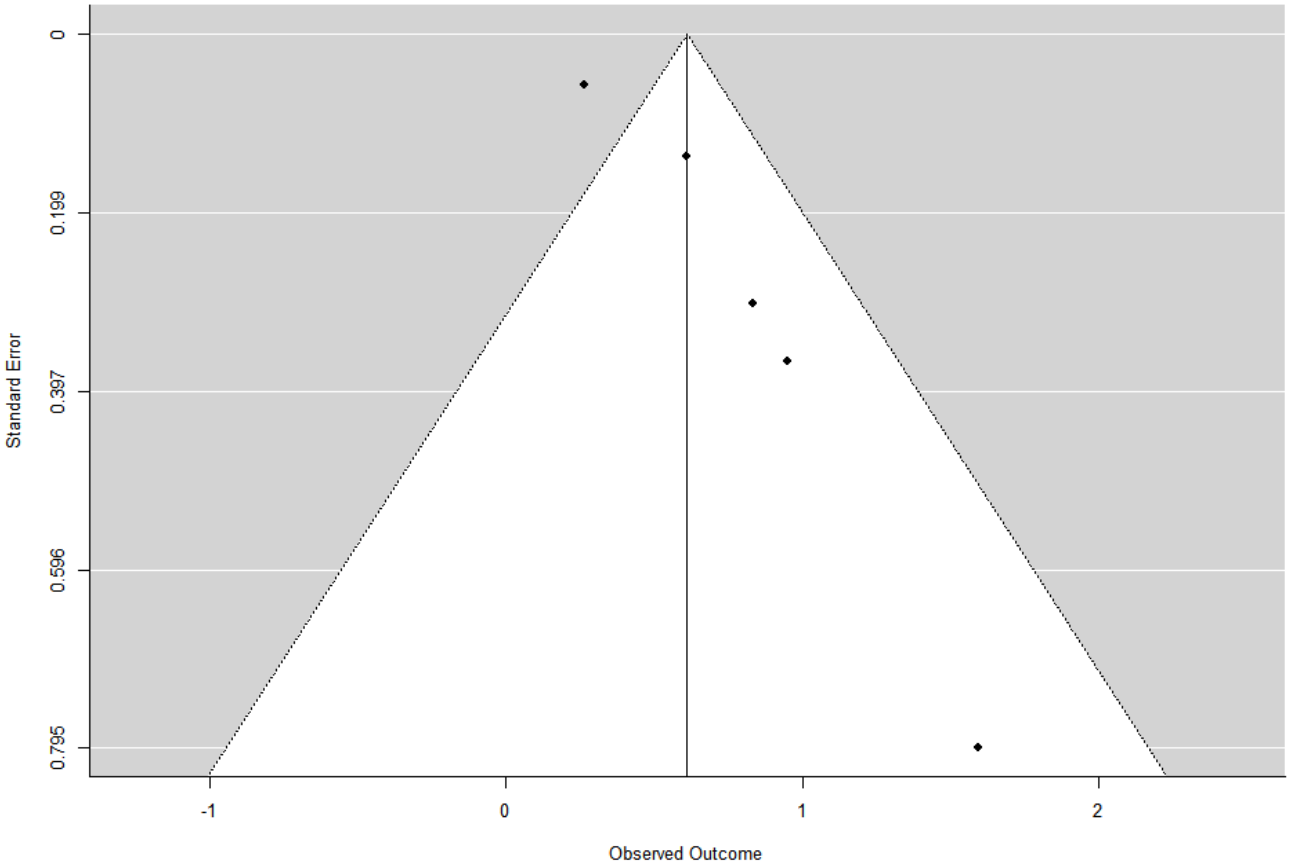
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 3 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S16. Immigration (Forest plot, funnel plot, p curve analysis plot)

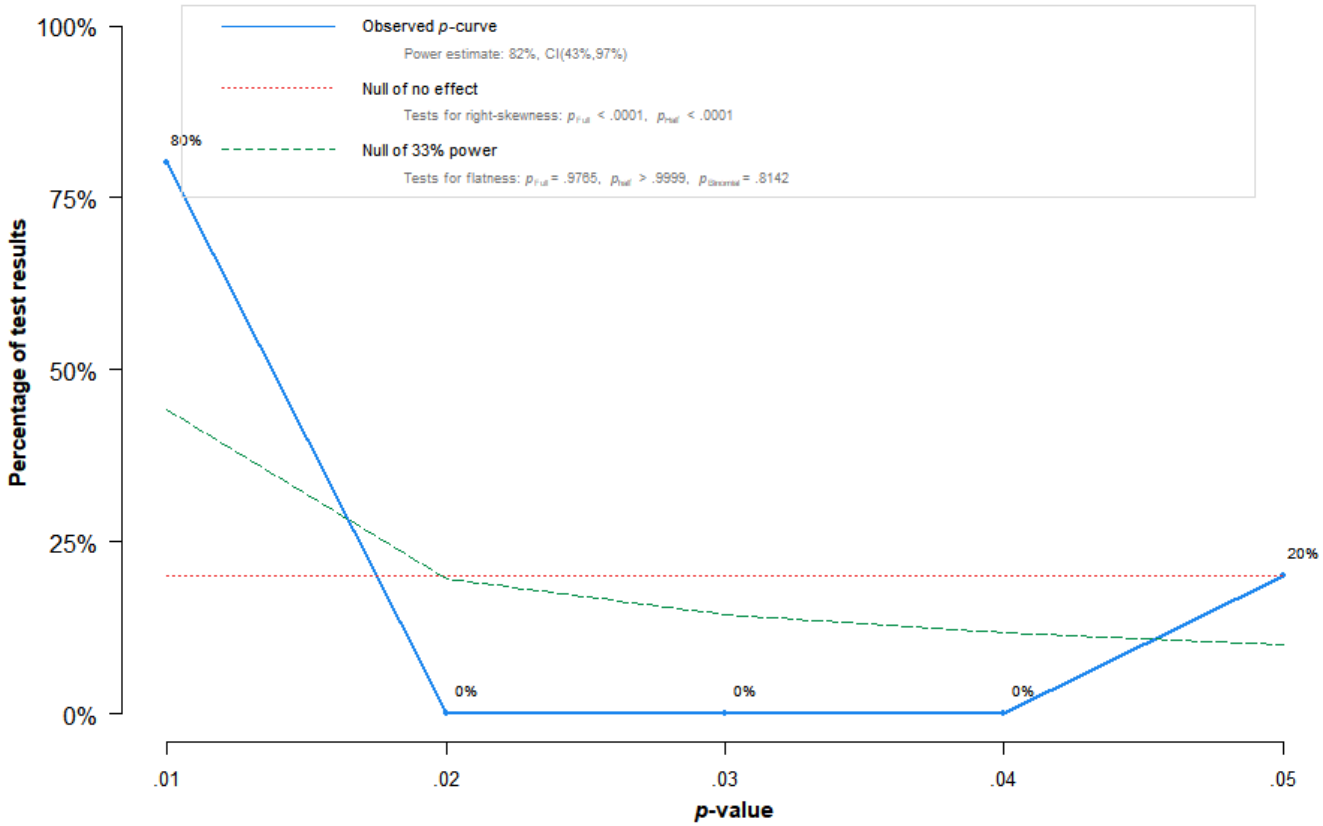
1) Forest plot



2) Funnel plot



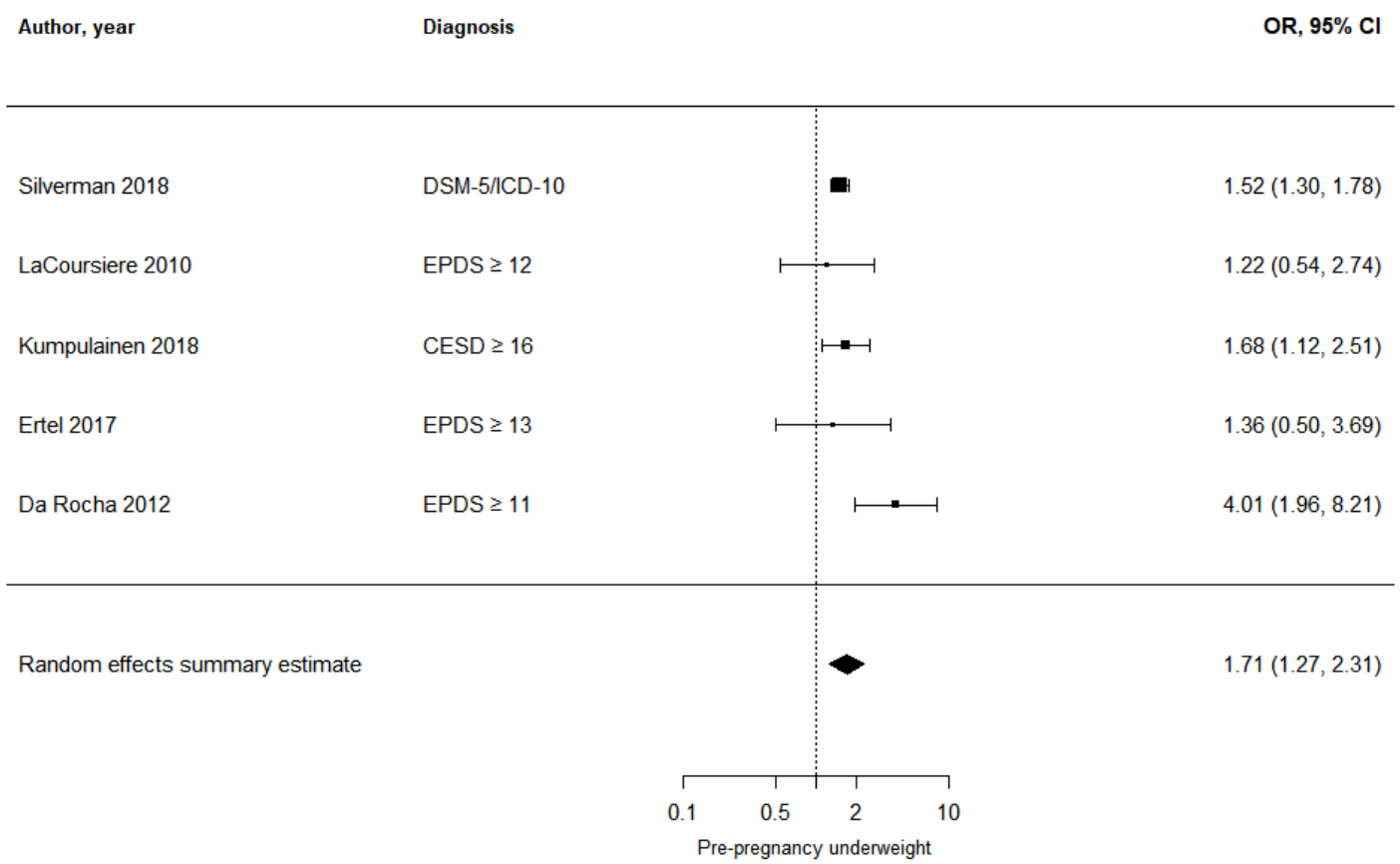
3) P curve analysis plot



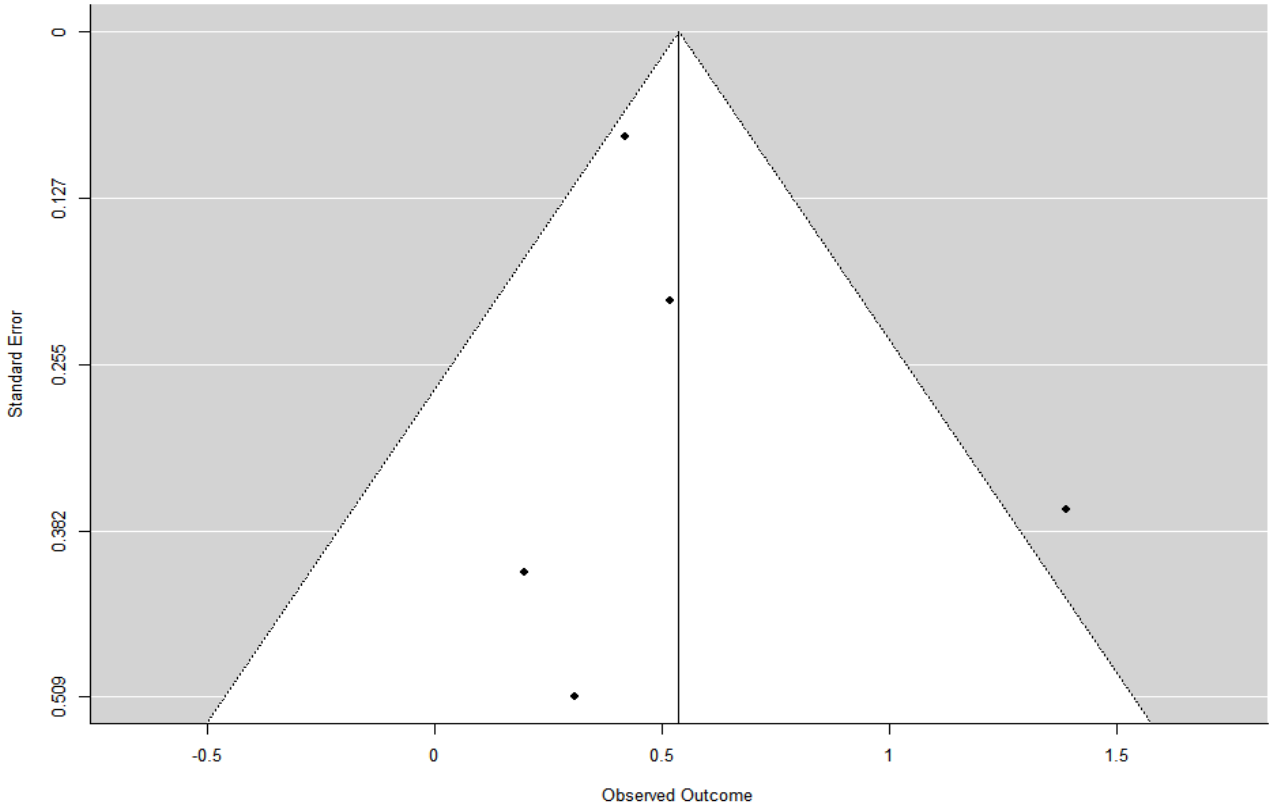
Note: The observed p-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were no non-significant results entered.

Figure S17. Pre-pregnancy underweight (Forest plot, funnel plot, p curve analysis plot)

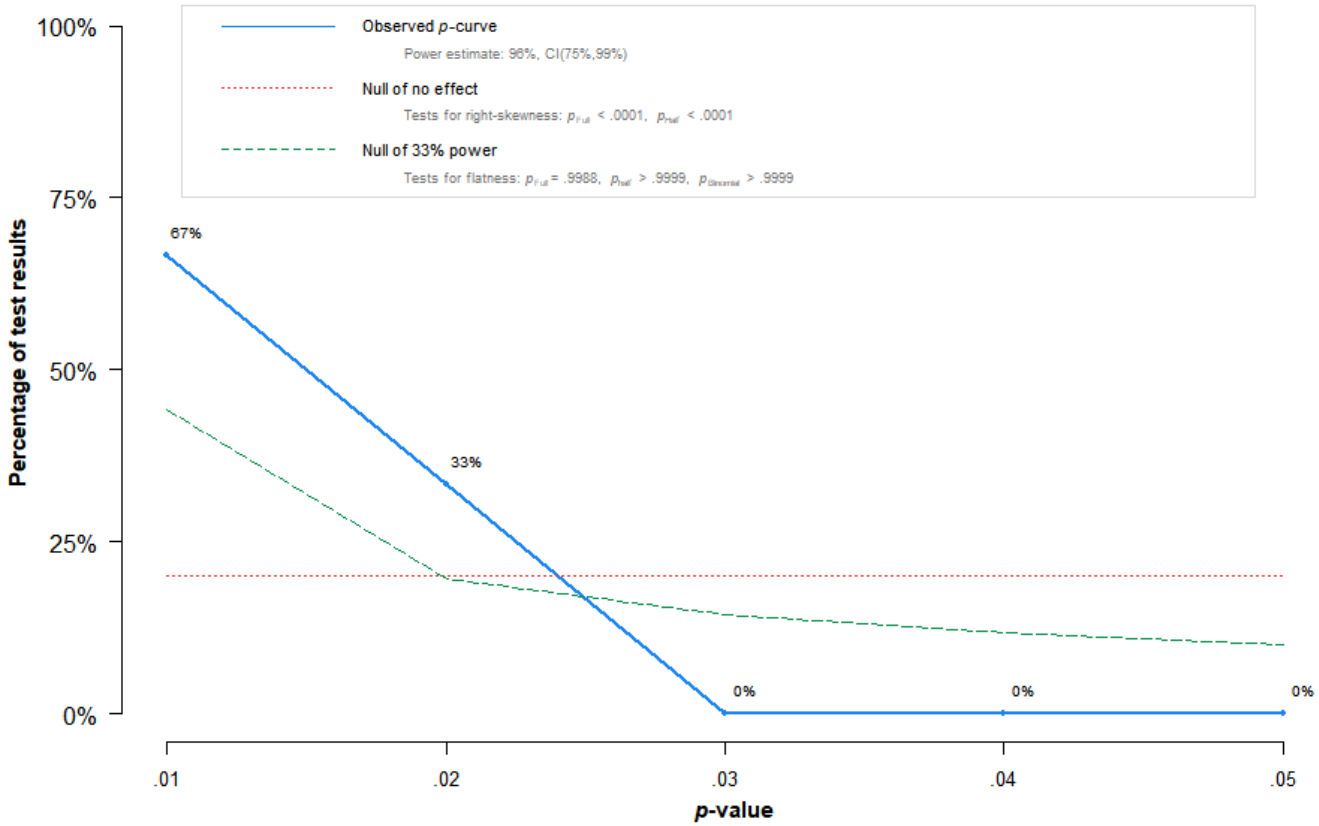
1) Forest plot



2) Funnel plot



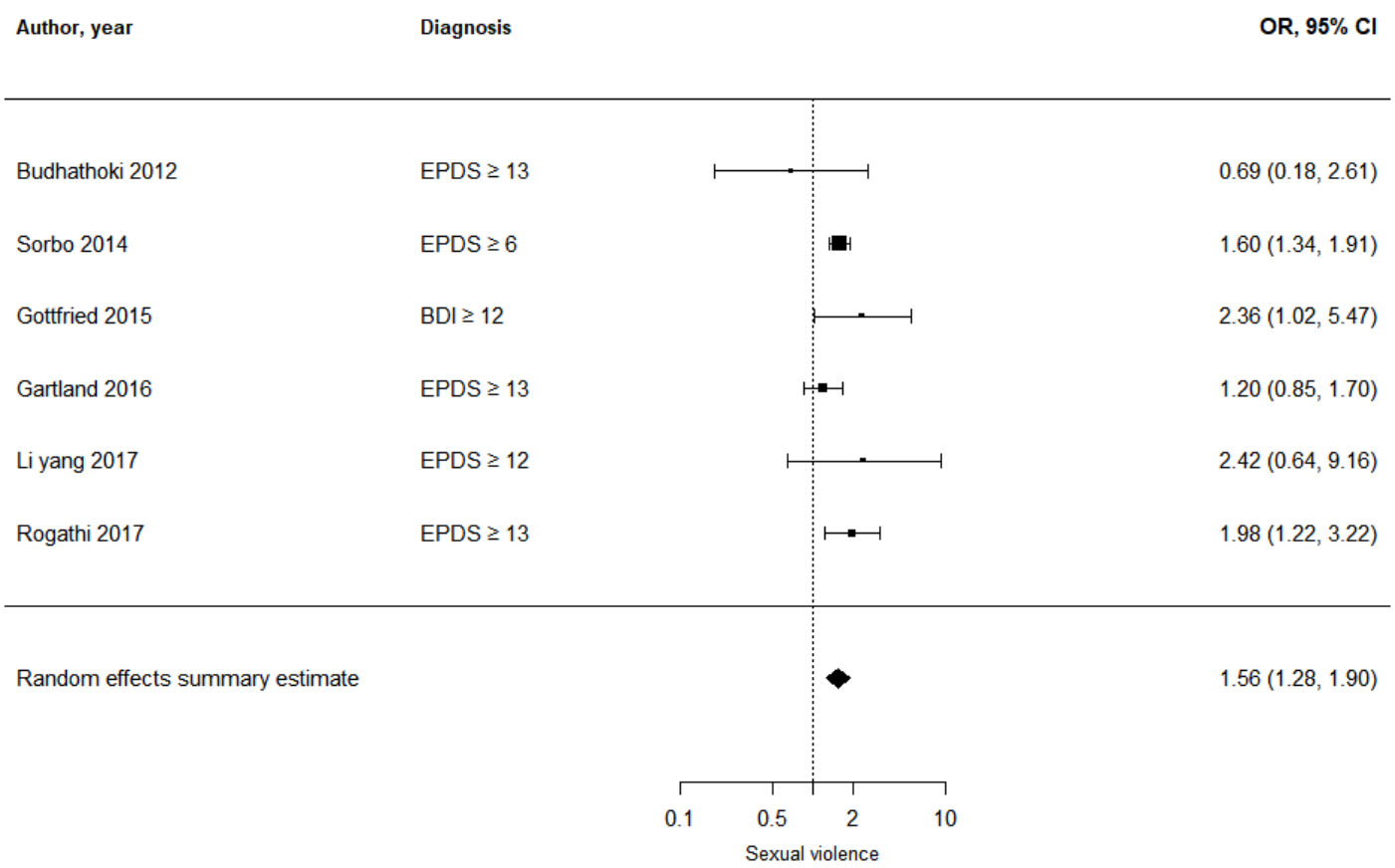
3) P curve analysis plot



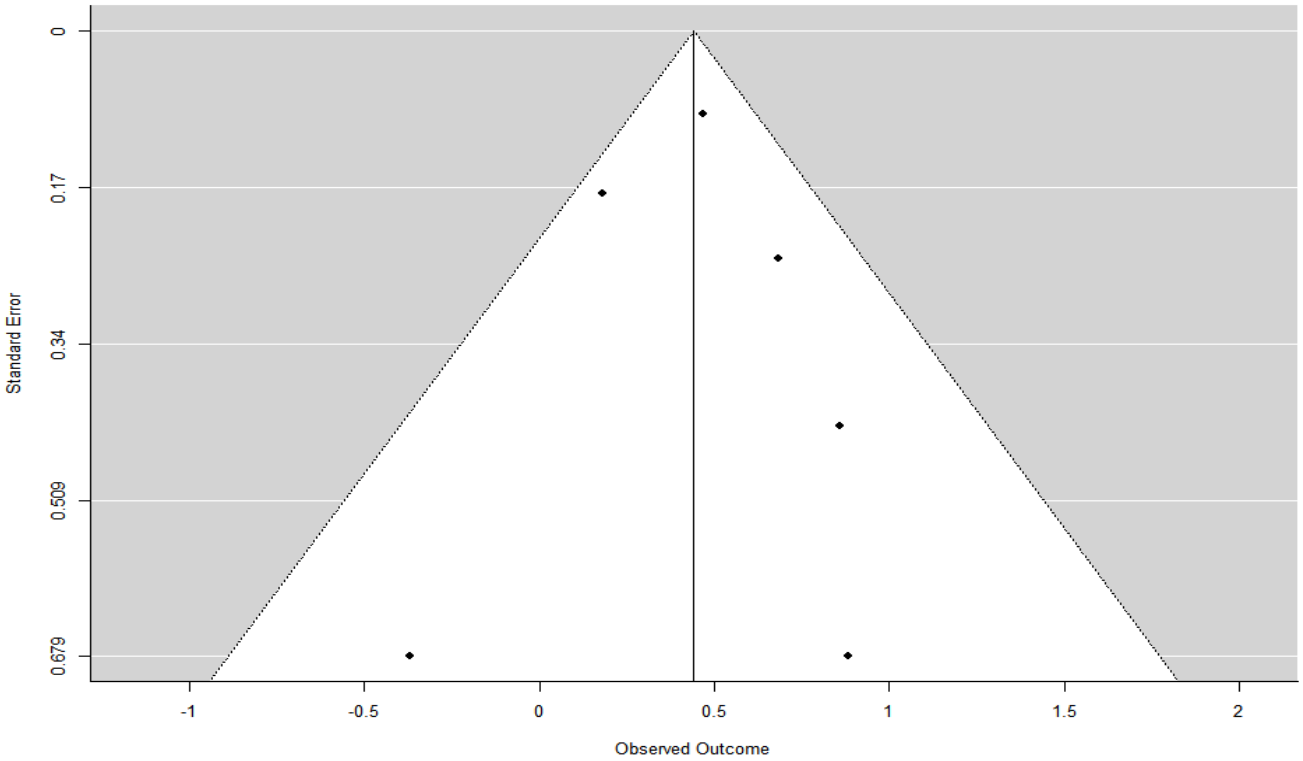
Note: The observed *p*-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were 2 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S18. Sexual violence (Forest plot, funnel plot, p curve analysis plot)

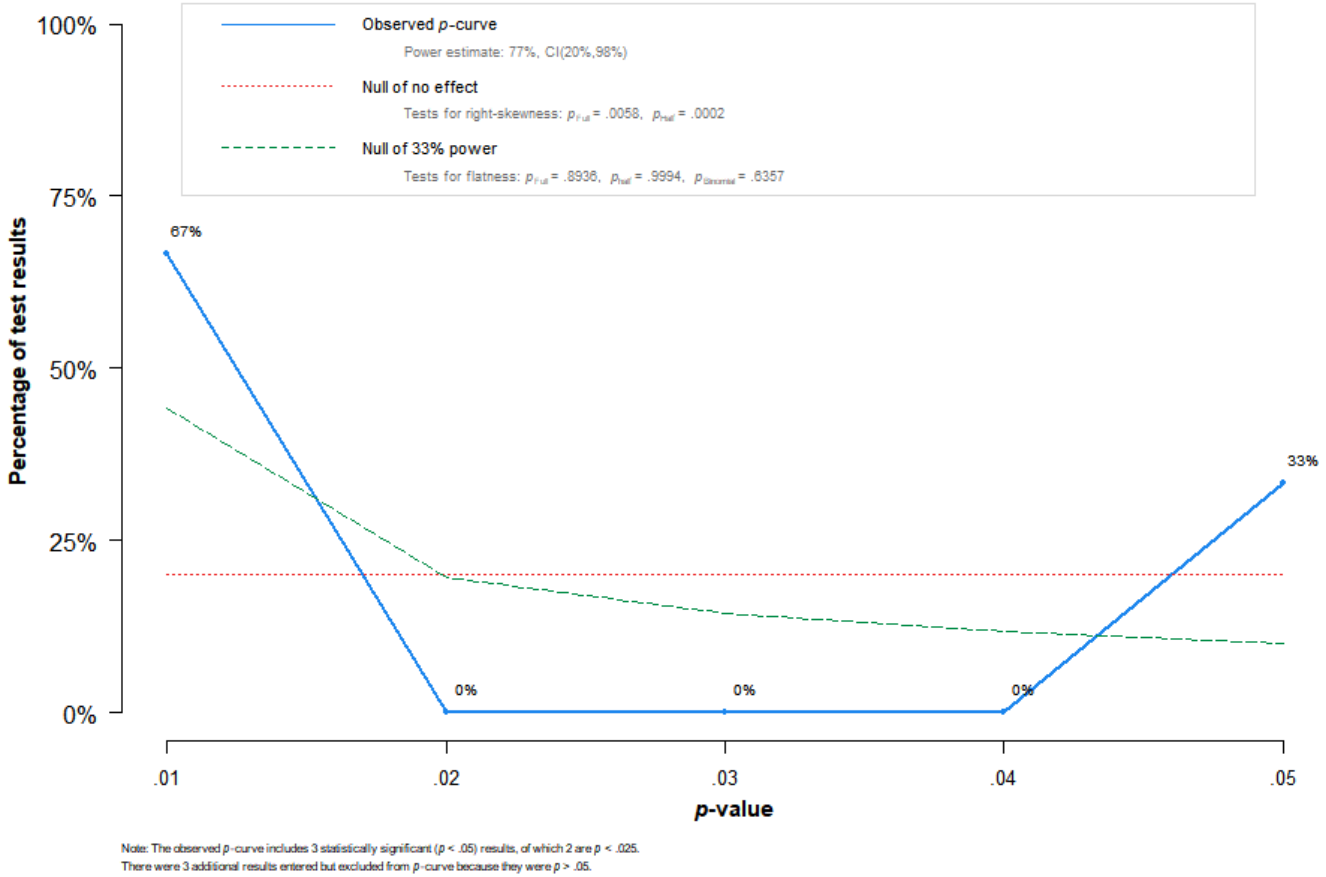
1) Forest plot



2) Funnel plot


Standard Error
0
0.17
0.34
0.509
0.679
-1
-0.5
0
0.5
1
1.5
2
Observed Outcome

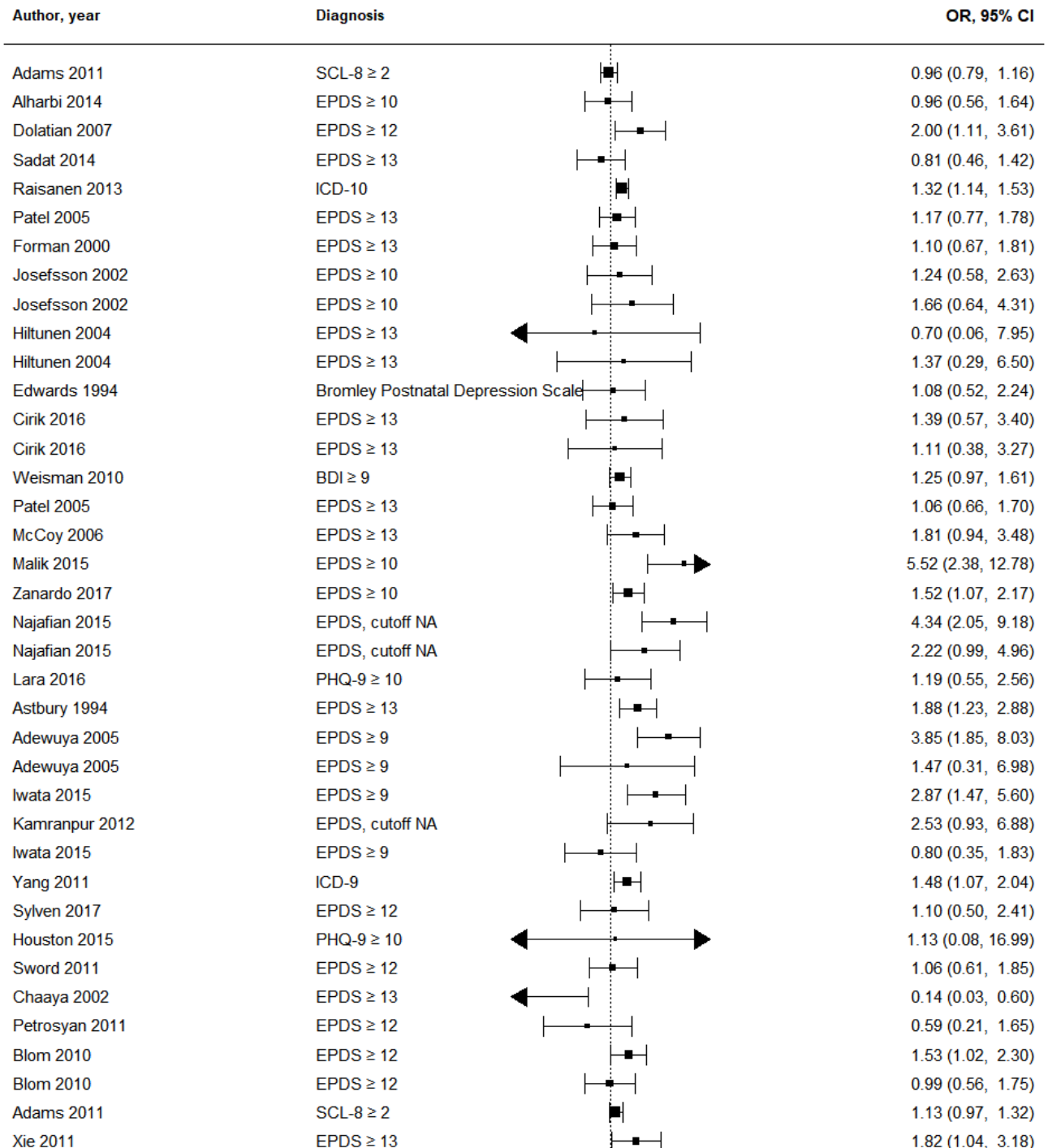
3) P curve analysis plot



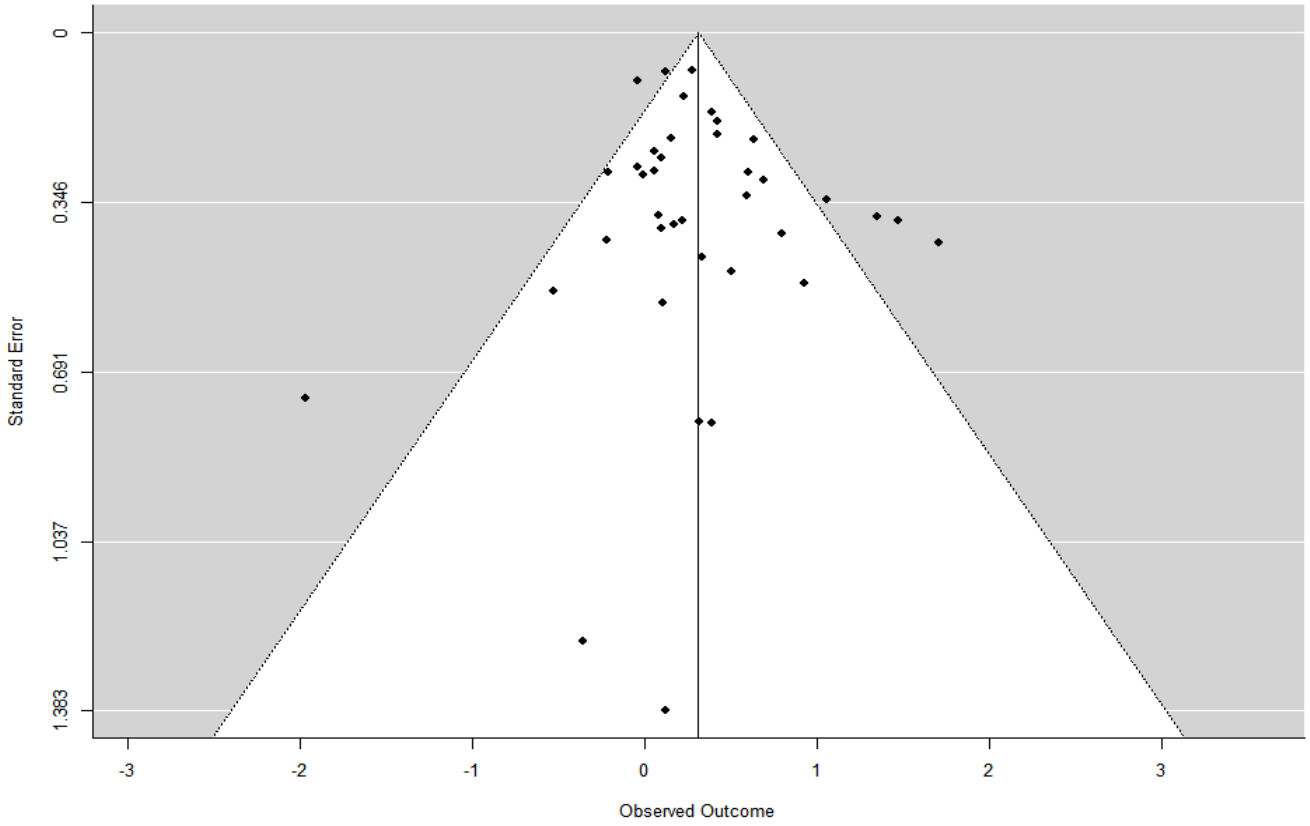
Note: The observed p-curve includes 3 statistically significant ($p < .05$) results, of which 2 are $p < .025$.
There were 3 additional results entered but excluded from p-curve because they were $p > .05$.

Figure S19. Cesarean section (Forest plot, funnel plot, p curve analysis plot)

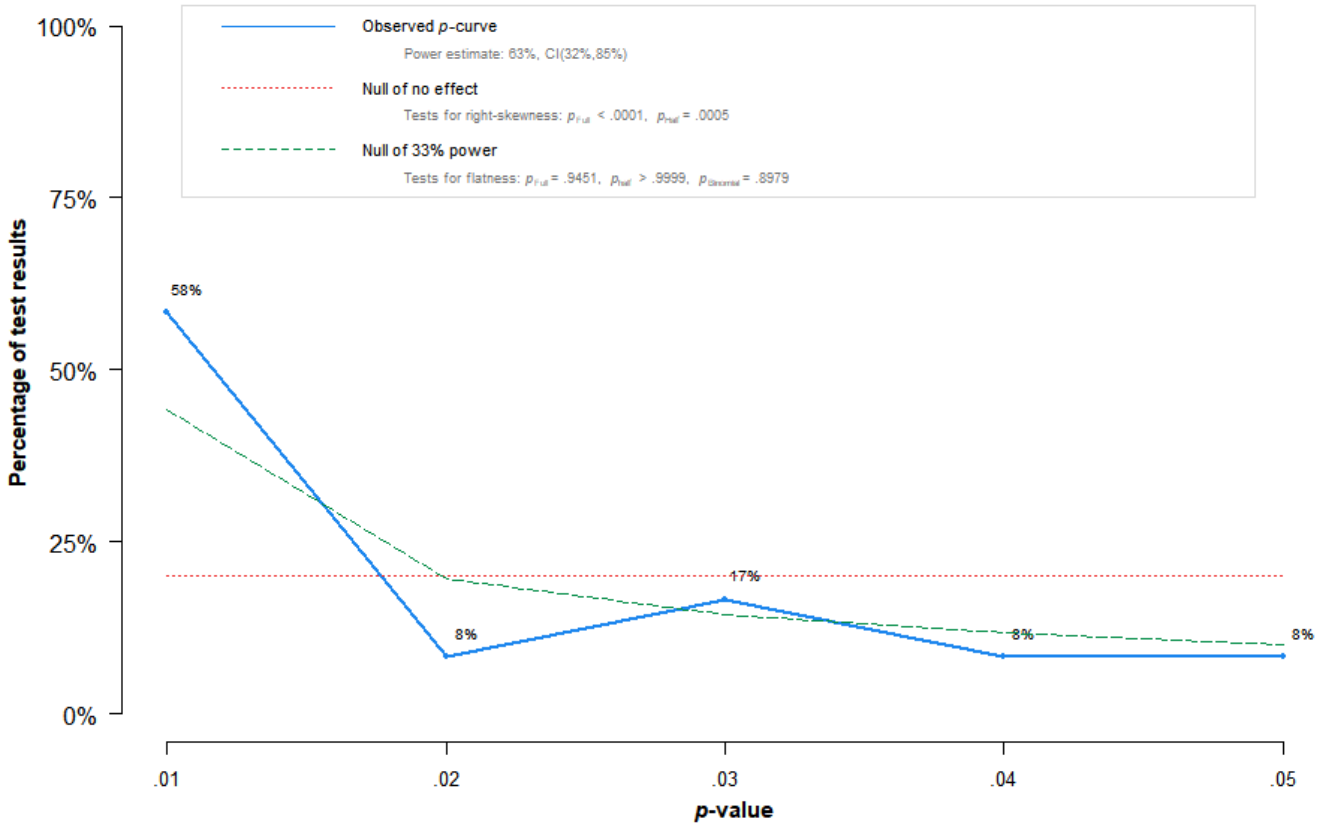
1) Forest plot


Author, year
Diagnosis
OR, 95% CI
Adams 2011 SCL-8 ≥ 2 0.96 (0.79, 1.16)
Alharbi 2014 EPDS ≥ 10 0.96 (0.56, 1.64)
Dolatian 2007 EPDS ≥ 12 2.00 (1.11, 3.61)
Sadat 2014 EPDS ≥ 13 0.81 (0.46, 1.42)
Raisanen 2013 ICD-10 1.32 (1.14, 1.53)
Patel 2005 EPDS ≥ 13 1.17 (0.77, 1.78)
Forman 2000 EPDS ≥ 13 1.10 (0.67, 1.81)
Josefsson 2002 EPDS ≥ 10 1.24 (0.58, 2.63)
Josefsson 2002 EPDS ≥ 10 1.66 (0.64, 4.31)
Hiltunen 2004 EPDS ≥ 13 0.70 (0.06, 7.95)
Hiltunen 2004 EPDS ≥ 13 1.37 (0.29, 6.50)
Edwards 1994 Bromley Postnatal Depression Scale 1.08 (0.52, 2.24)
Cirik 2016 EPDS ≥ 13 1.39 (0.57, 3.40)
Cirik 2016 EPDS ≥ 13 1.11 (0.38, 3.27)
Weisman 2010 BDI ≥ 9 1.25 (0.97, 1.61)
Patel 2005 EPDS ≥ 13 1.06 (0.66, 1.70)
McCoy 2006 EPDS ≥ 13 1.81 (0.94, 3.48)
Malik 2015 EPDS ≥ 10 5.52 (2.38, 12.78)
Zanardo 2017 EPDS ≥ 10 1.52 (1.07, 2.17)
Najafian 2015 EPDS, cutoff NA 4.34 (2.05, 9.18)
Najafian 2015 EPDS, cutoff NA 2.22 (0.99, 4.96)
Lara 2016 PHQ-9 ≥ 10 1.19 (0.55, 2.56)
Astbury 1994 EPDS ≥ 13 1.88 (1.23, 2.88)
Adewuya 2005 EPDS ≥ 9 3.85 (1.85, 8.03)
Adewuya 2005 EPDS ≥ 9 1.47 (0.31, 6.98)
Iwata 2015 EPDS ≥ 9 2.87 (1.47, 5.60)
Kamranpur 2012 EPDS, cutoff NA 2.53 (0.93, 6.88)
Iwata 2015 EPDS ≥ 9 0.80 (0.35, 1.83)
Yang 2011 ICD-9 1.48 (1.07, 2.04)
Sylven 2017 EPDS ≥ 12 1.10 (0.50, 2.41)
Houston 2015 PHQ-9 ≥ 10 1.13 (0.08, 16.99)
Sword 2011 EPDS ≥ 12 1.06 (0.61, 1.85)
Chaaya 2002 EPDS ≥ 13 0.14 (0.03, 0.60)
Petrosyan 2011 EPDS ≥ 12 0.59 (0.21, 1.65)
Blom 2010 EPDS ≥ 12 1.53 (1.02, 2.30)
Blom 2010 EPDS ≥ 12 0.99 (0.56, 1.75)
Adams 2011 SCL-8 ≥ 2 1.13 (0.97, 1.32)
Xie 2011 EPDS ≥ 13 1.82 (1.04, 3.18)

2) Funnel plot



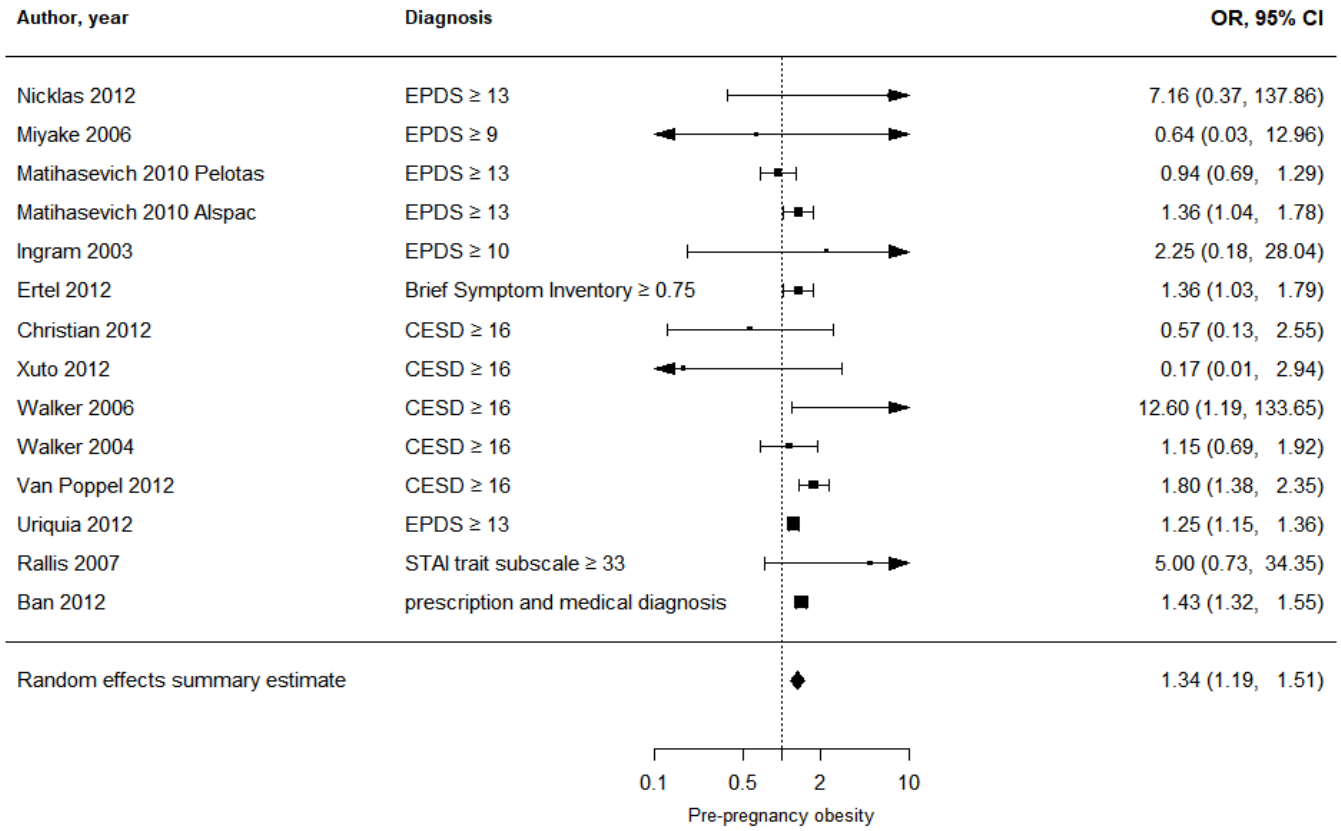
3) P curve analysis plot



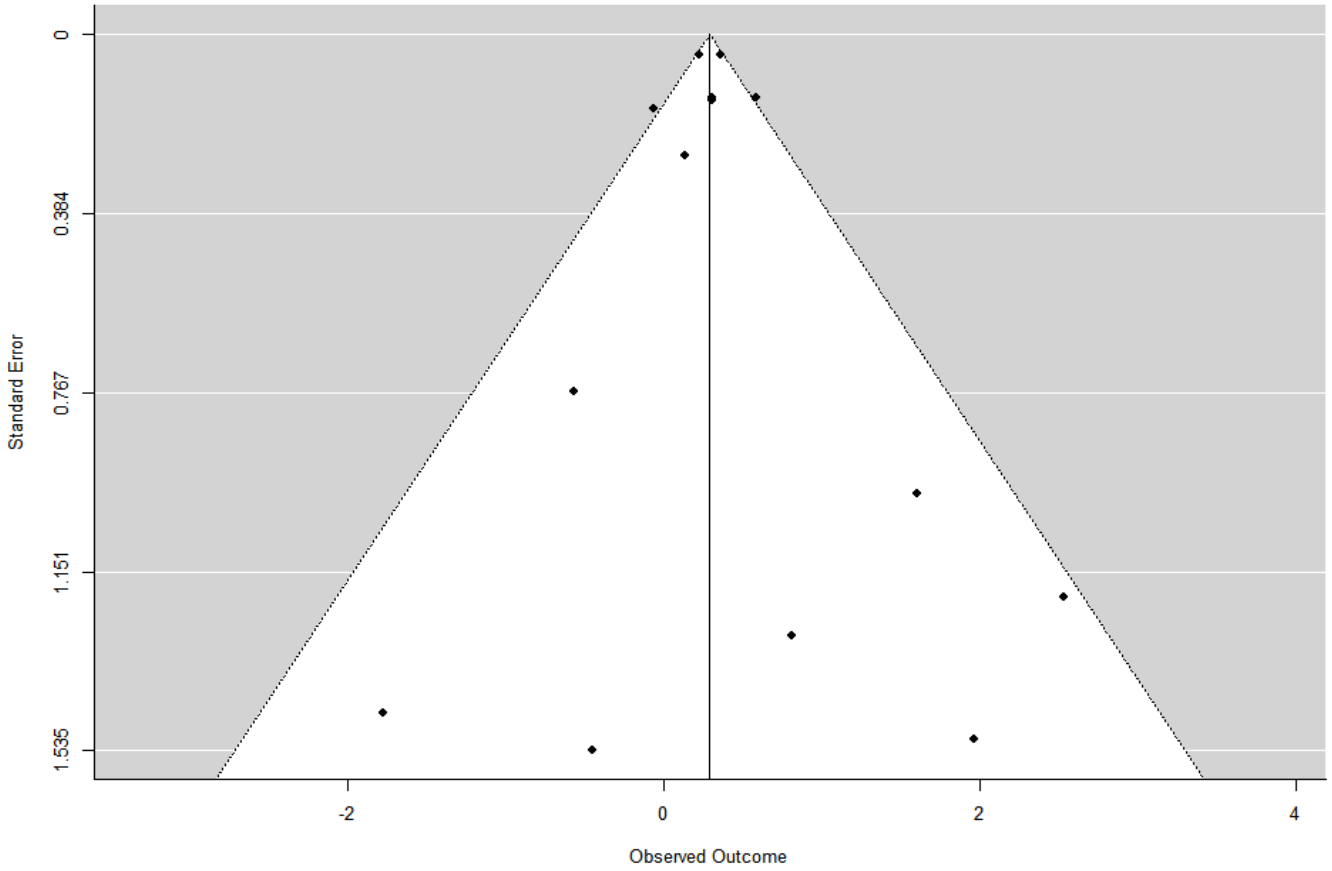
Note: The observed *p*-curve includes 12 statistically significant ($p < .05$) results, of which 10 are $p < .025$.
There were 26 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S20. Pre-pregnancy obesity (Forest plot, funnel plot, p curve analysis plot)

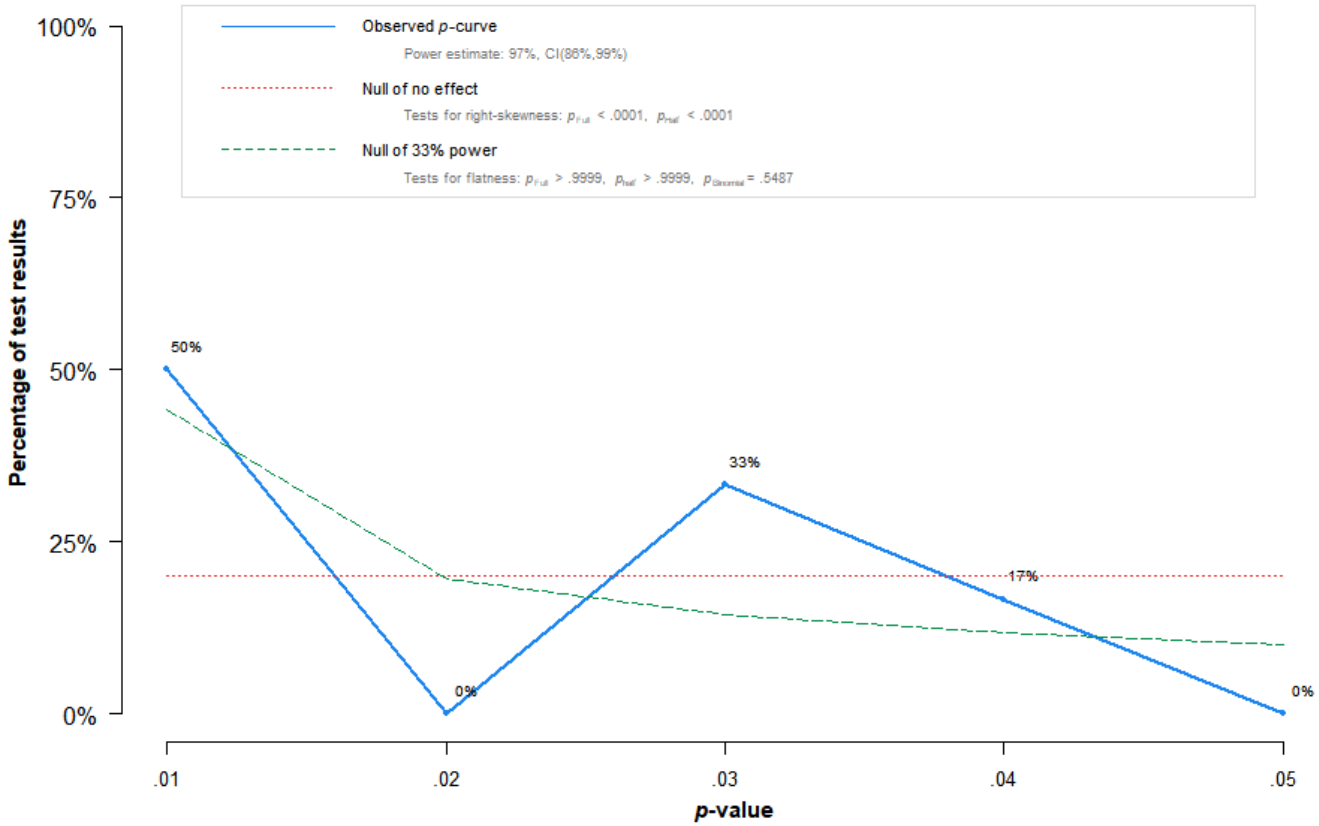
1) Forest plot



2) Funnel plot



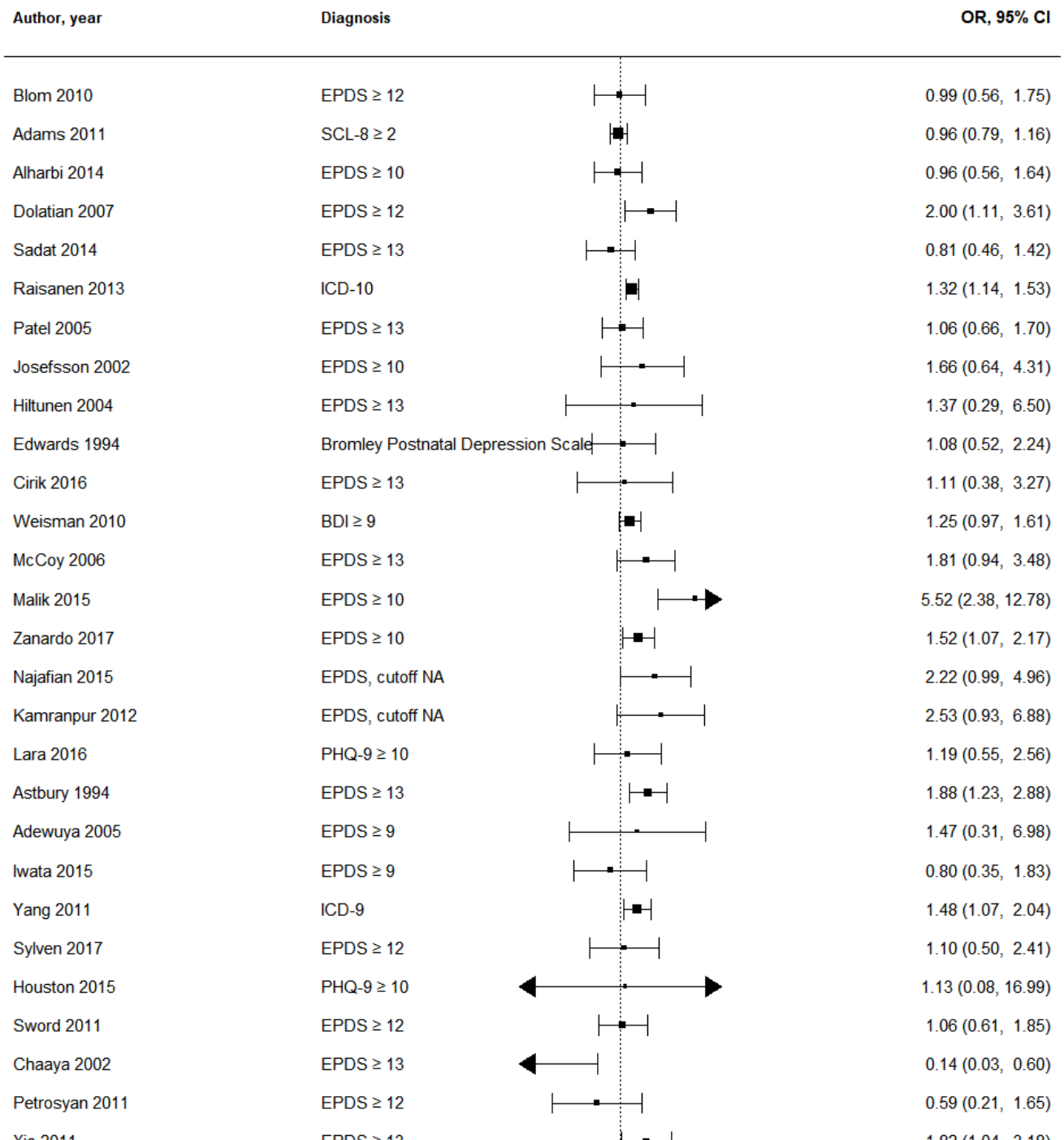
3) P curve analysis plot



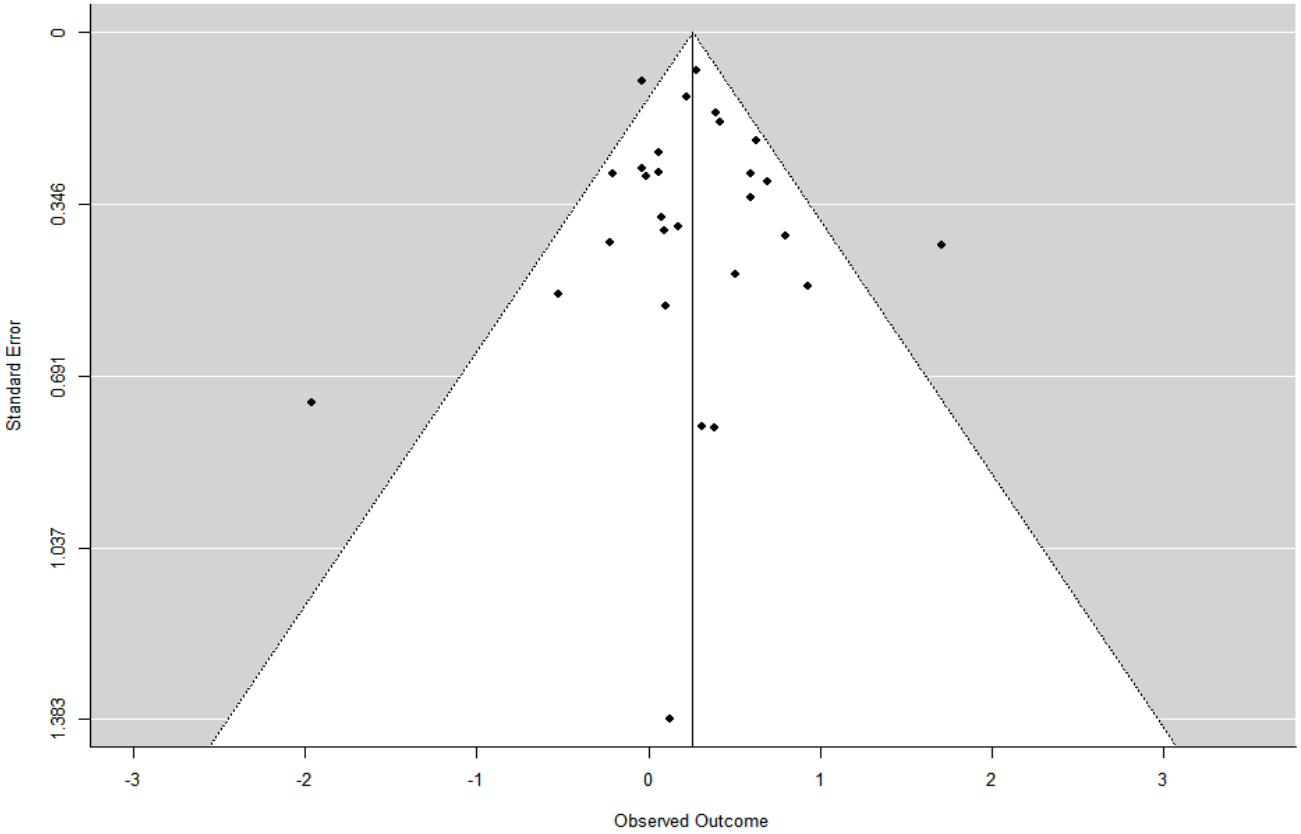
Note: The observed *p*-curve includes 6 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 8 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S21. Elective cesarean section (Forest plot, funnel plot, p curve analysis plot)

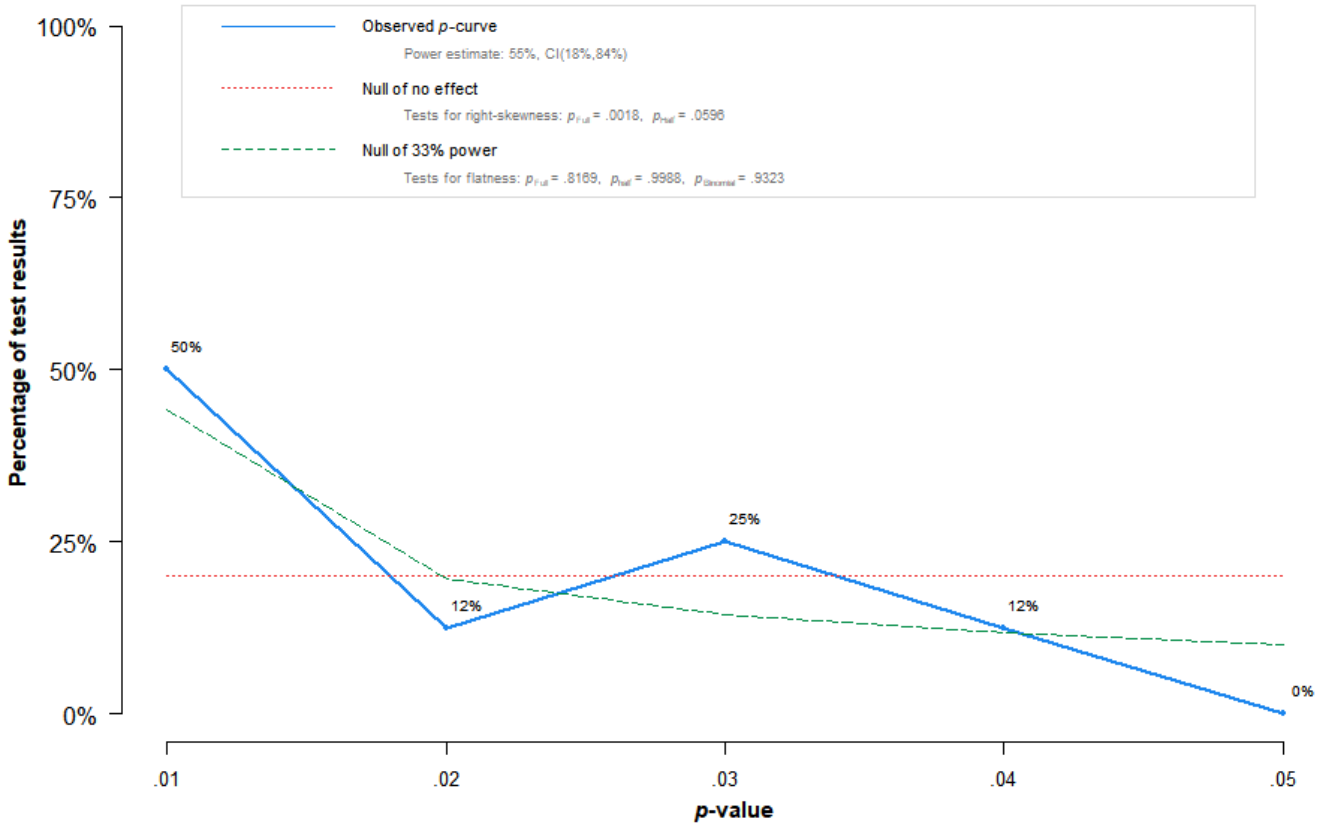
1) Forest plot


Author, year
Diagnosis
OR, 95% CI
Blom 2010
EPDS ≥ 12
0.99 (0.56, 1.75)
Adams 2011
SCL-8 ≥ 2
0.96 (0.79, 1.16)
Alharbi 2014
EPDS ≥ 10
0.96 (0.56, 1.64)
Dolatian 2007
EPDS ≥ 12
2.00 (1.11, 3.61)
Sadat 2014
EPDS ≥ 13
0.81 (0.46, 1.42)
Raisanen 2013
ICD-10
1.32 (1.14, 1.53)
Patel 2005
EPDS ≥ 13
1.06 (0.66, 1.70)
Josefsson 2002
EPDS ≥ 10
1.66 (0.64, 4.31)
Hiltunen 2004
EPDS ≥ 13
1.37 (0.29, 6.50)
Edwards 1994
Bromley Postnatal Depression Scale
1.08 (0.52, 2.24)
Cirik 2016
EPDS ≥ 13
1.11 (0.38, 3.27)
Weisman 2010
BDI ≥ 9
1.25 (0.97, 1.61)
McCoy 2006
EPDS ≥ 13
1.81 (0.94, 3.48)
Malik 2015
EPDS ≥ 10
5.52 (2.38, 12.78)
Zanardo 2017
EPDS ≥ 10
1.52 (1.07, 2.17)
Najafian 2015
EPDS, cutoff NA
2.22 (0.99, 4.96)
Kamranpur 2012
EPDS, cutoff NA
2.53 (0.93, 6.88)
Lara 2016
PHQ-9 ≥ 10
1.19 (0.55, 2.56)
Astbury 1994
EPDS ≥ 13
1.88 (1.23, 2.88)
Adewuya 2005
EPDS ≥ 9
1.47 (0.31, 6.98)
Iwata 2015
EPDS ≥ 9
0.80 (0.35, 1.83)
Yang 2011
ICD-9
1.48 (1.07, 2.04)
Sylven 2017
EPDS ≥ 12
1.10 (0.50, 2.41)
Houston 2015
PHQ-9 ≥ 10
1.13 (0.08, 16.99)
Sword 2011
EPDS ≥ 12
1.06 (0.61, 1.85)
Chaaya 2002
EPDS ≥ 13
0.14 (0.03, 0.60)
Petrosyan 2011
EPDS ≥ 12
0.59 (0.21, 1.65)

2) Funnel plot



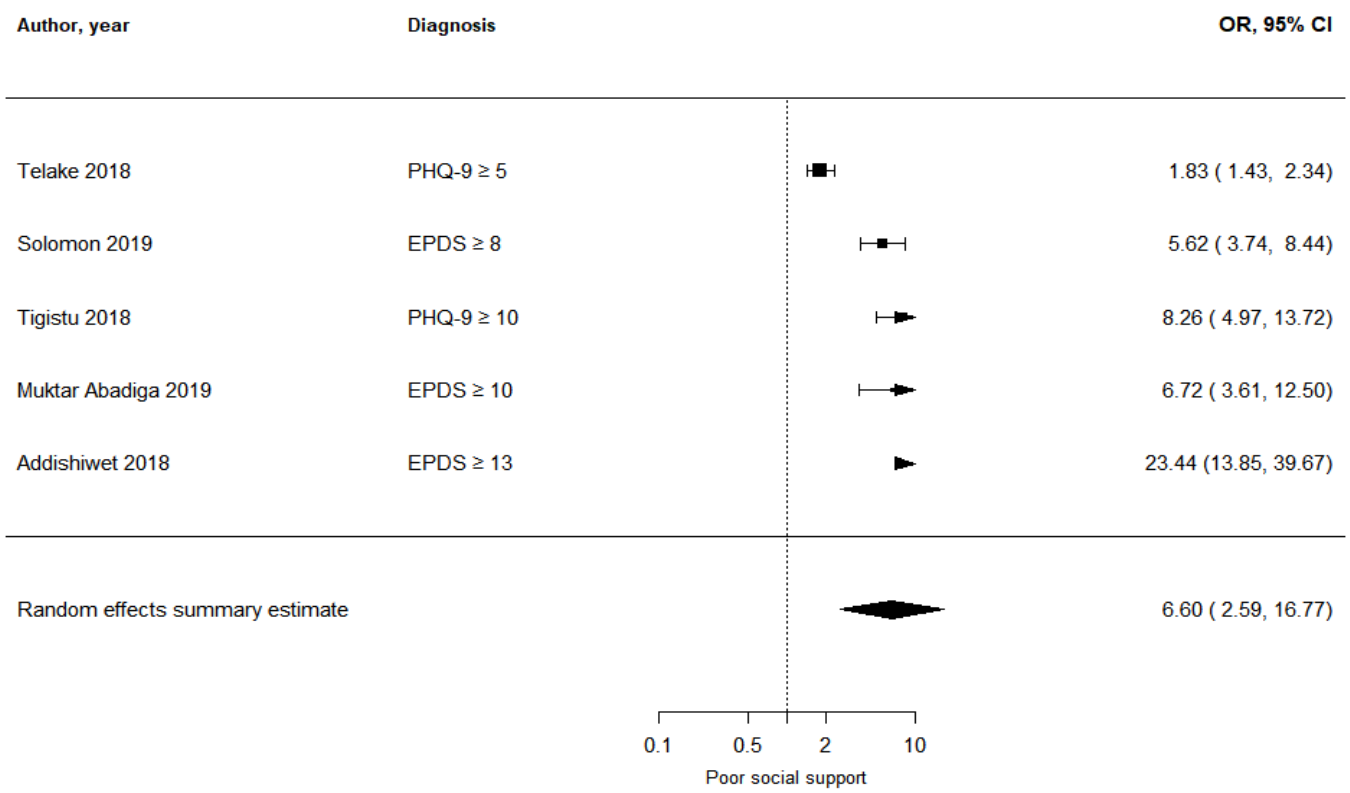
3) P curve analysis plot



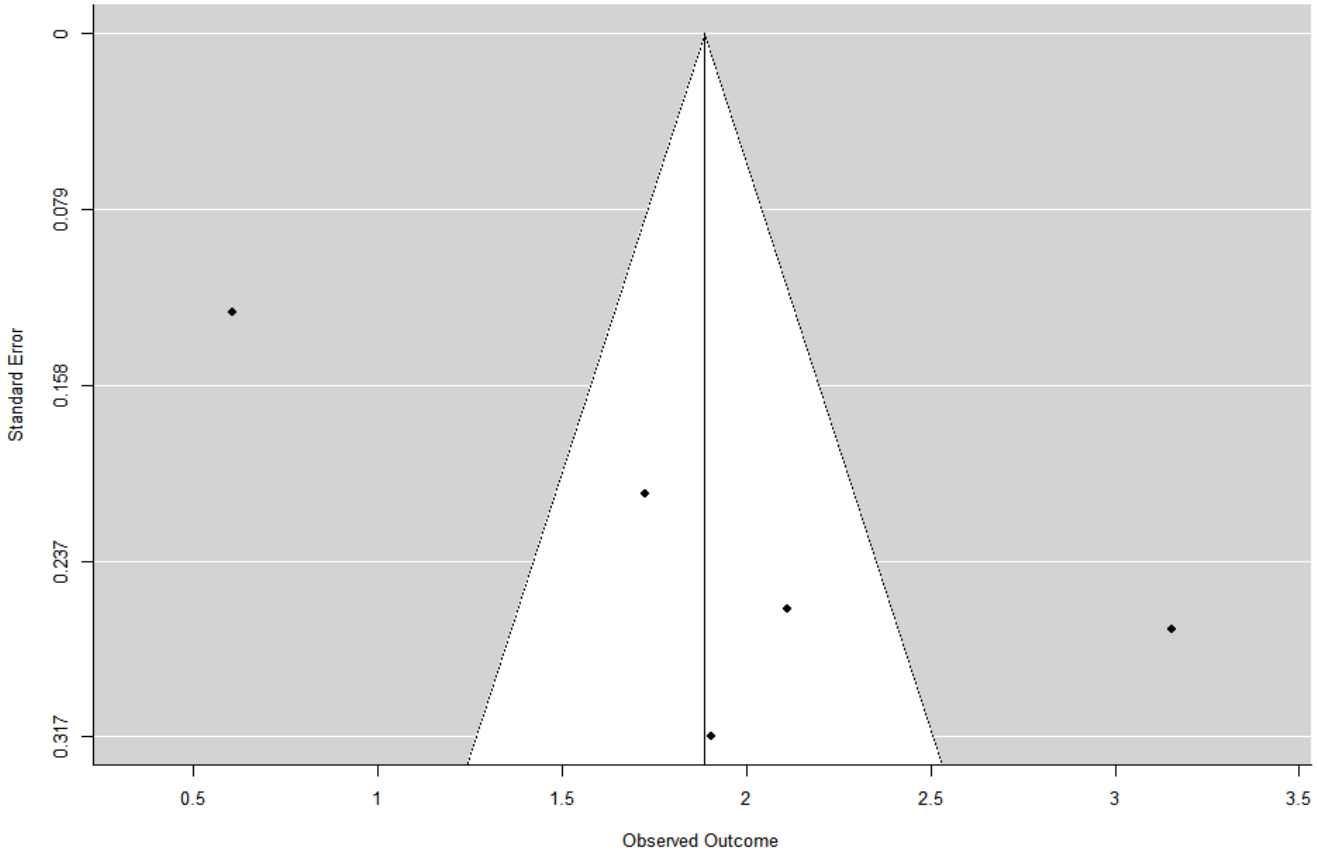
Note: The observed *p*-curve includes 8 statistically significant ($p < .05$) results, of which 7 are $p < .025$.
There were 20 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S22. Poor social support (Forest plot, funnel plot, p curve analysis plot)

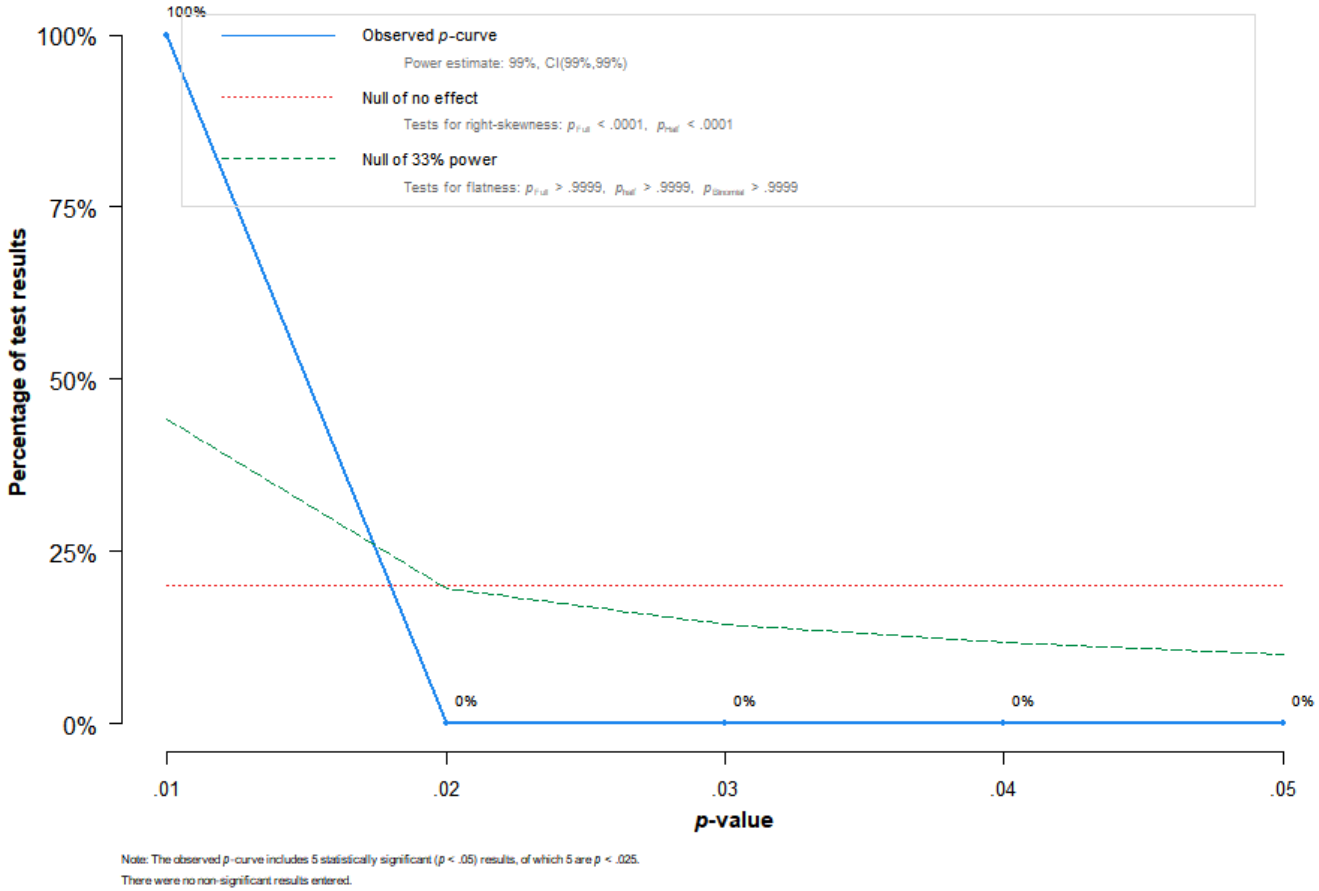
1) Forest plot



2) Funnel plot


Standard Error
0
0.079
0.158
0.237
0.317
0.5
1
1.5
2
2.5
3
3.5
Observed Outcome

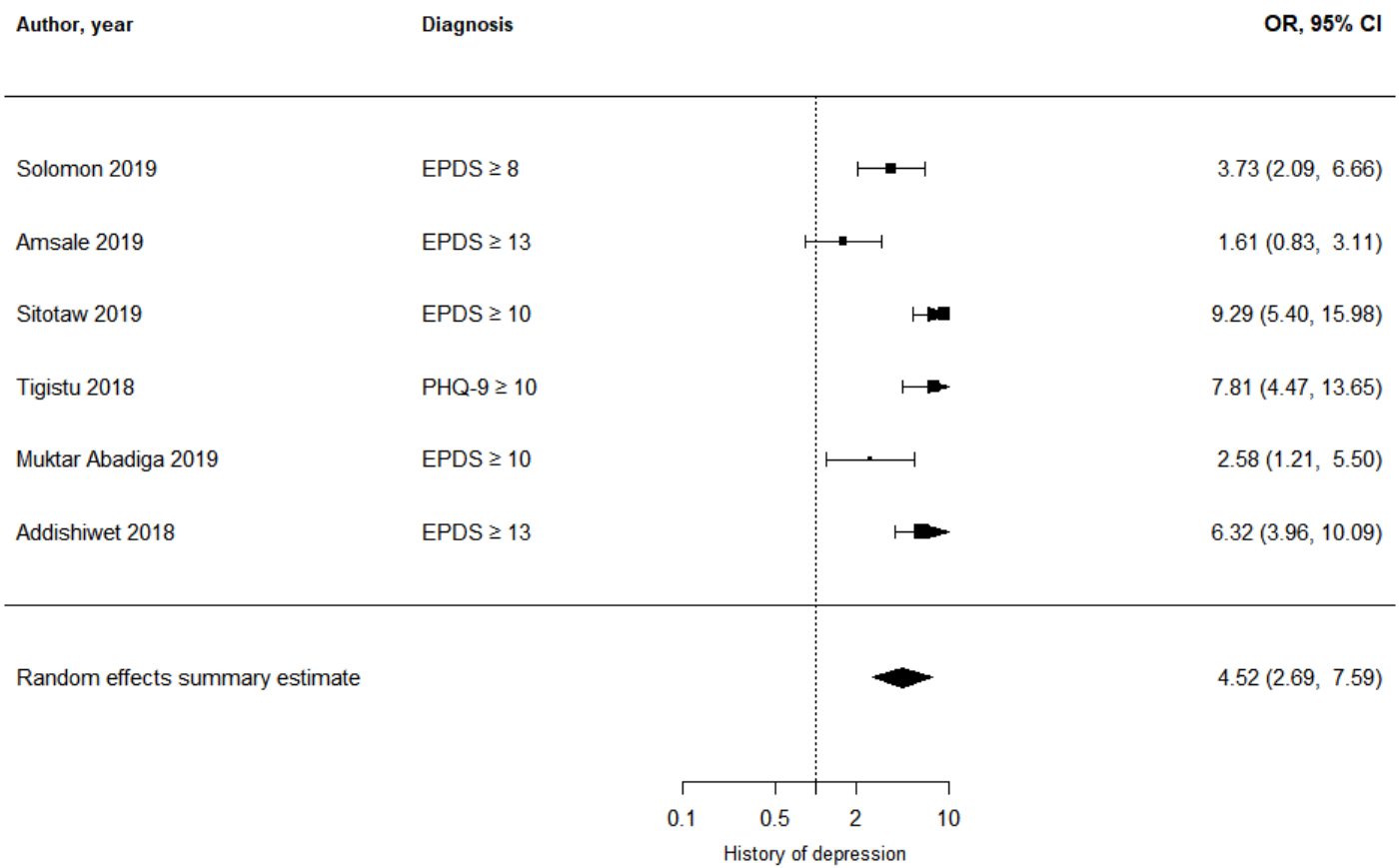
3) P curve analysis plot



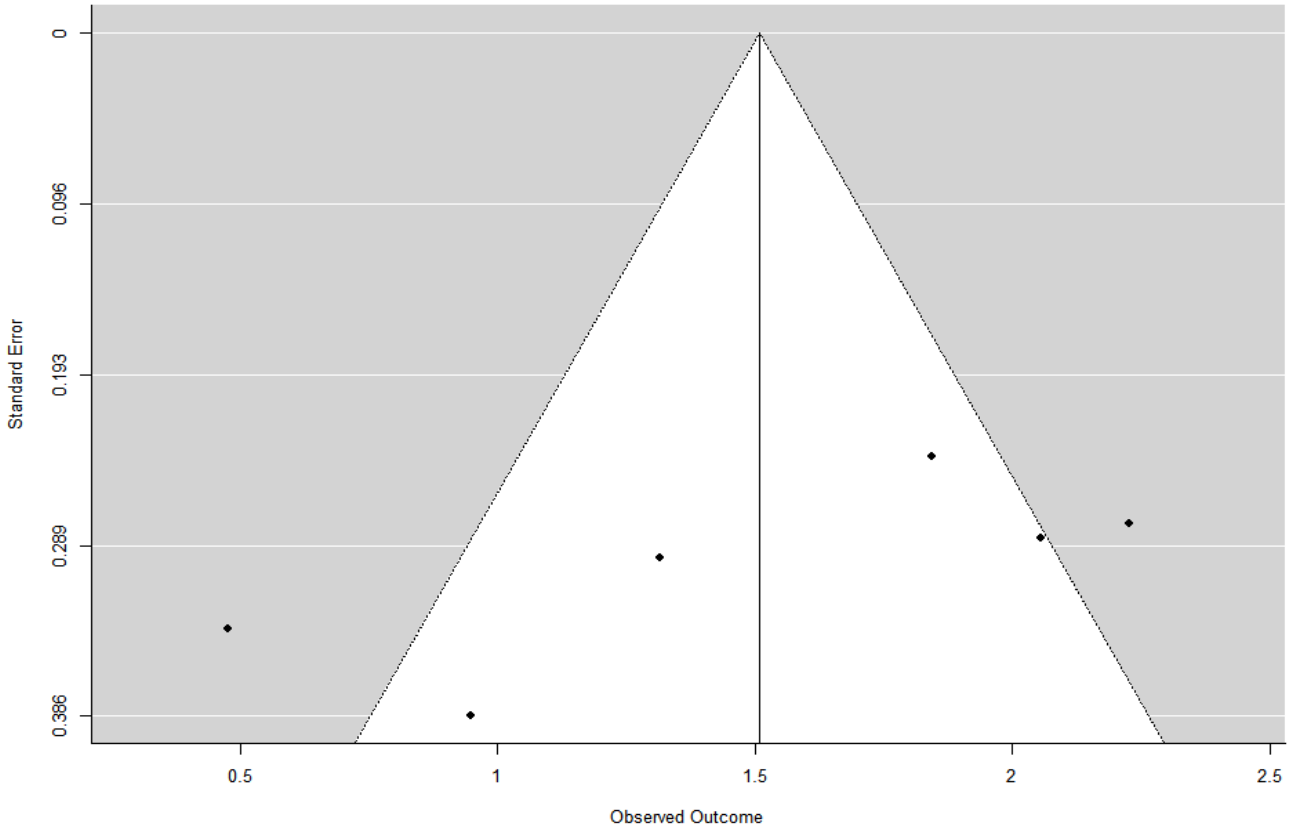
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 5 are $p < .025$.
There were no non-significant results entered.

Figure S23. History of depression (Forest plot, funnel plot, p curve analysis plot)

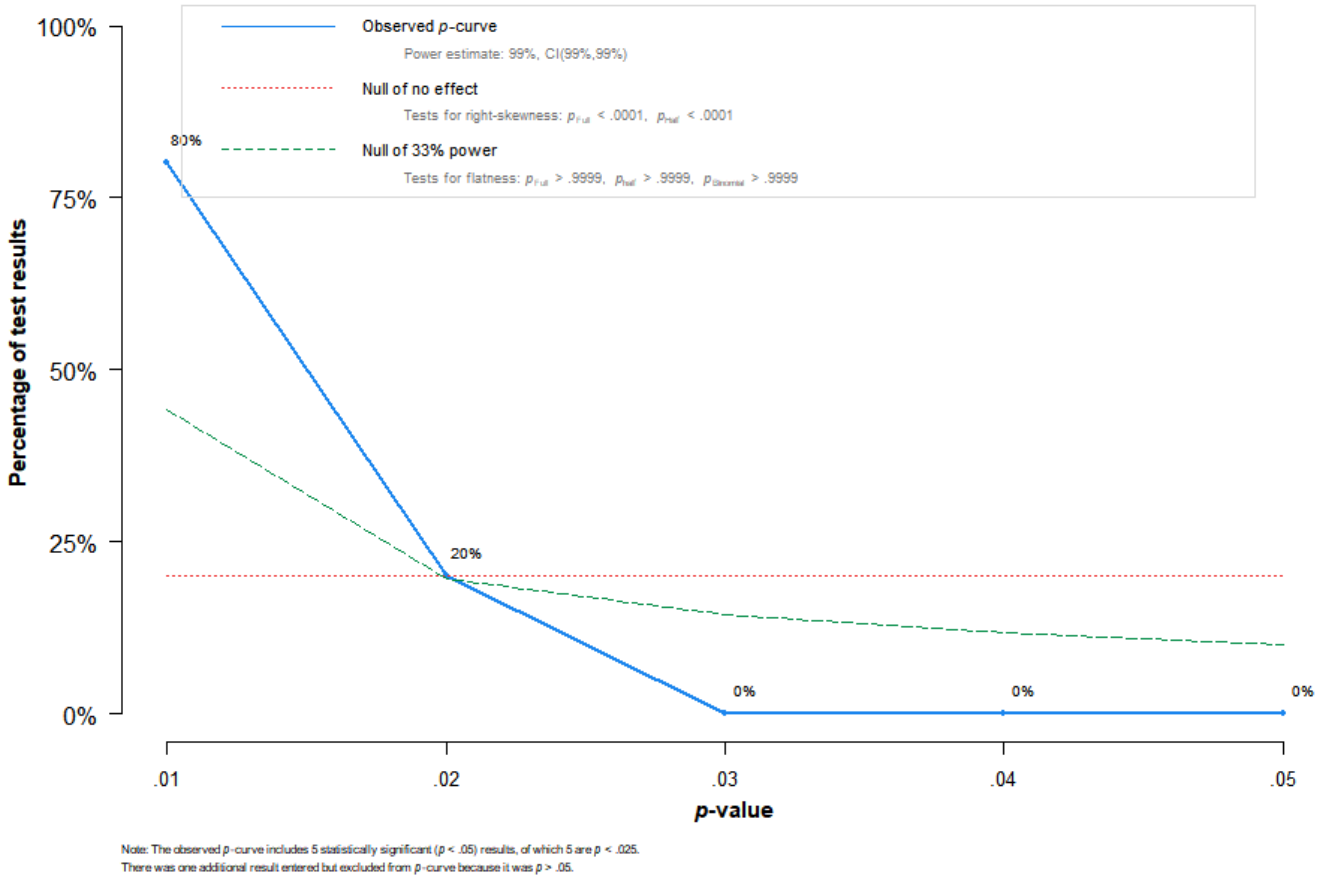
1) Forest plot



2) Funnel plot



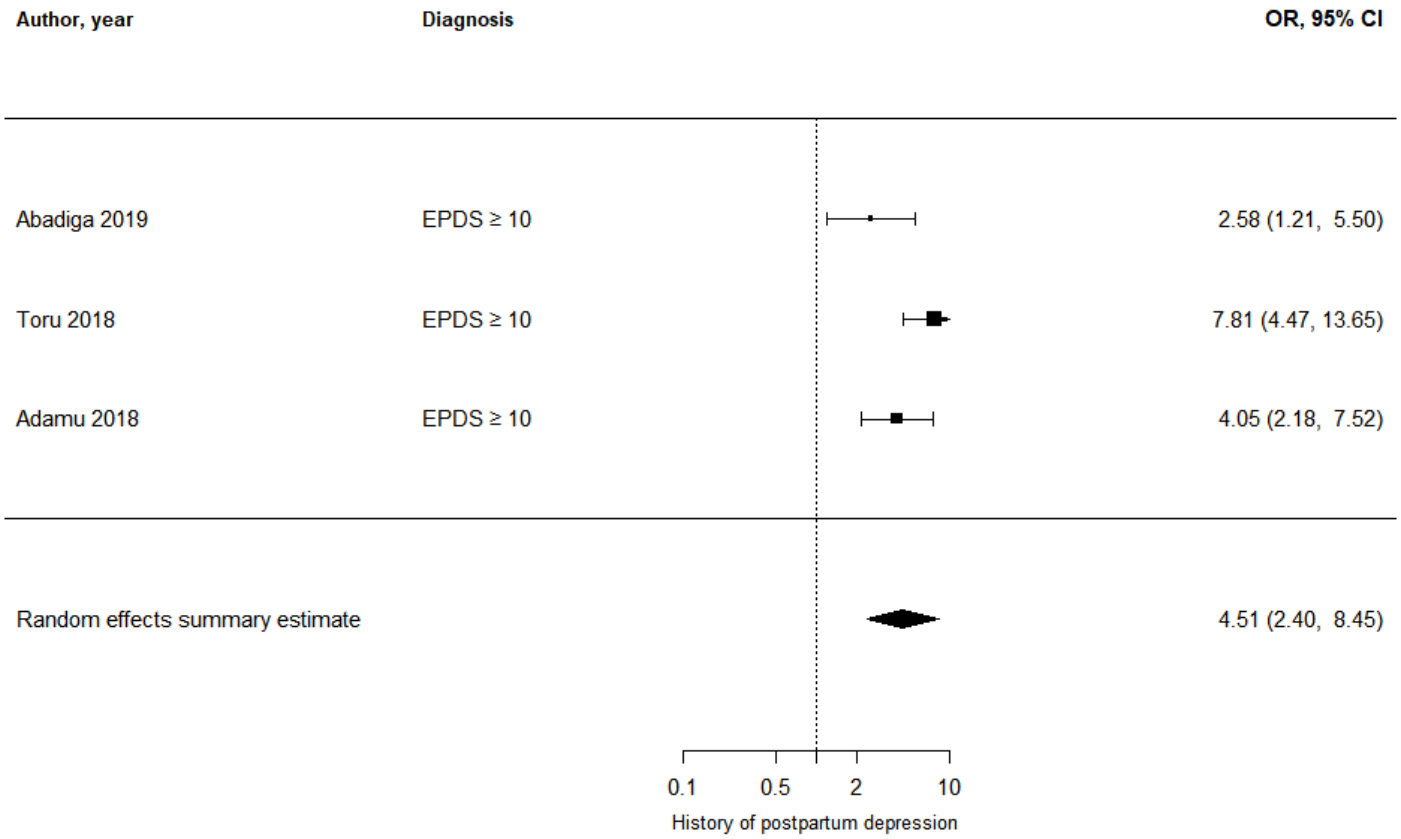
3) P curve analysis plot



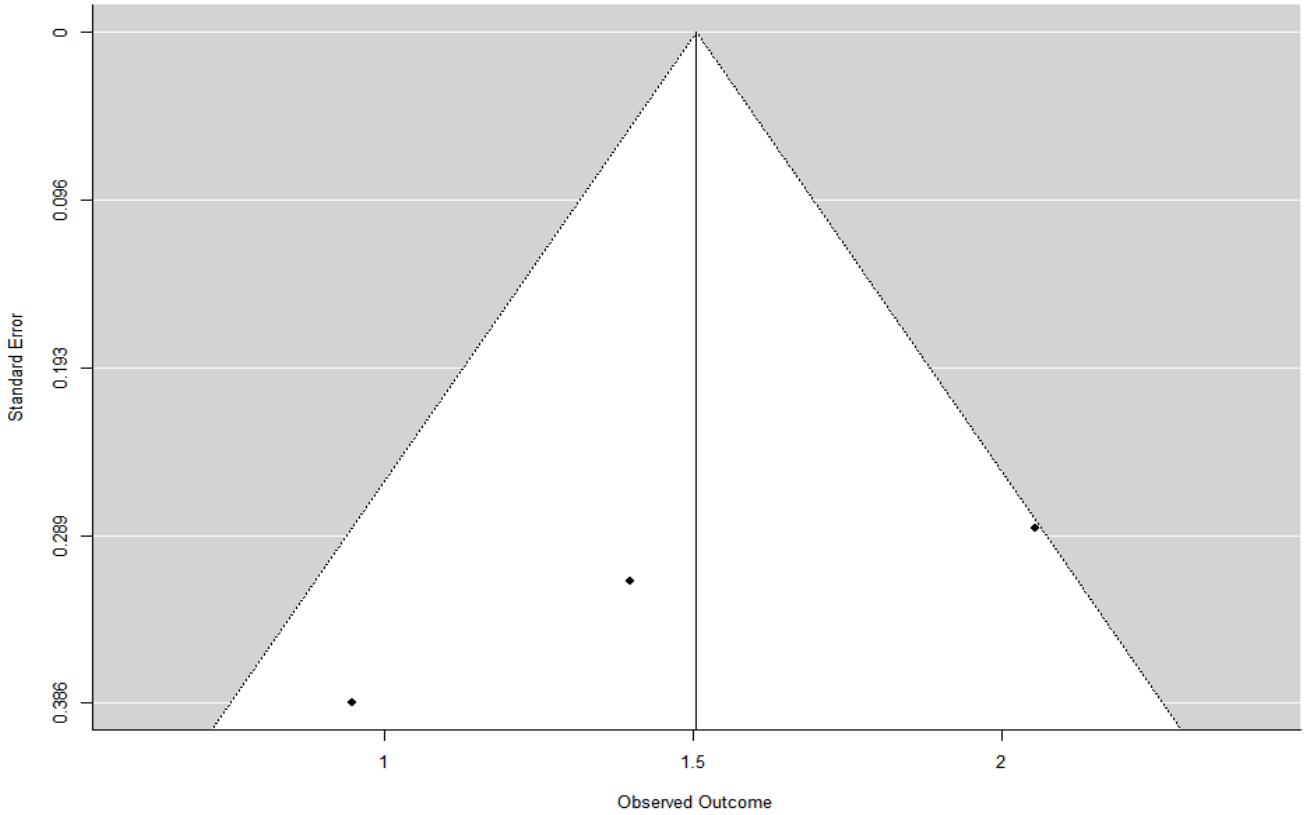
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 5 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S24. History of postpartum depression (Forest plot, funnel plot, p curve analysis plot)

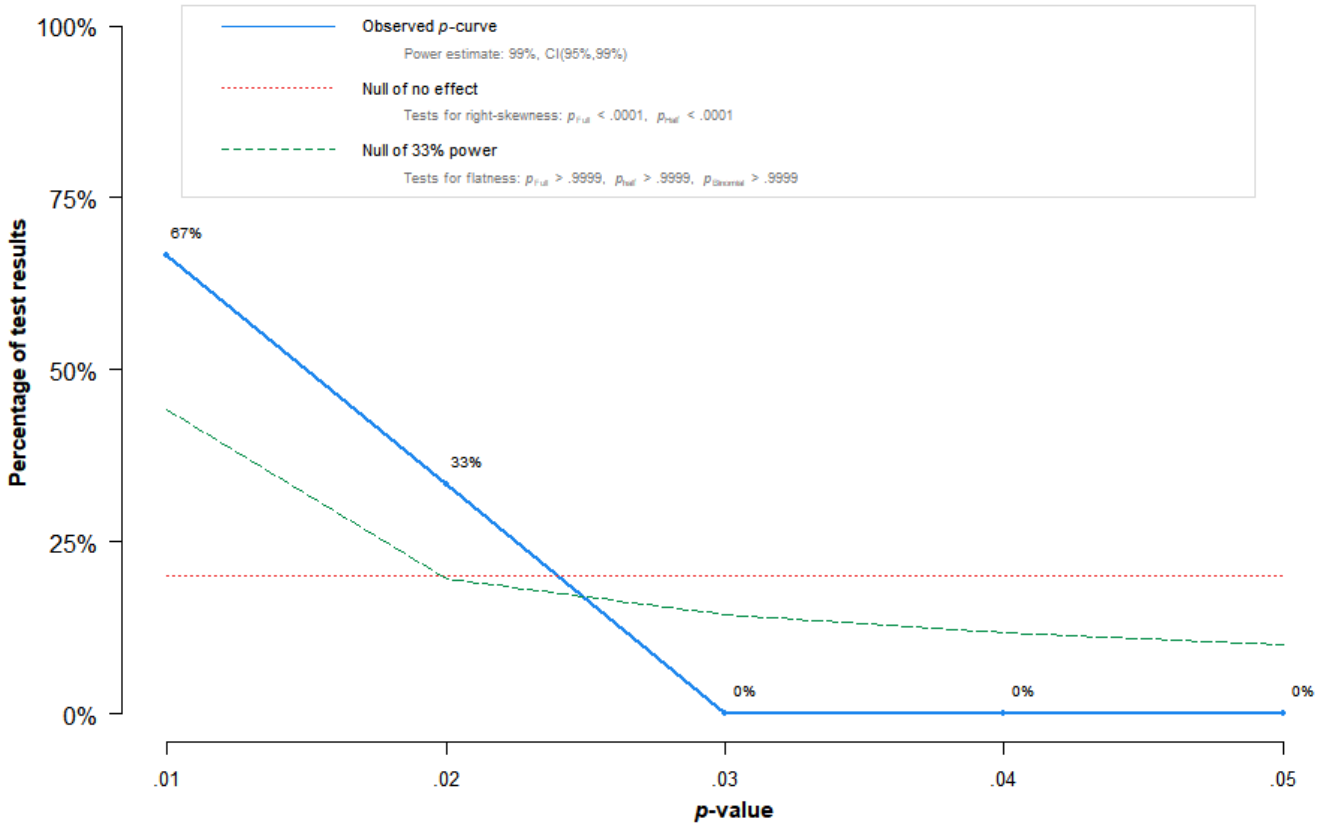
1) Forest plot



2) Funnel plot



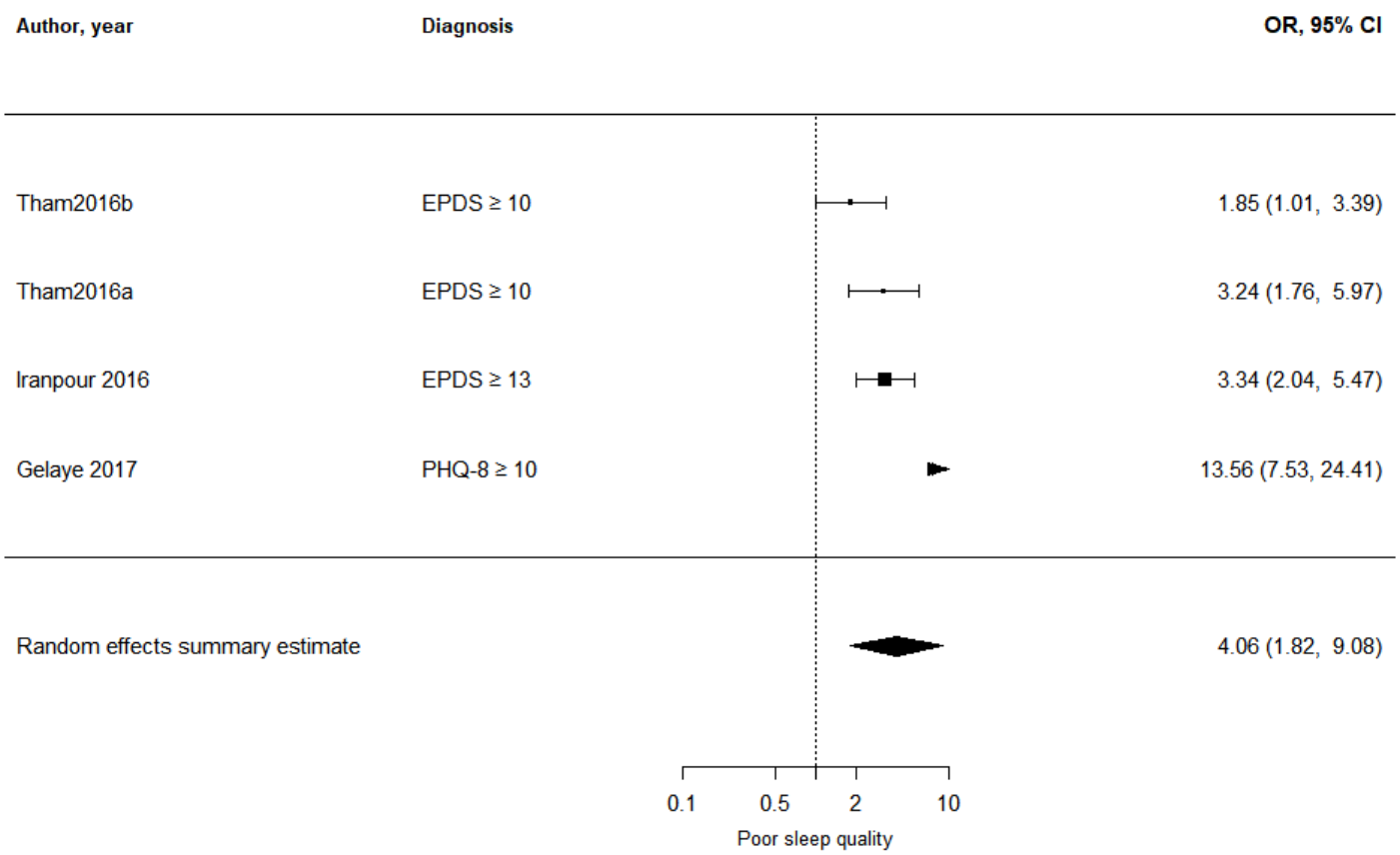
3) P curve analysis plot



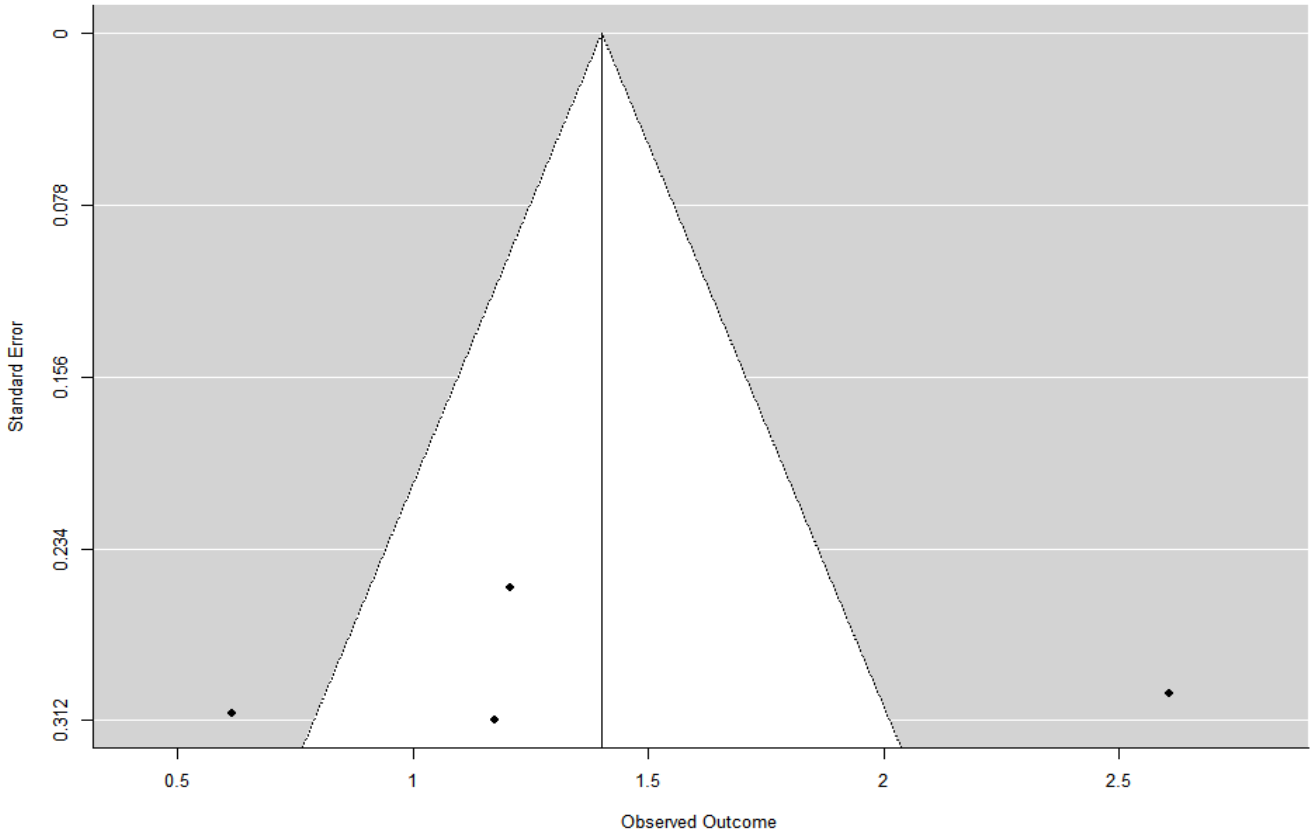
Note: The observed *p*-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were no non-significant results entered.

Figure S25. Poor sleep quality (Forest plot, funnel plot, p curve analysis plot)

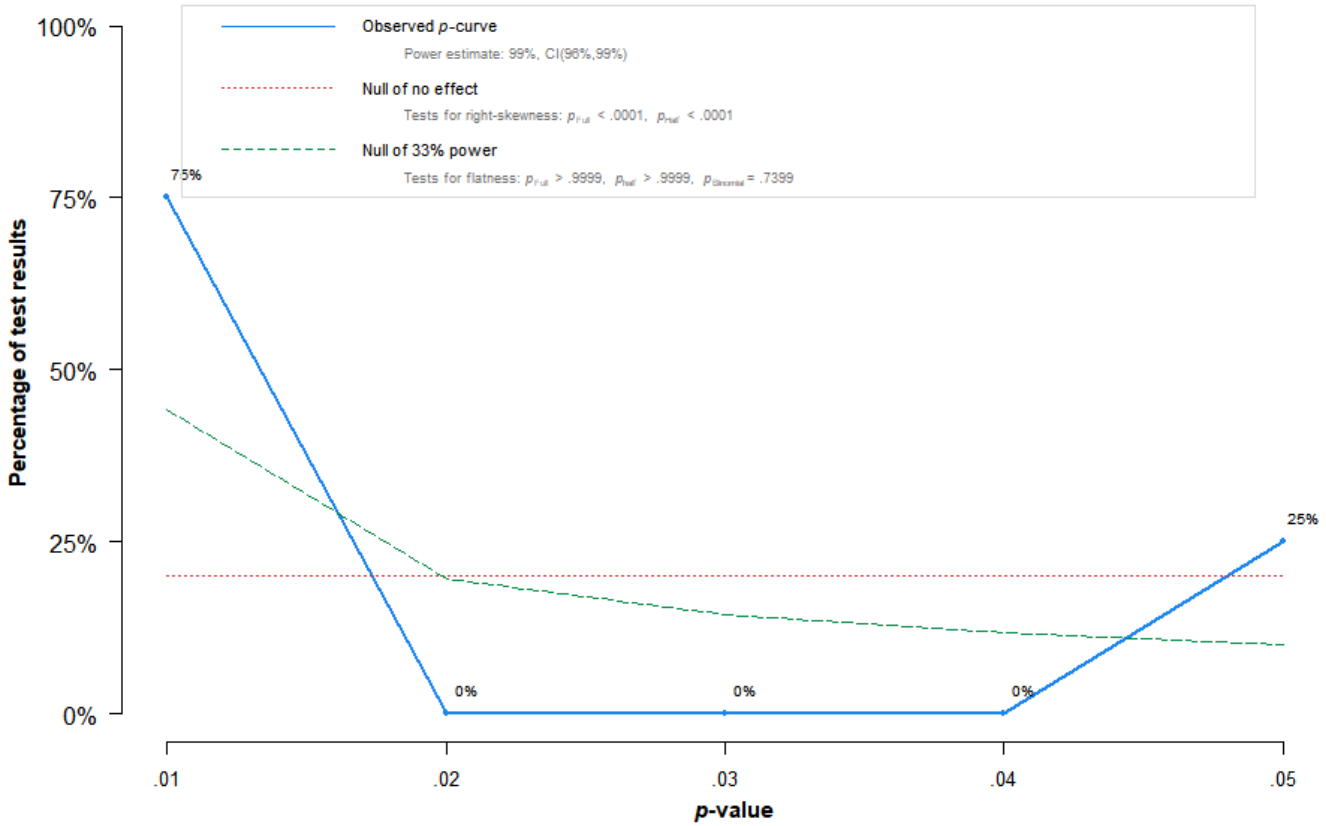
1) Forest plot



2) Funnel plot



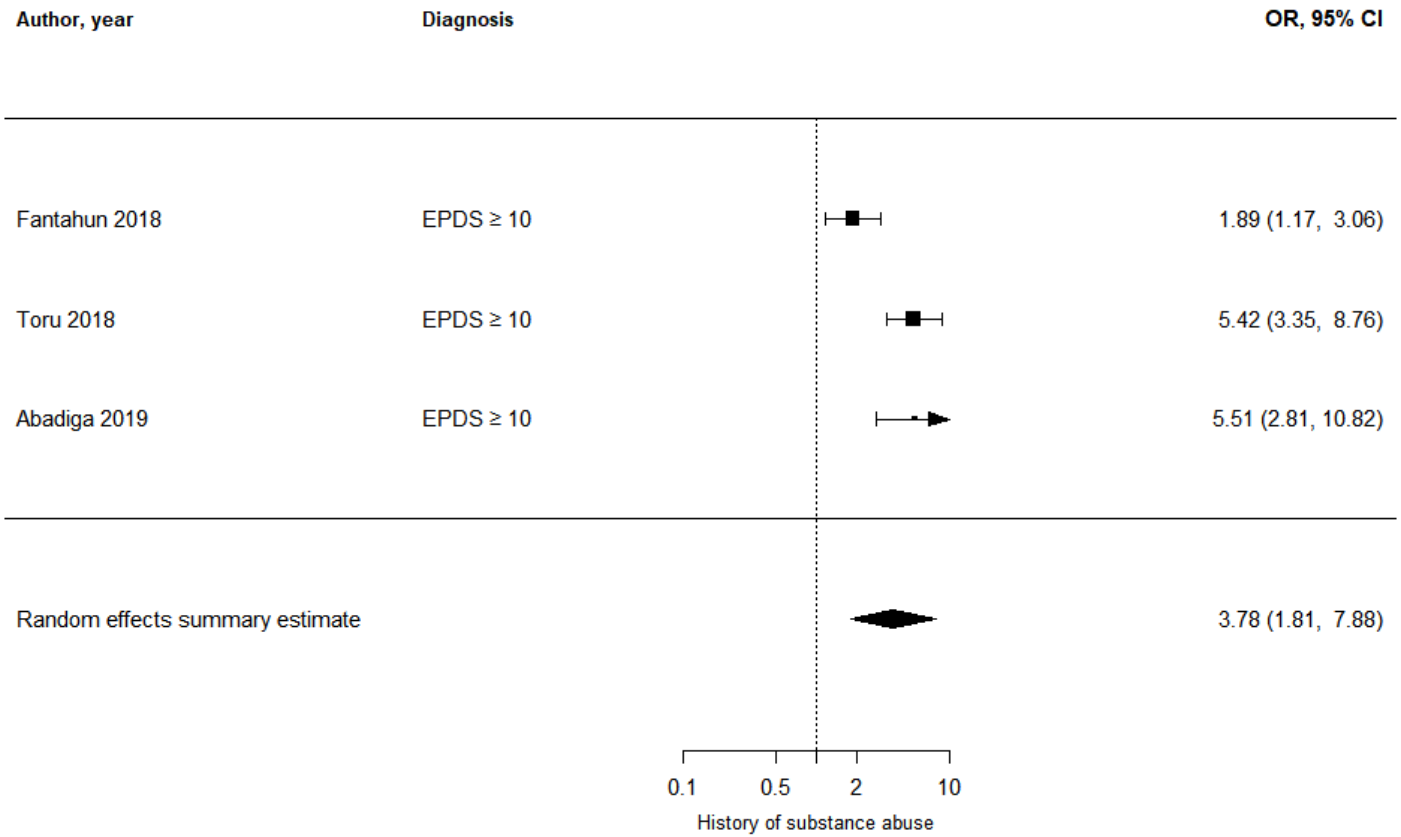
3) P curve analysis plot



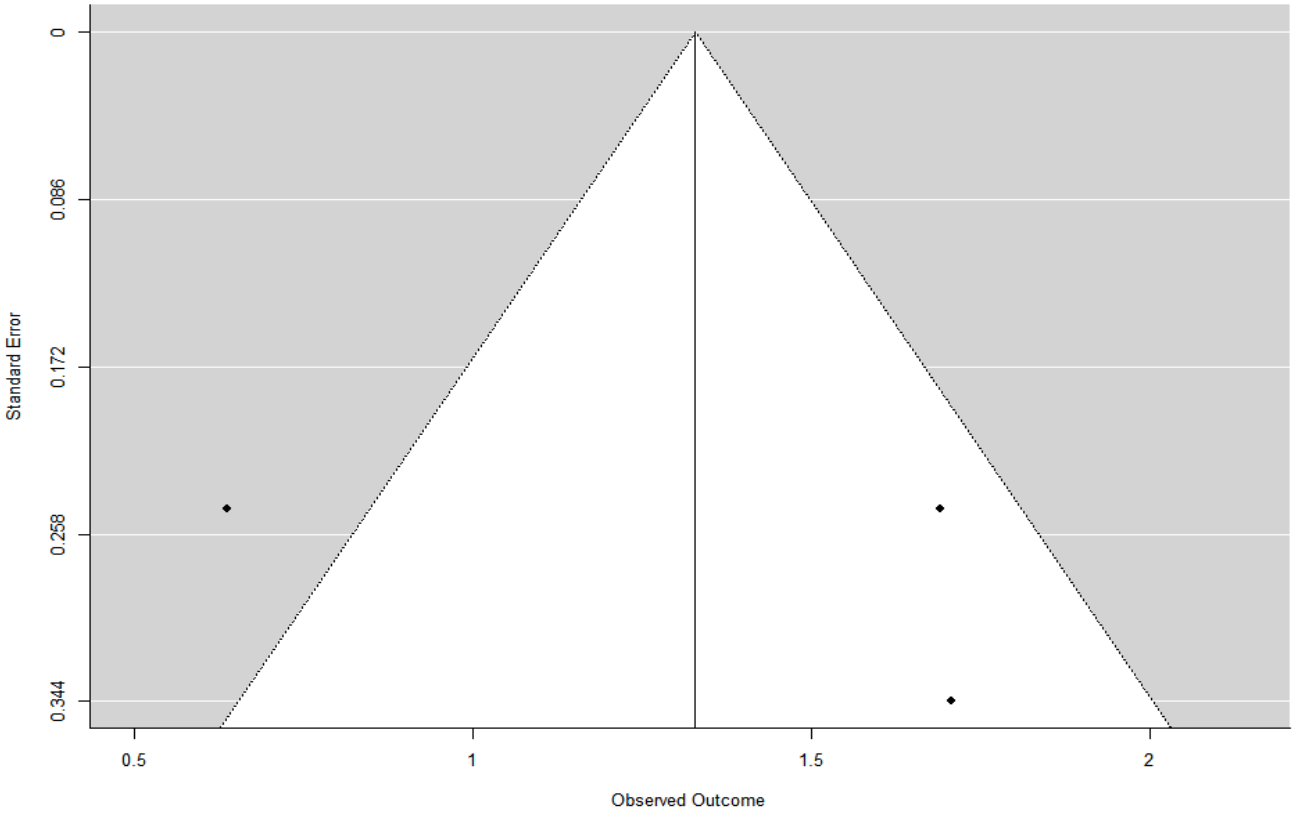
Note: The observed *p*-curve includes 4 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were no non-significant results entered.

Figure S26. History of substance abuse (Forest plot, funnel plot, p curve analysis plot)

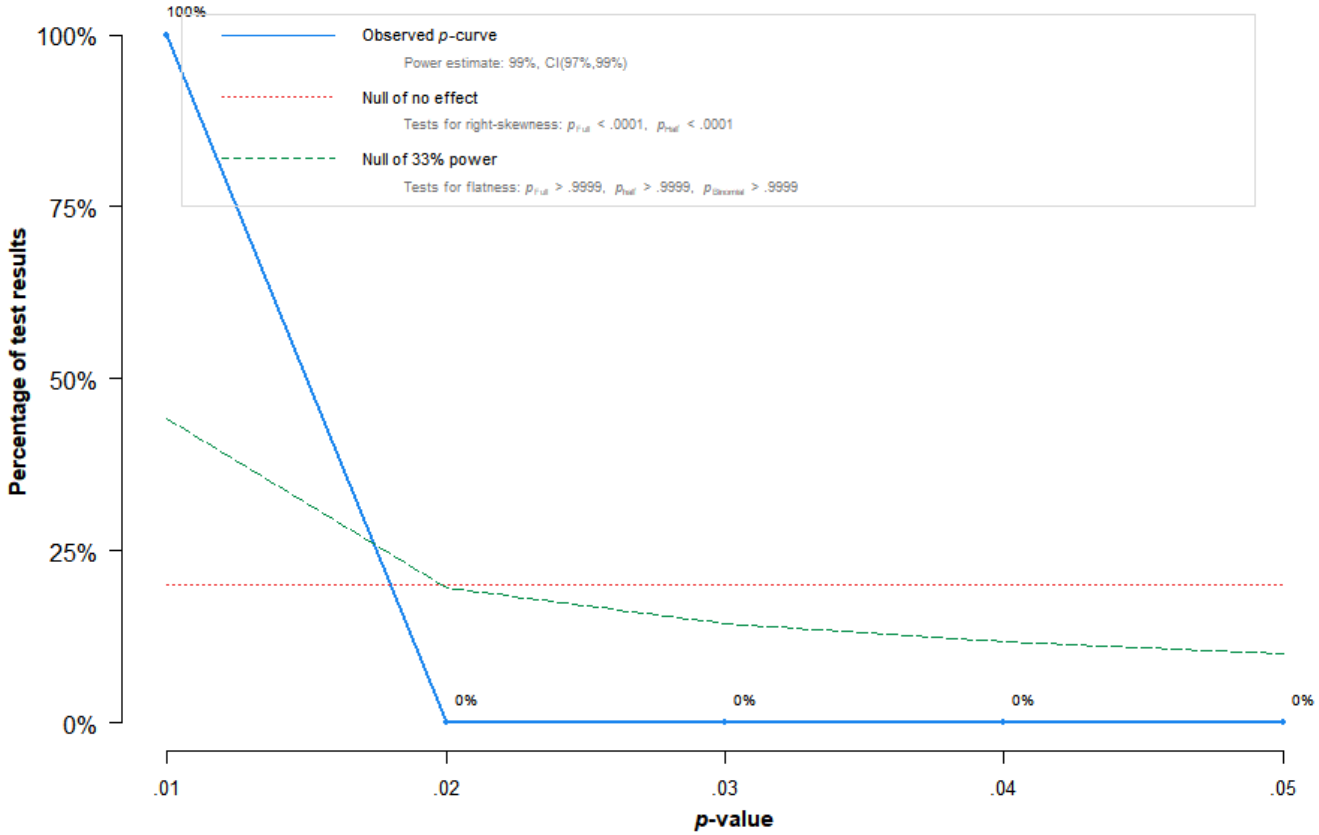
1) Forest plot



2) Funnel plot



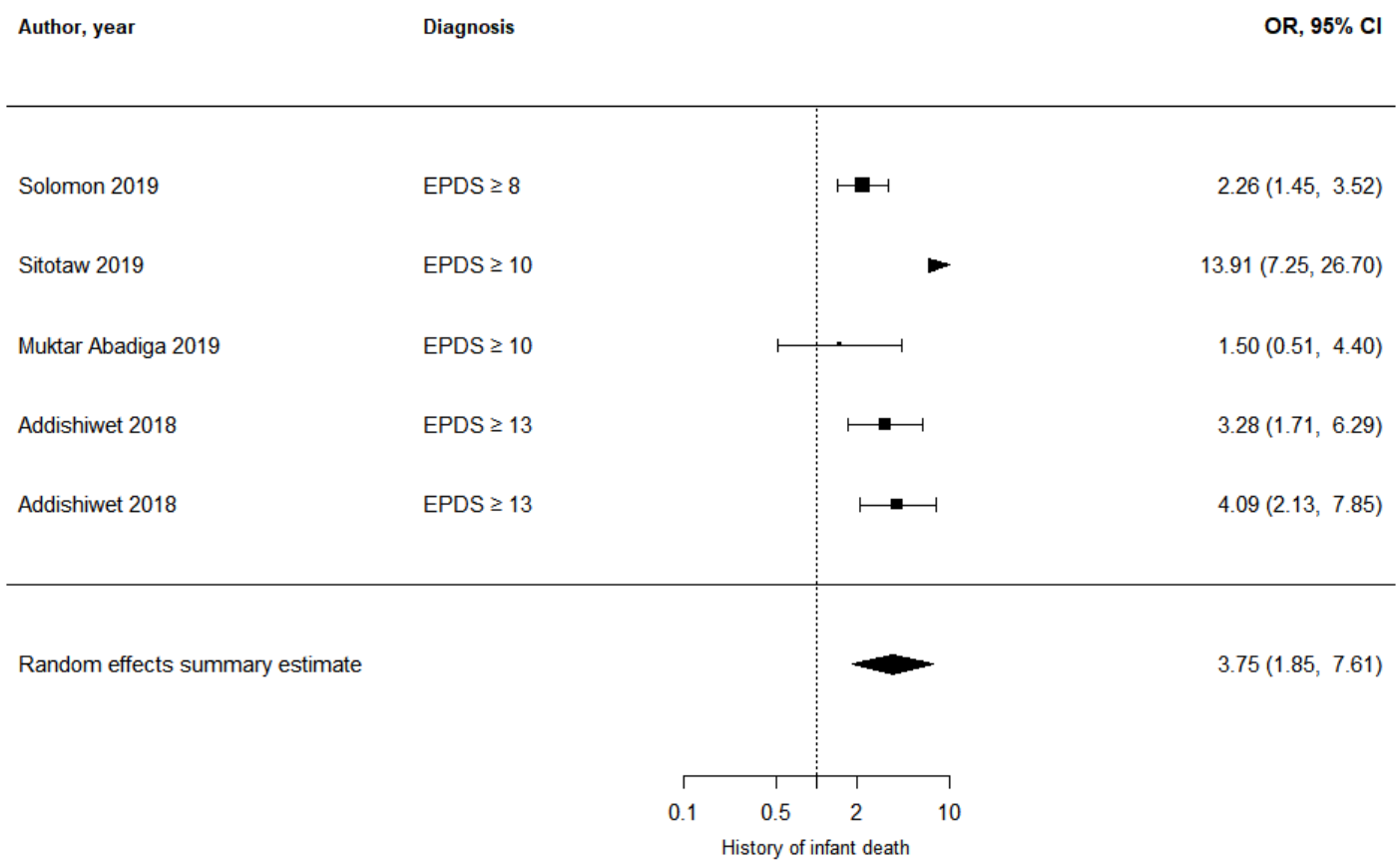
3) P curve analysis plot



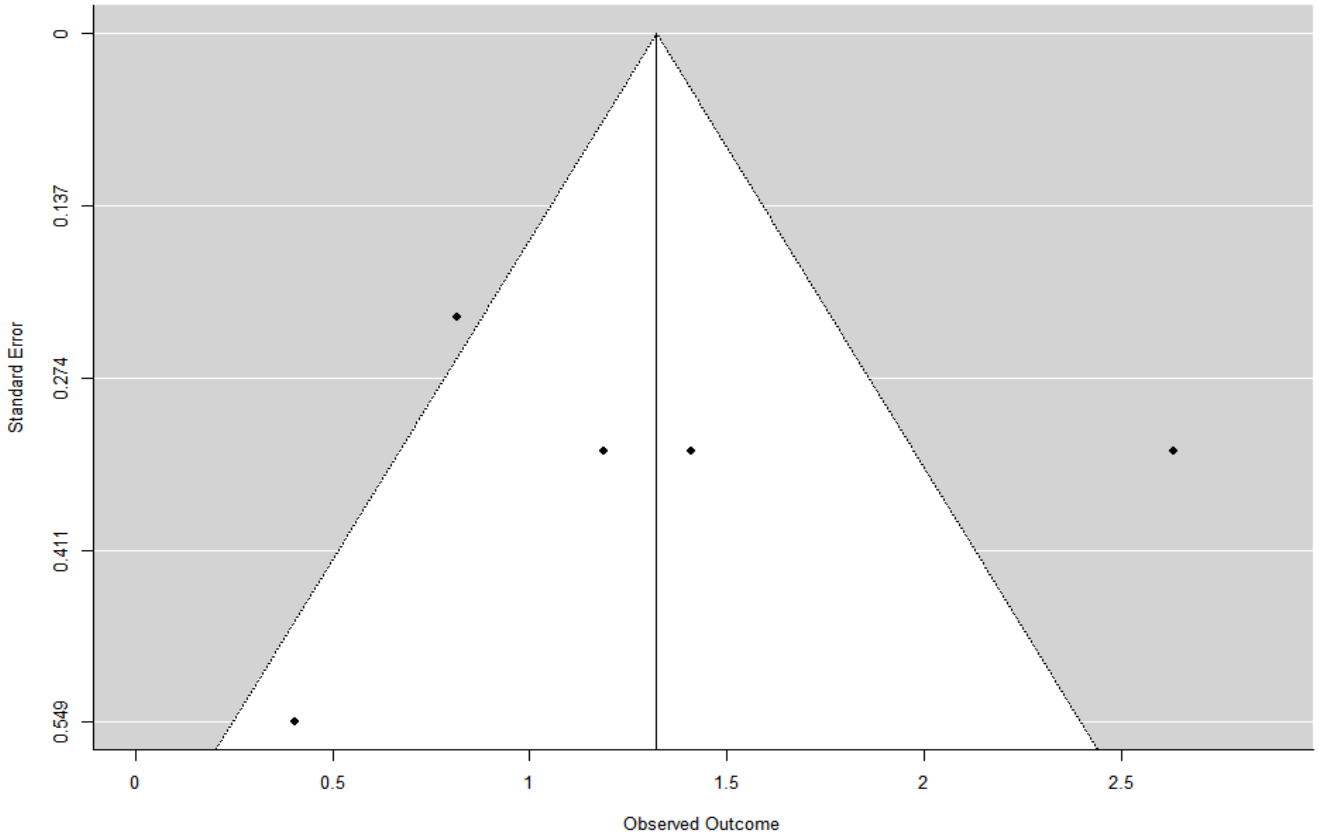
Note: The observed p-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were no non-significant results entered.

Figure S27. History of infant death (Forest plot, funnel plot, p curve analysis plot)

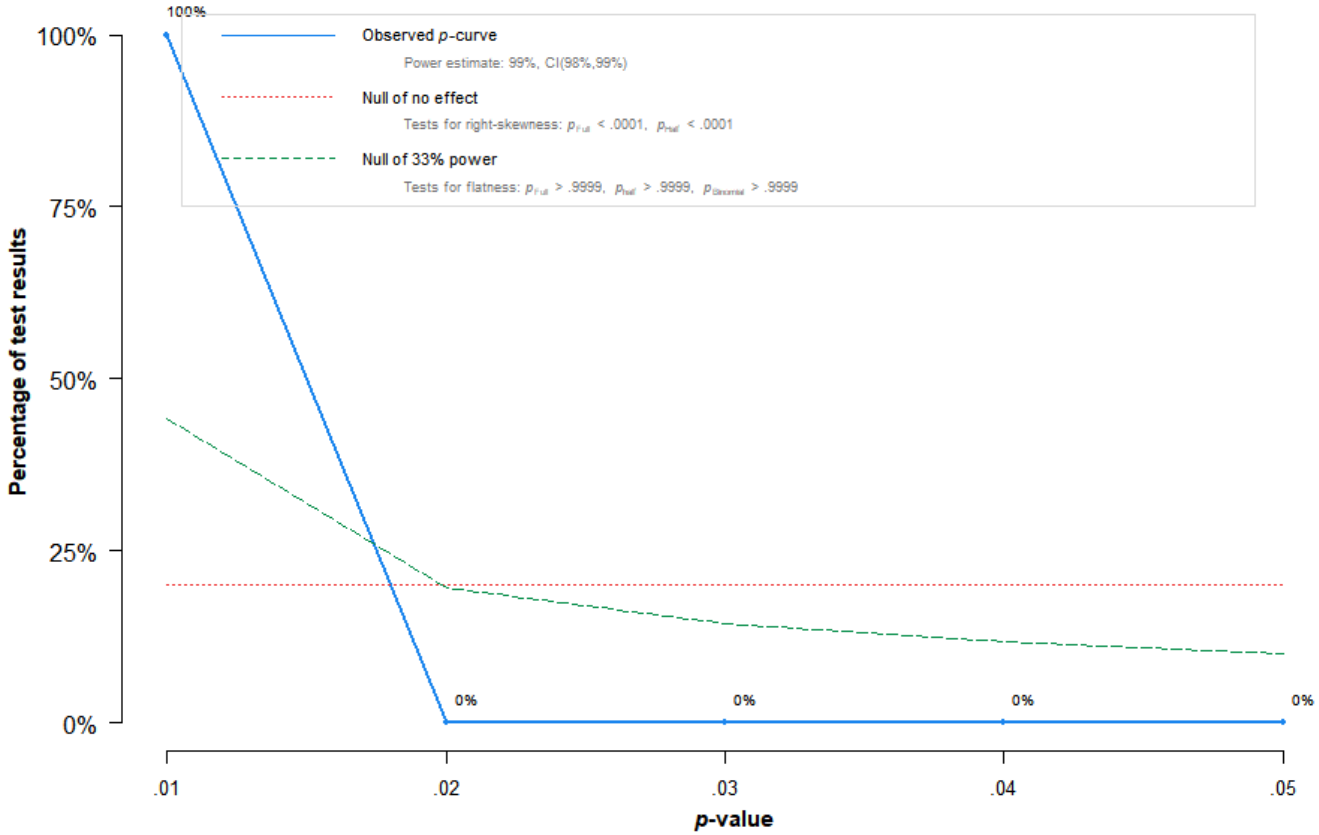
1) Forest plot



2) Funnel plot



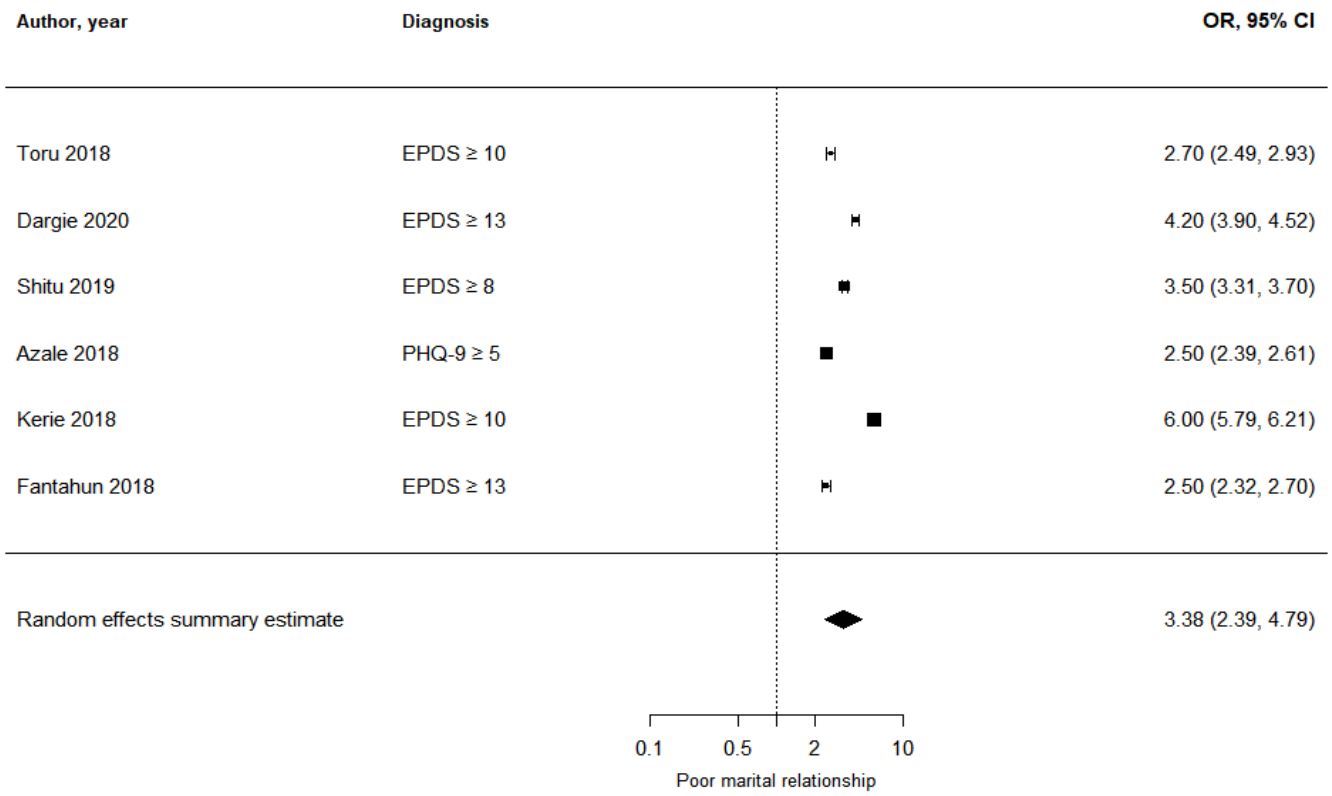
3) P curve analysis plot



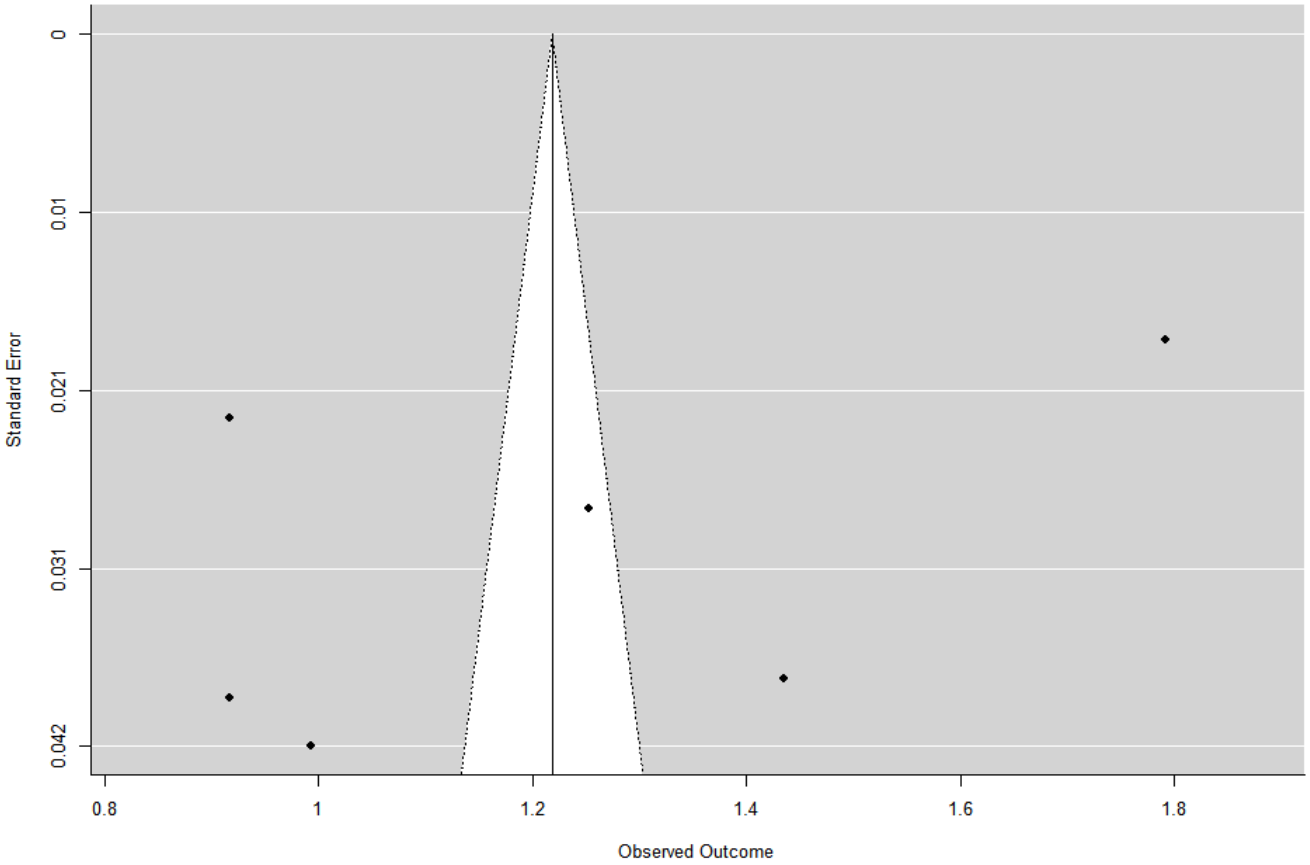
Note: The observed *p*-curve includes 4 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S28. Poor marital relationship (Forest plot, funnel plot, p curve analysis plot)

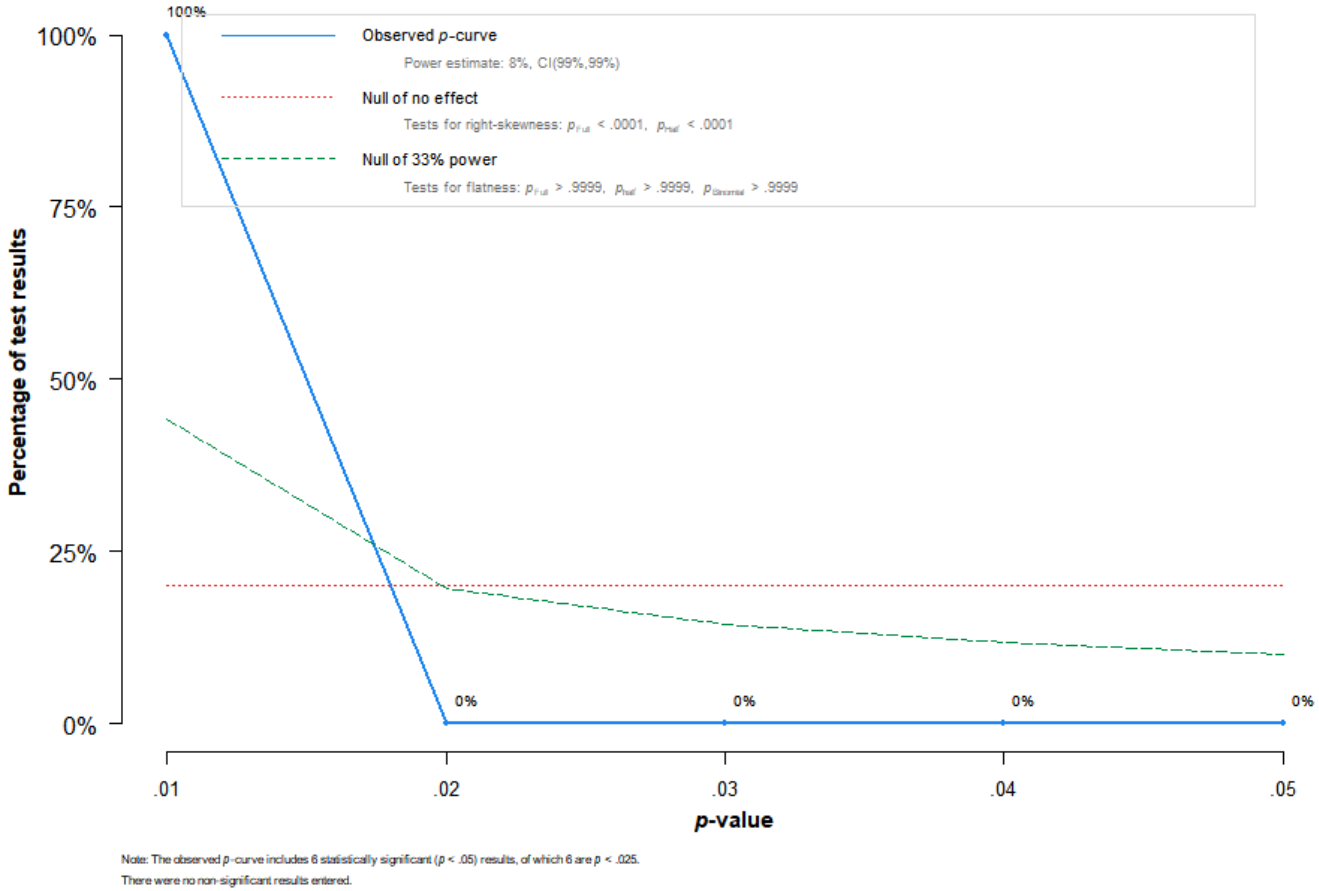
1) Forest plot



2) Funnel plot


Standard Error
0
0.01
0.021
0.031
0.042
0.8
1
1.2
1.4
1.6
1.8
Observed Outcome

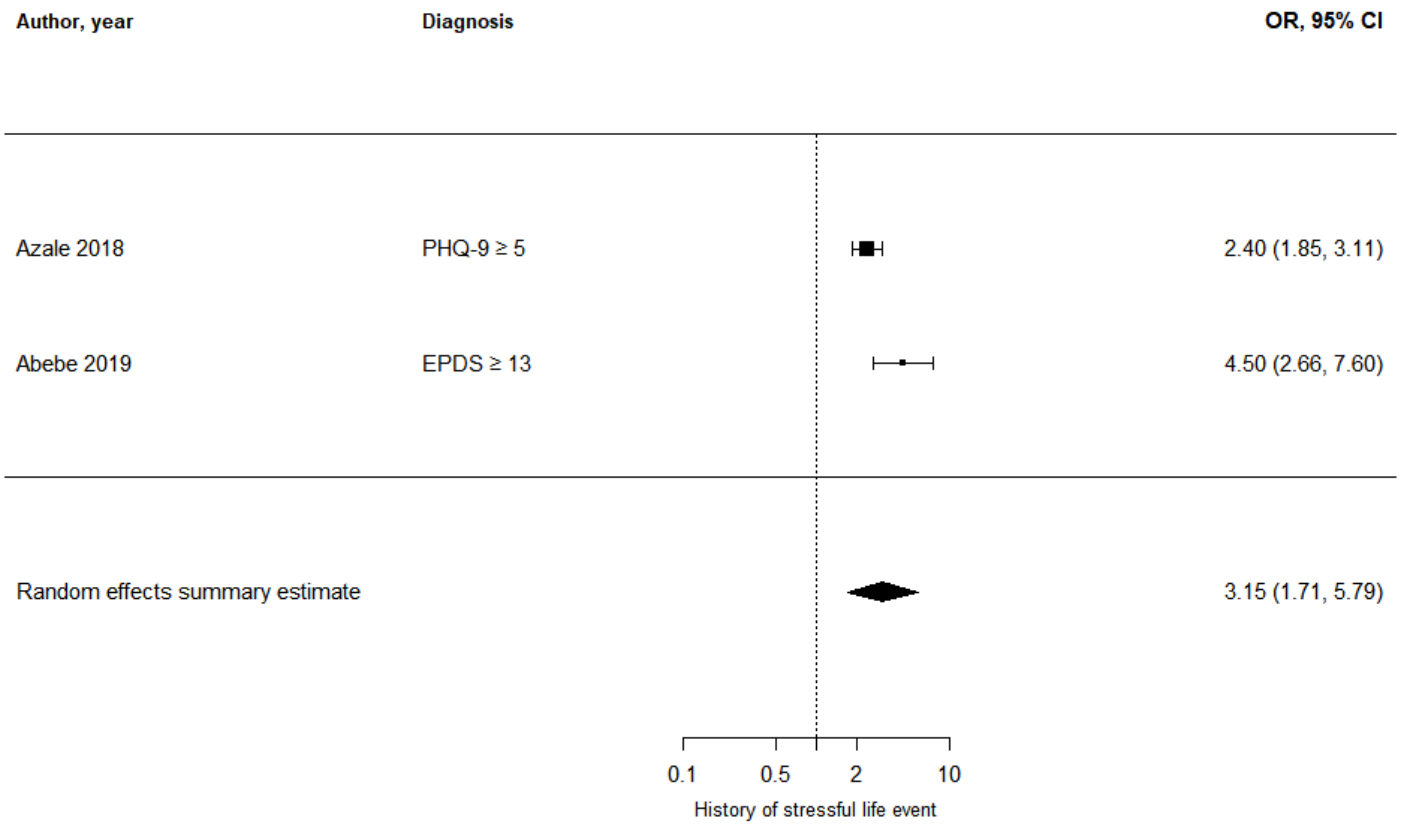
3) P curve analysis plot



Note: The observed *p*-curve includes 6 statistically significant ($p < .05$) results, of which 6 are $p < .025$.
There were no non-significant results entered.

Figure S29. History of stressful life event (Forest plot)

1) Forest plot



2) Funnel plot

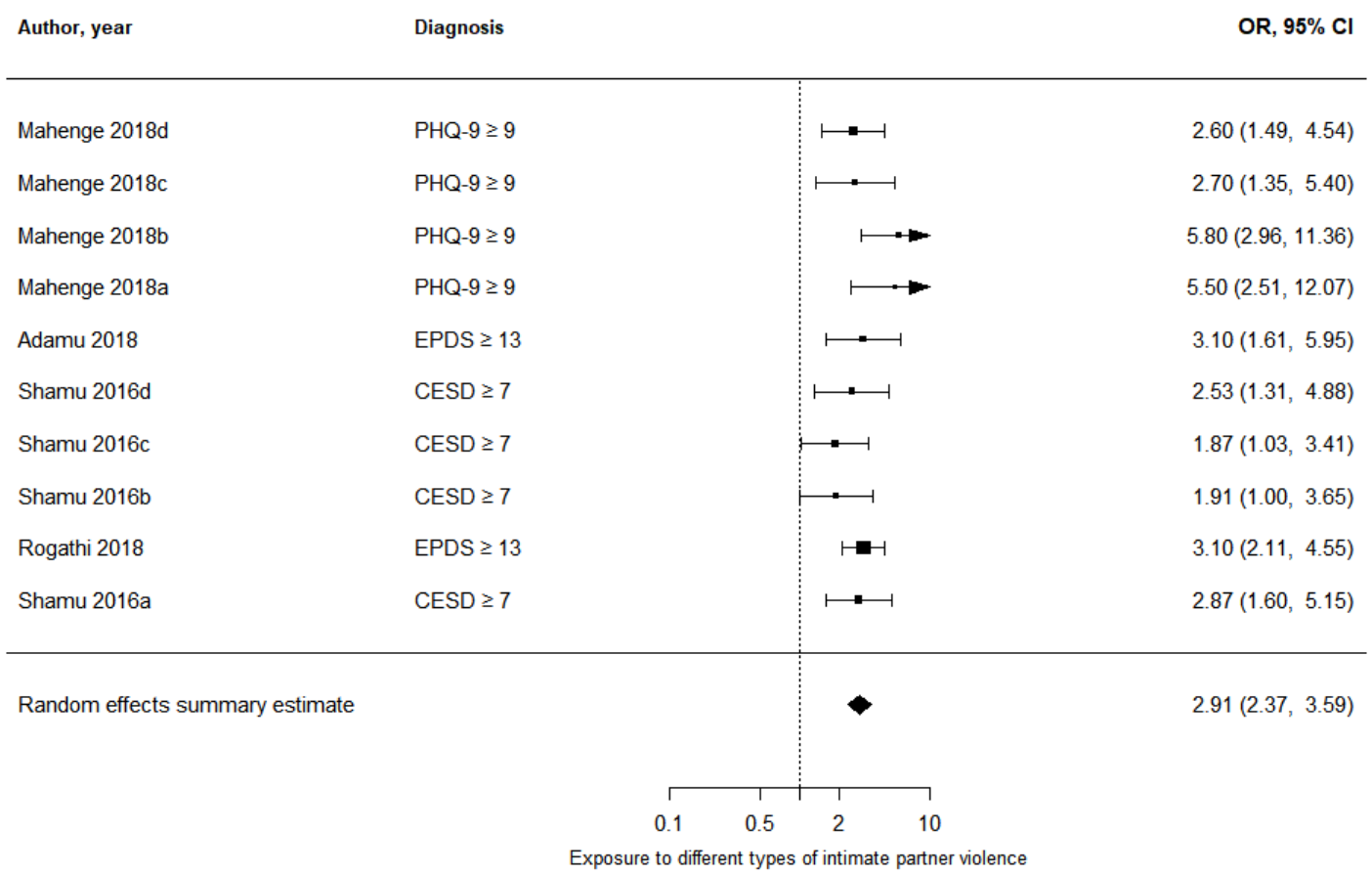
Not available because of the small number of studies

3) P curve analysis plot

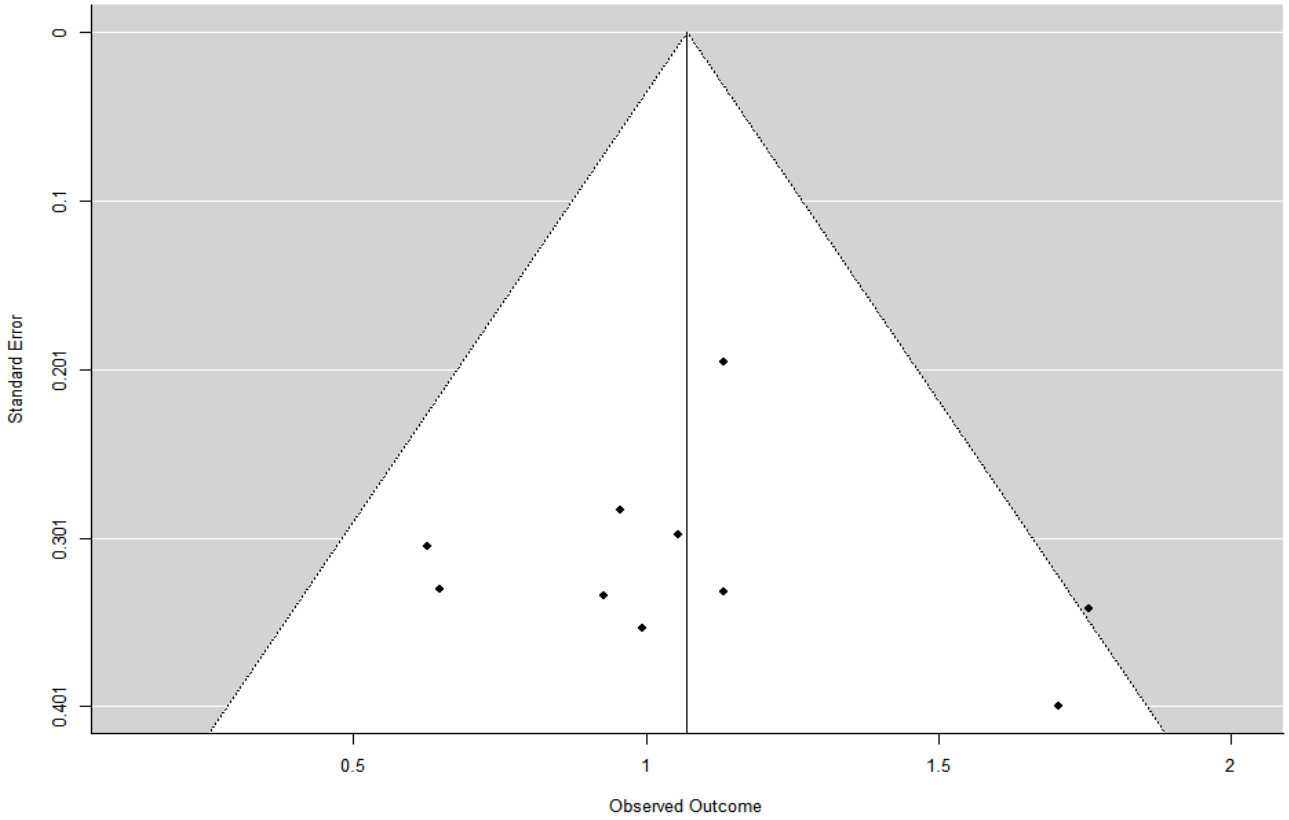
Not available because of the small number of studies

Figure S30. Exposure to different types of intimate partner violence (Forest plot, funnel plot, p curve analysis plot)

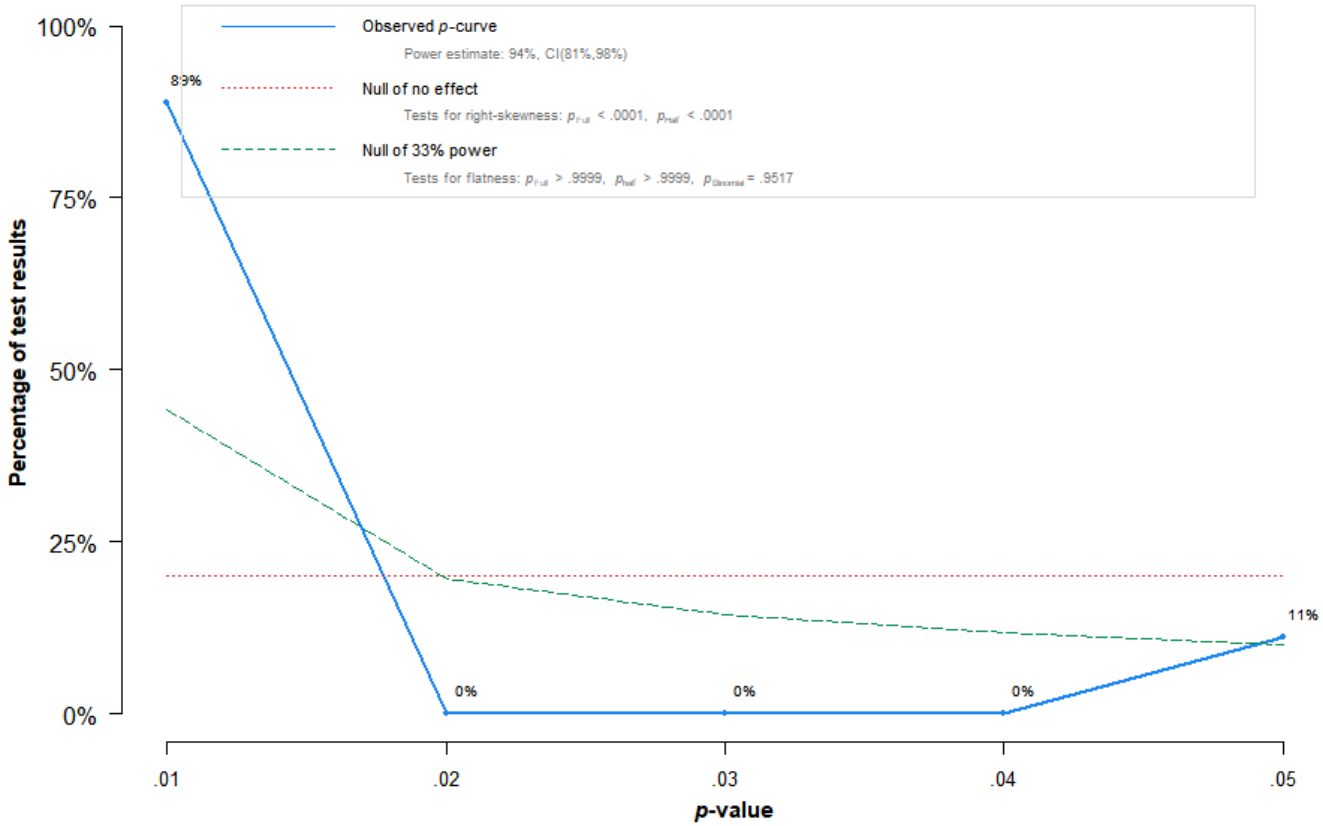
1) Forest plot



2) Funnel plot



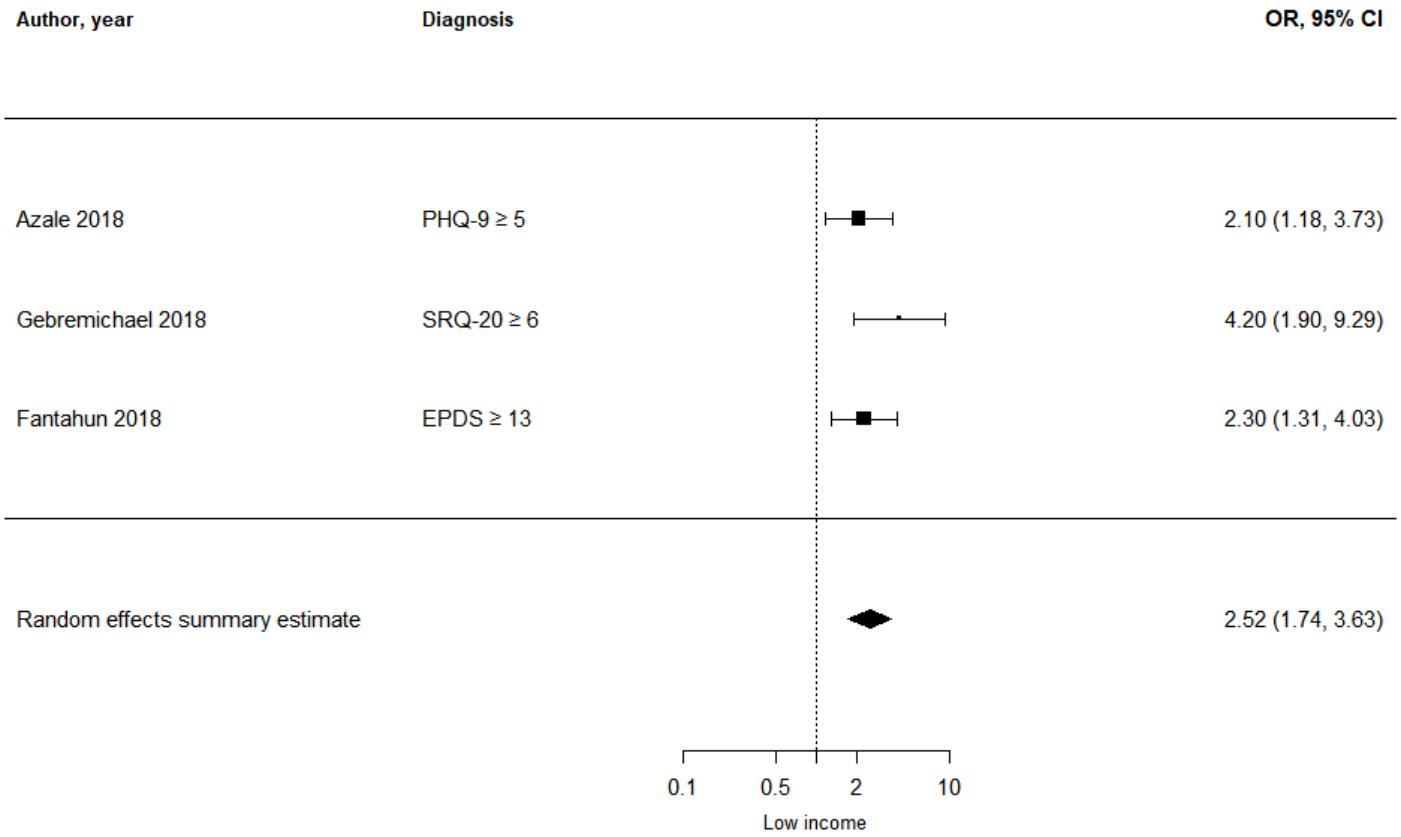
3) P curve analysis plot



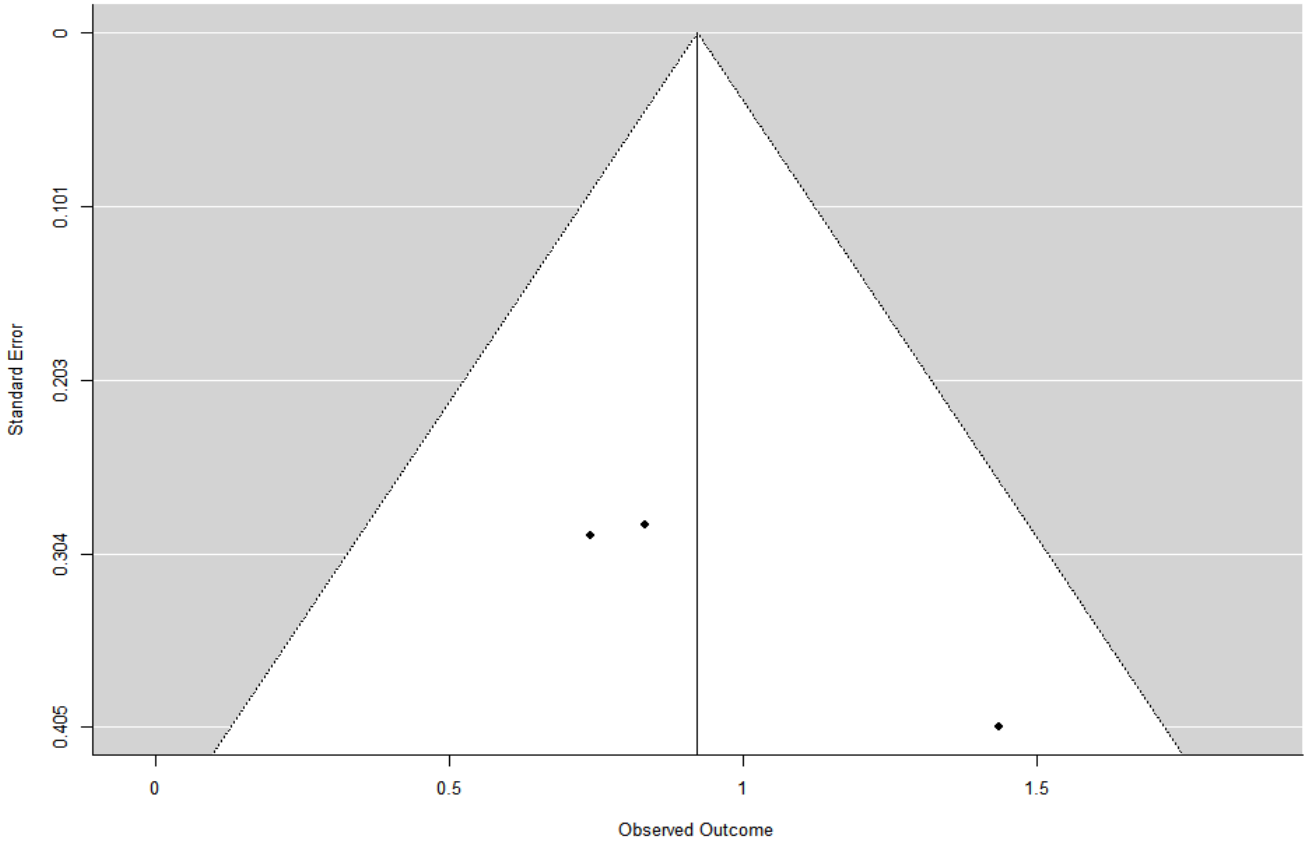
Note: The observed *p*-curve includes 9 statistically significant ($p < .05$) results, of which 8 are $p < .025$.
There was one additional result entered but excluded from *p*-curve because it was $p > .05$.

Figure S31. Low income (Forest plot, funnel plot, p curve analysis plot)

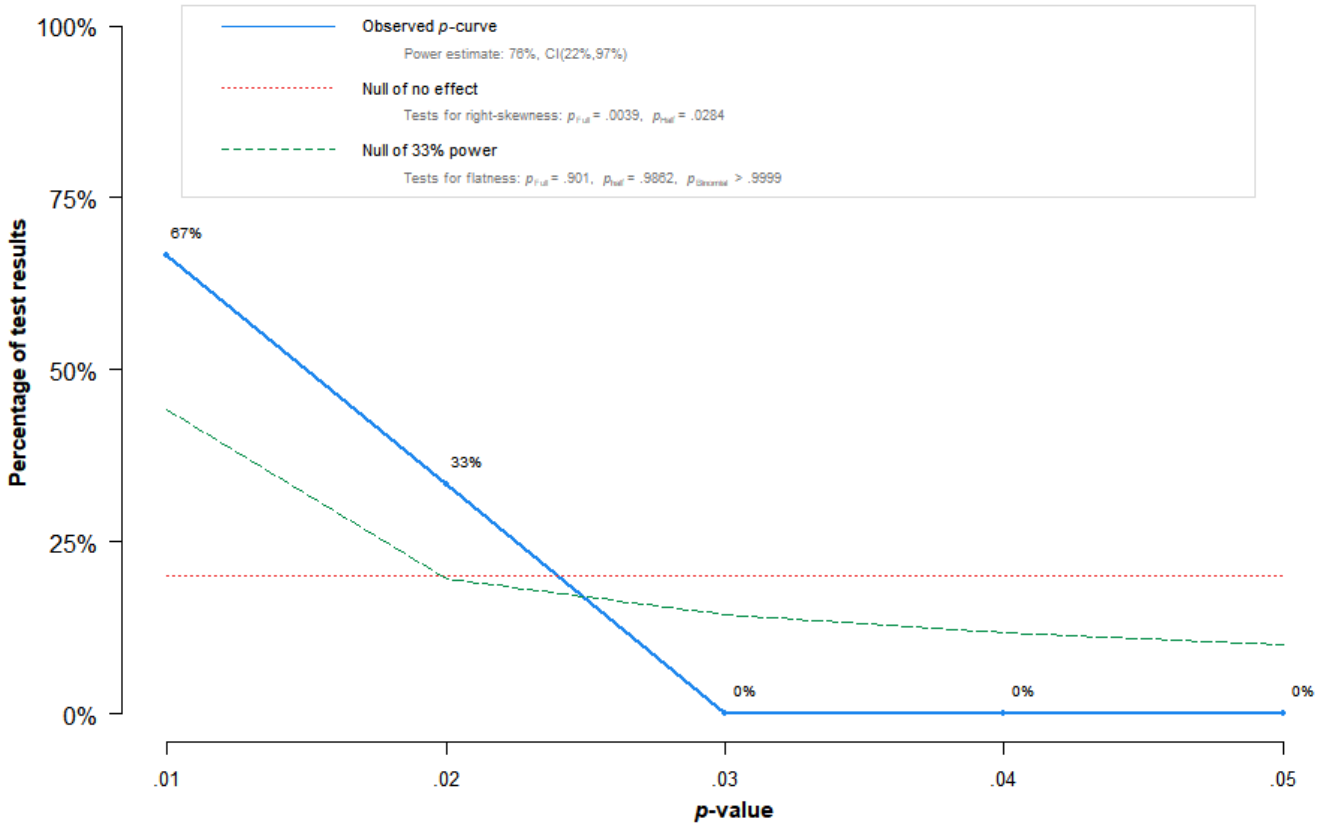
1) Forest plot



2) Funnel plot



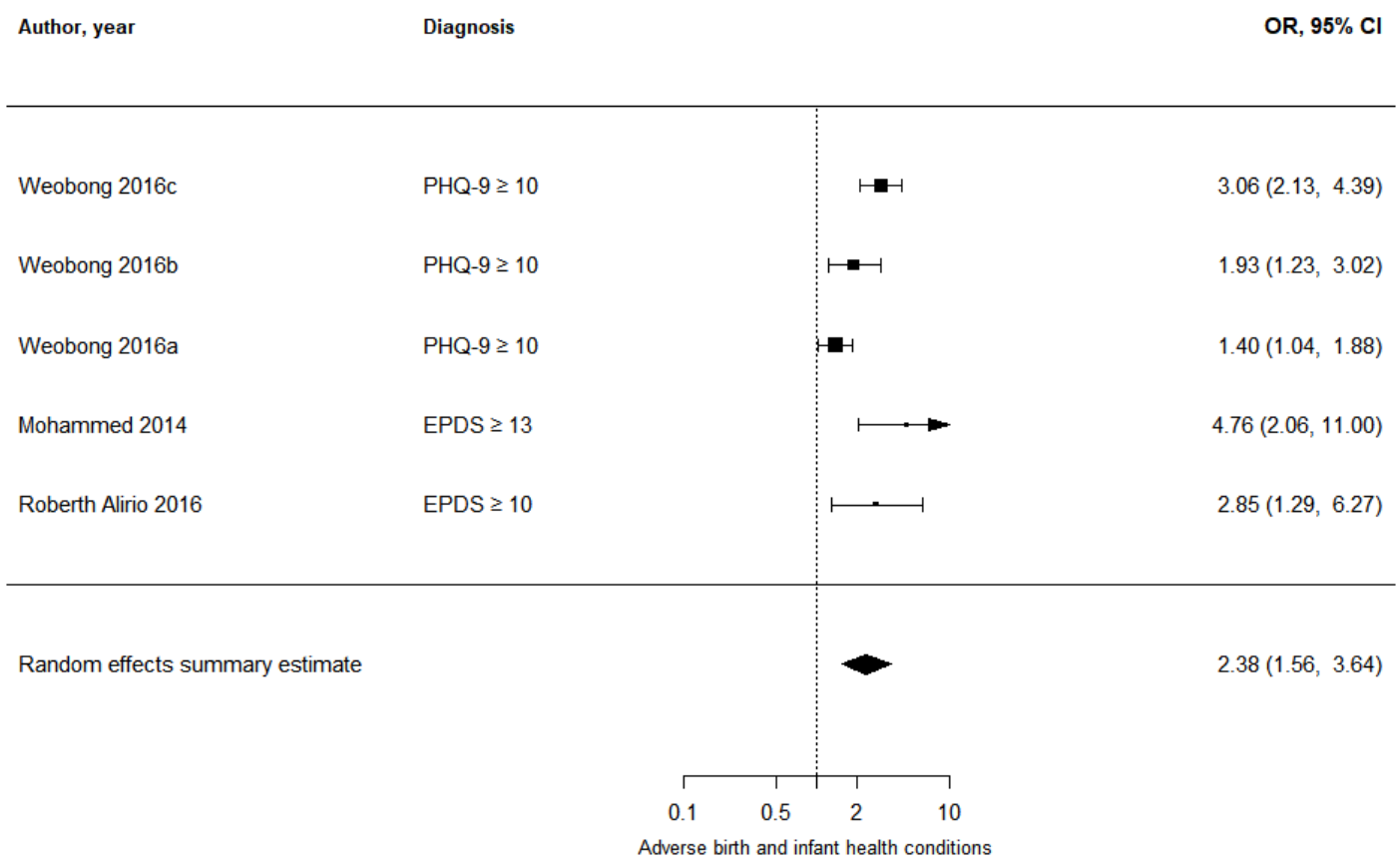
3) P curve analysis plot



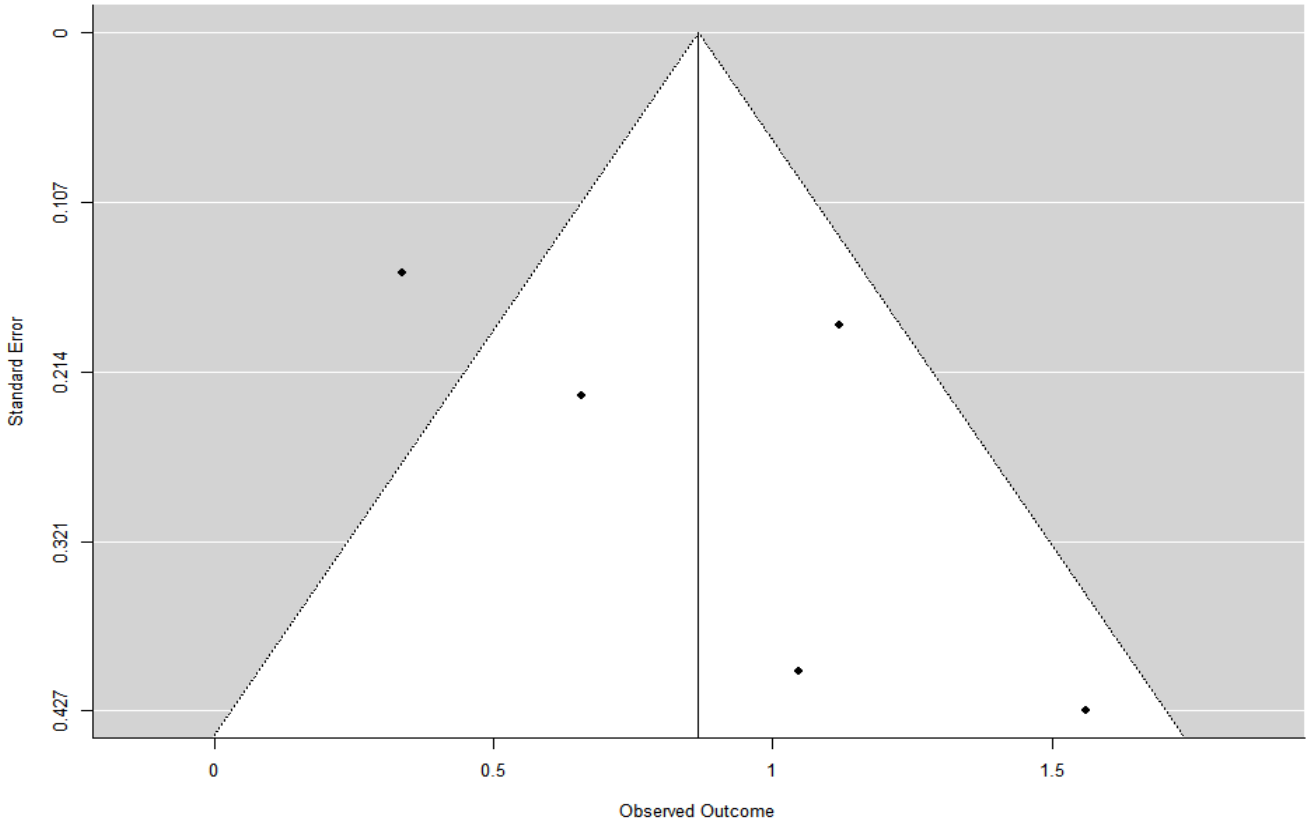
Note: The observed *p*-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were no non-significant results entered.

Figure S32. Adverse birth and infant health conditions (Forest plot, funnel plot, p curve analysis plot)

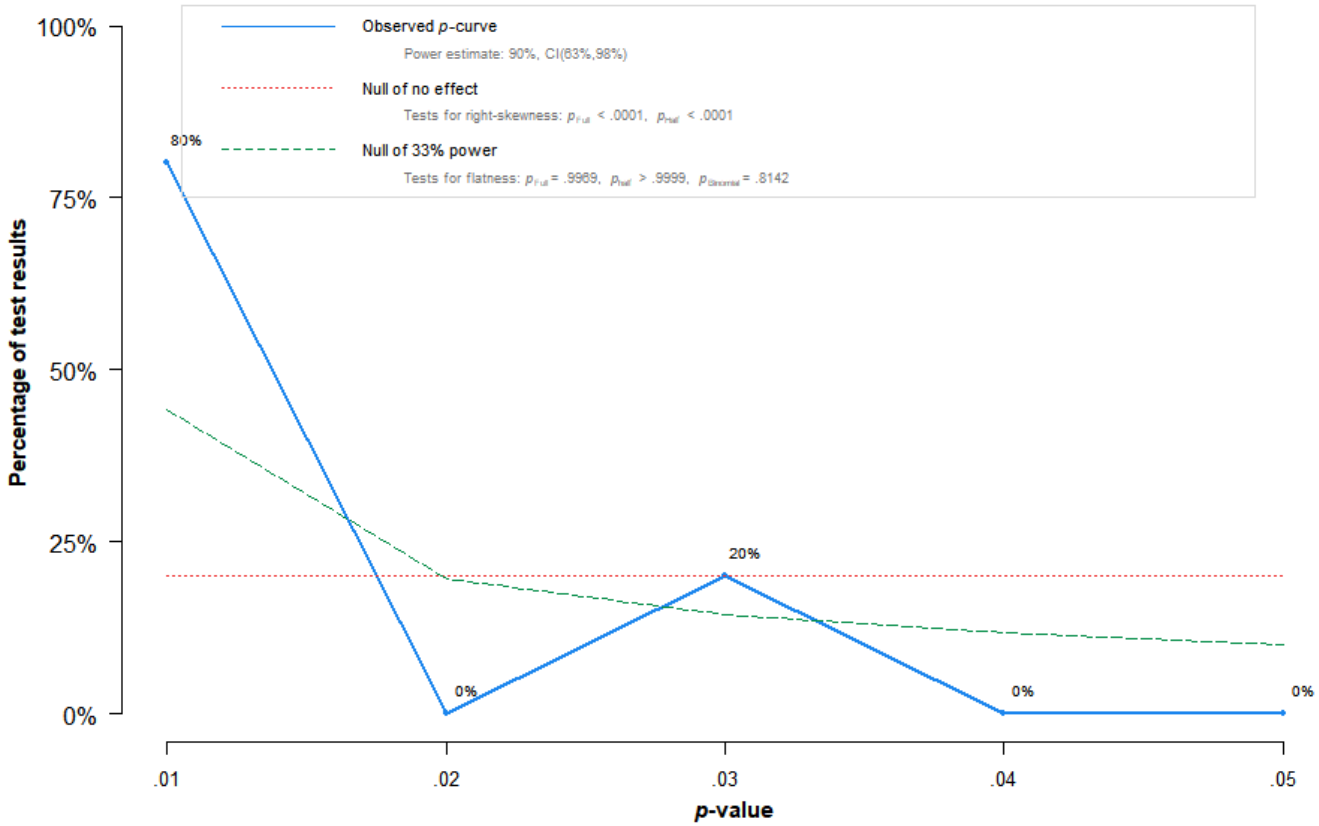
1) Forest plot



2) Funnel plot



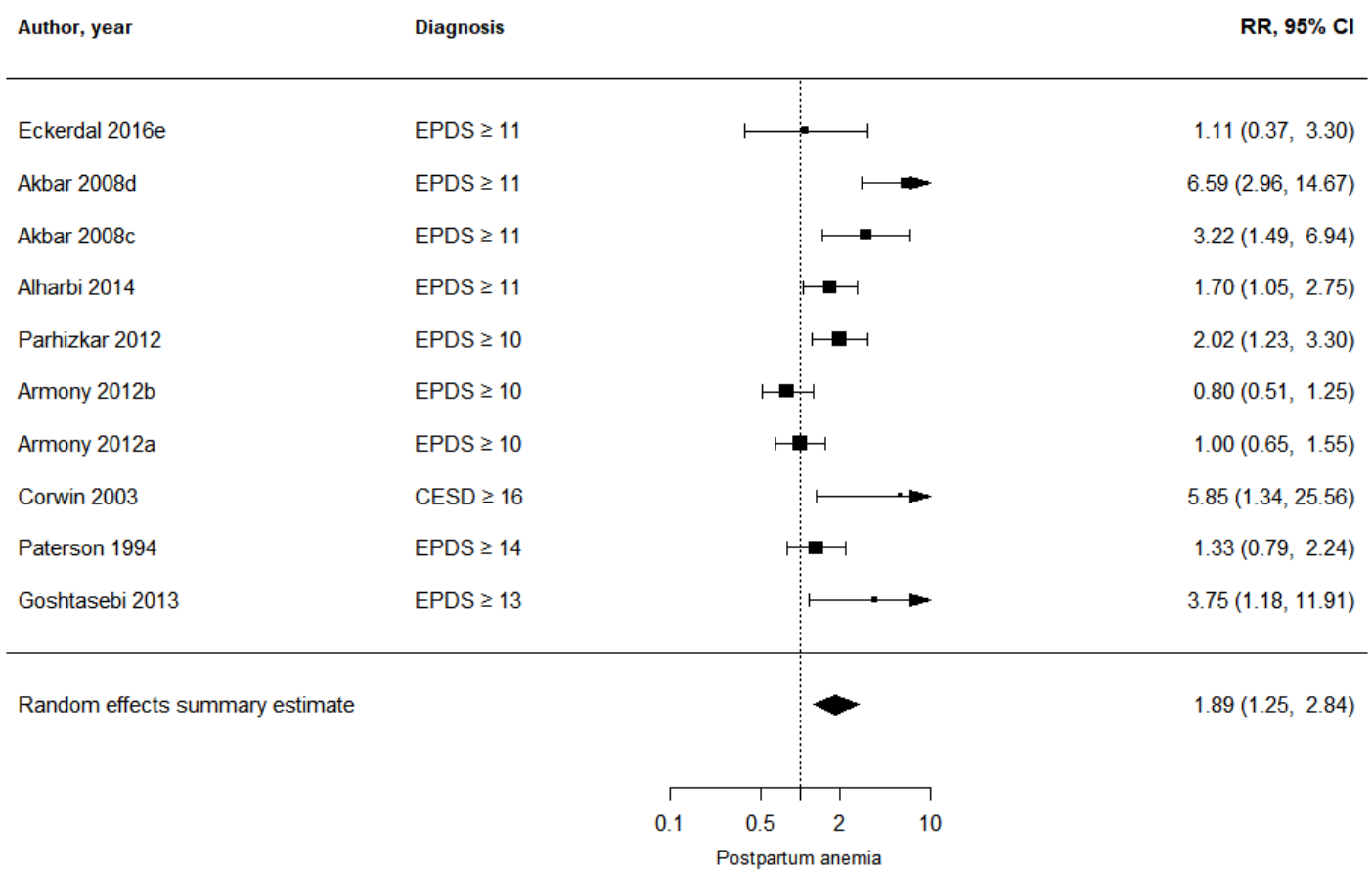
3) P curve analysis plot



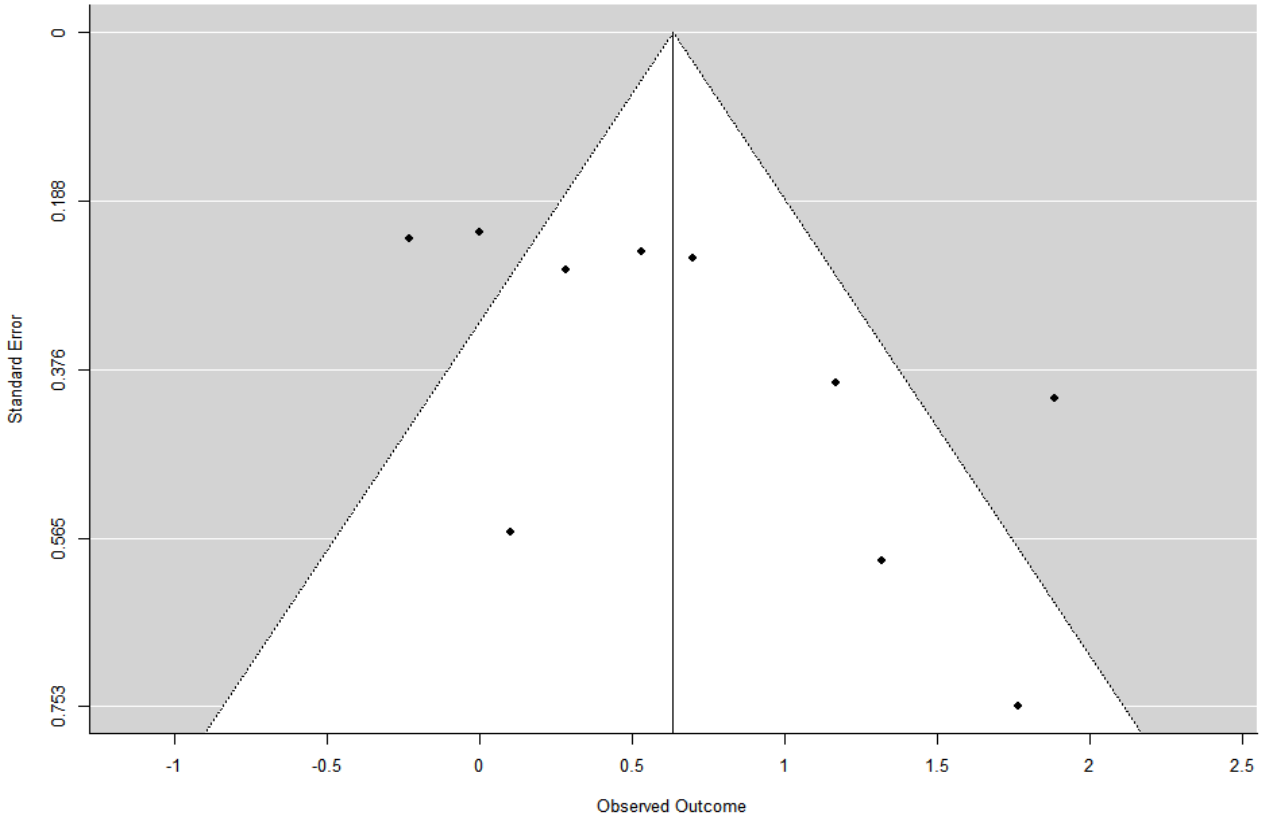
Note: The observed *p*-curve includes 5 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were no non-significant results entered.

Figure S33. Postpartum anemia (Forest plot, funnel plot, p curve analysis plot)

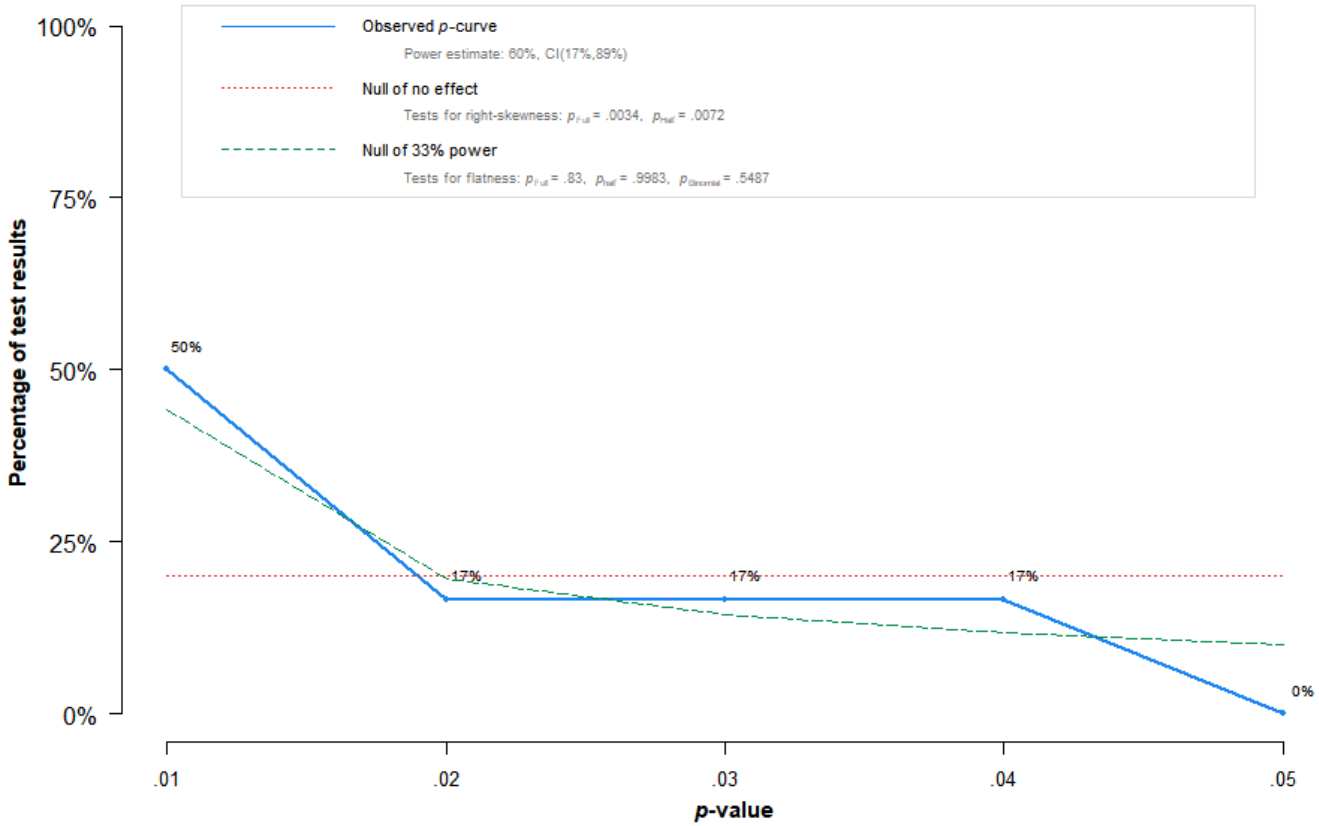
1) Forest plot



2) Funnel plot



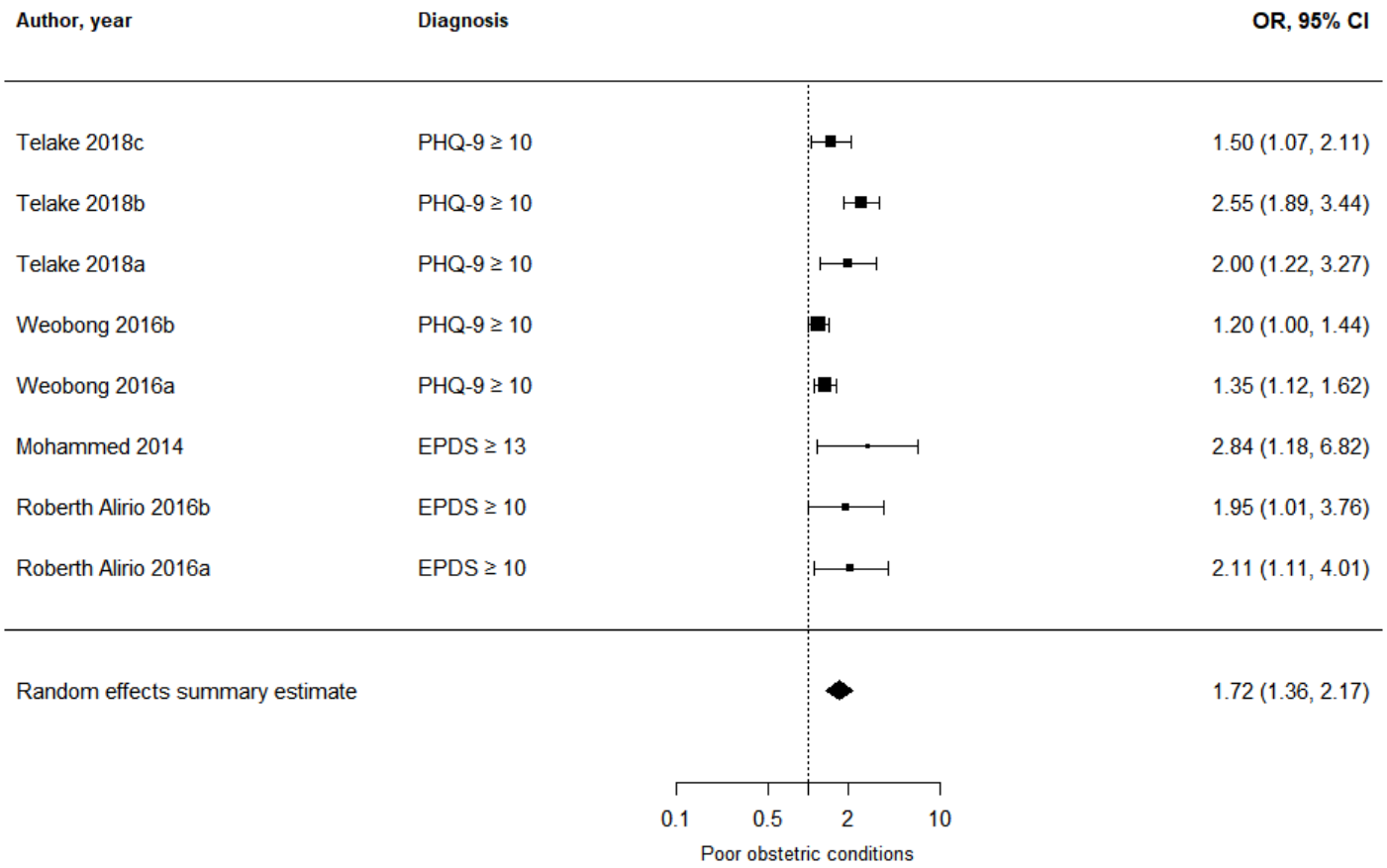
3) P curve analysis plot



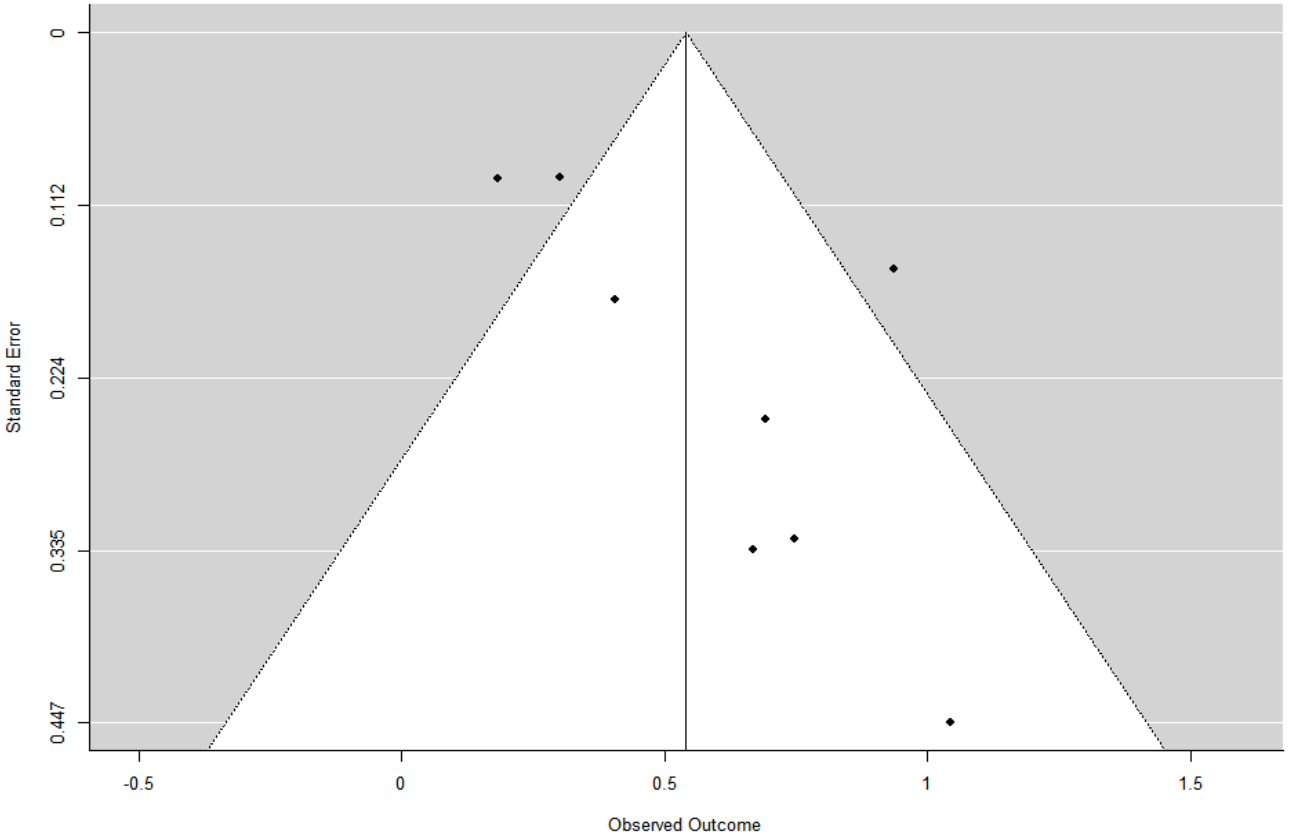
Note: The observed *p*-curve includes 6 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 4 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S34. Poor obstetric conditions (Forest plot, funnel plot, p curve analysis plot)

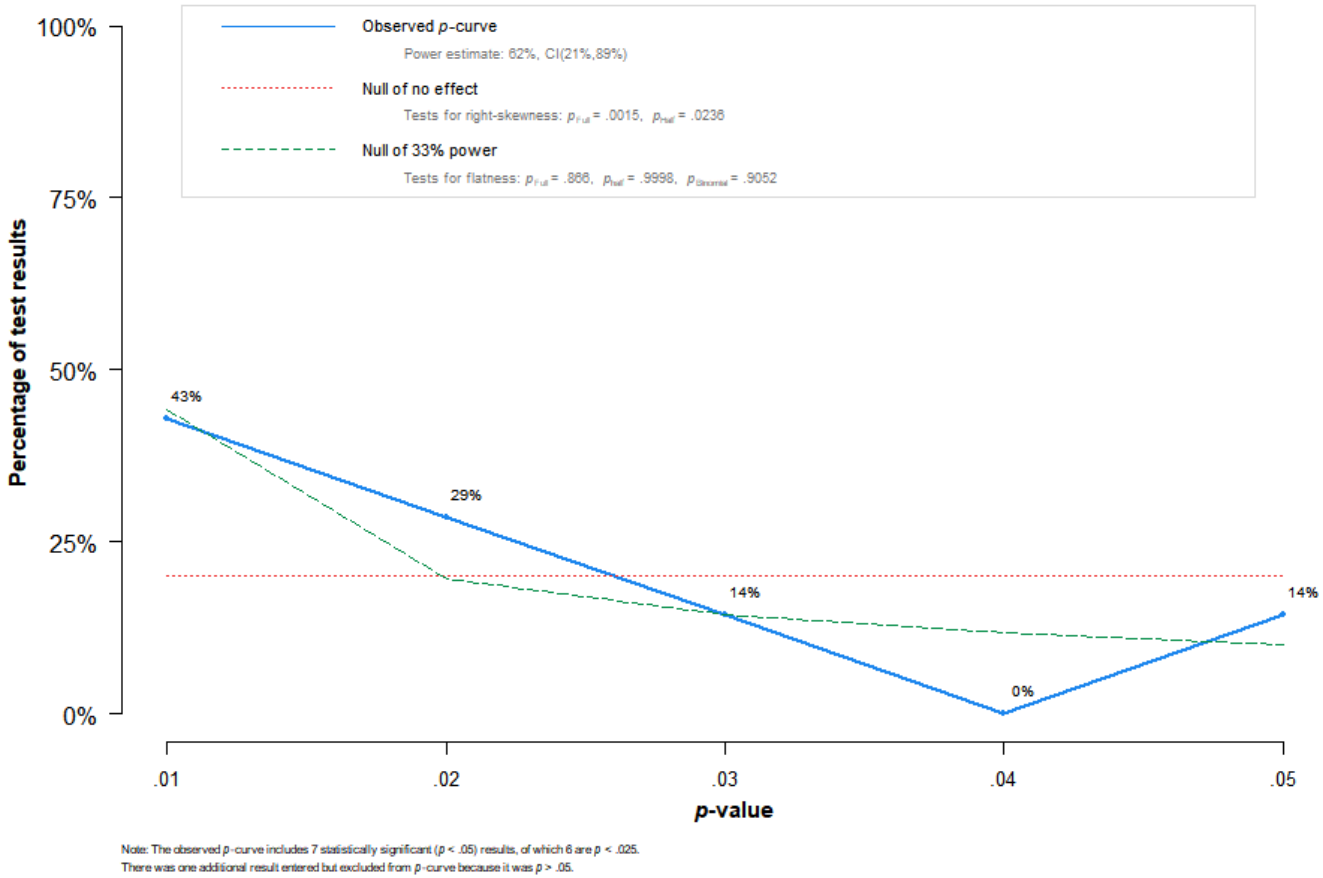
1) Forest plot



2) Funnel plot



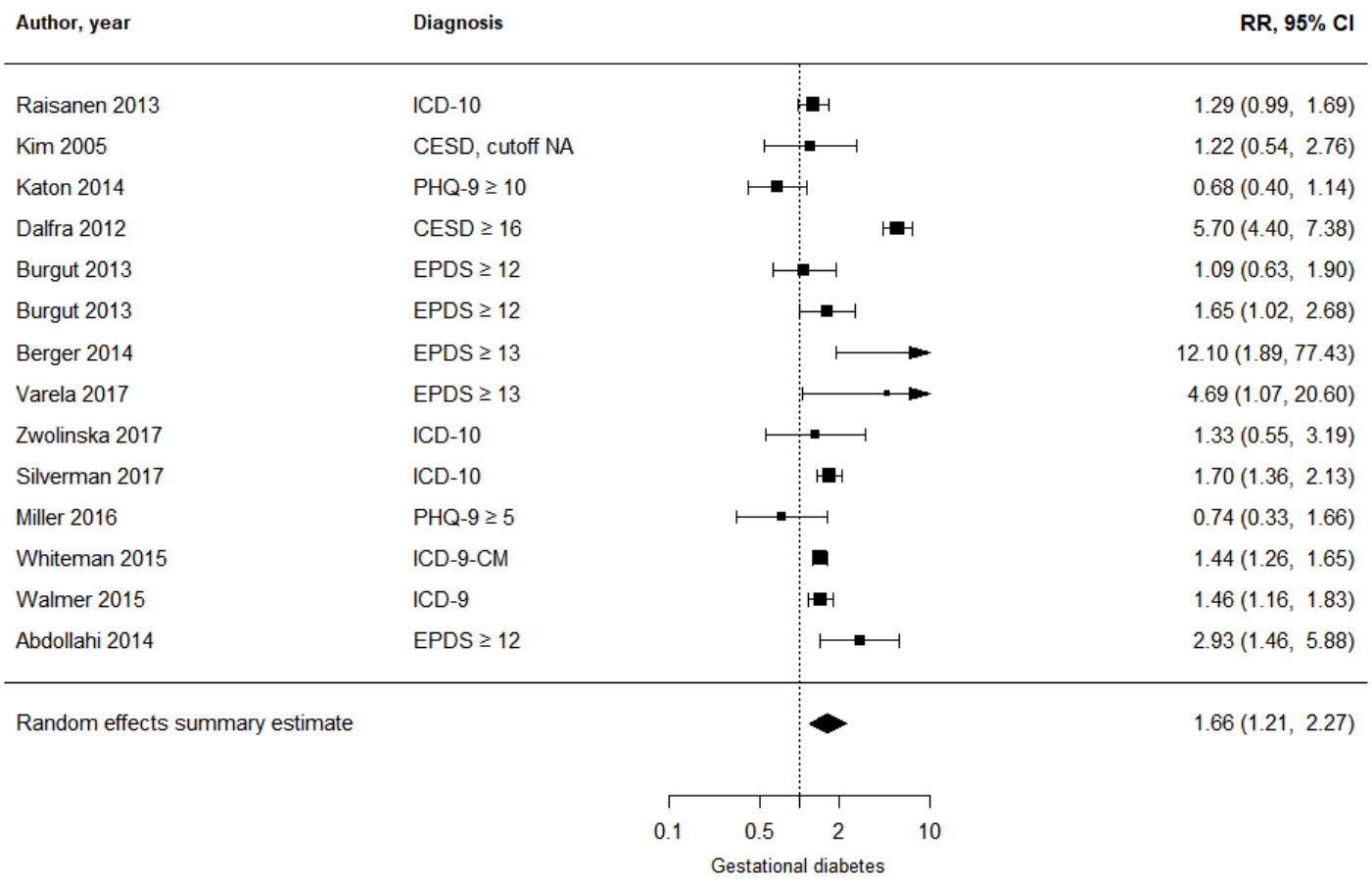
3) P curve analysis plot



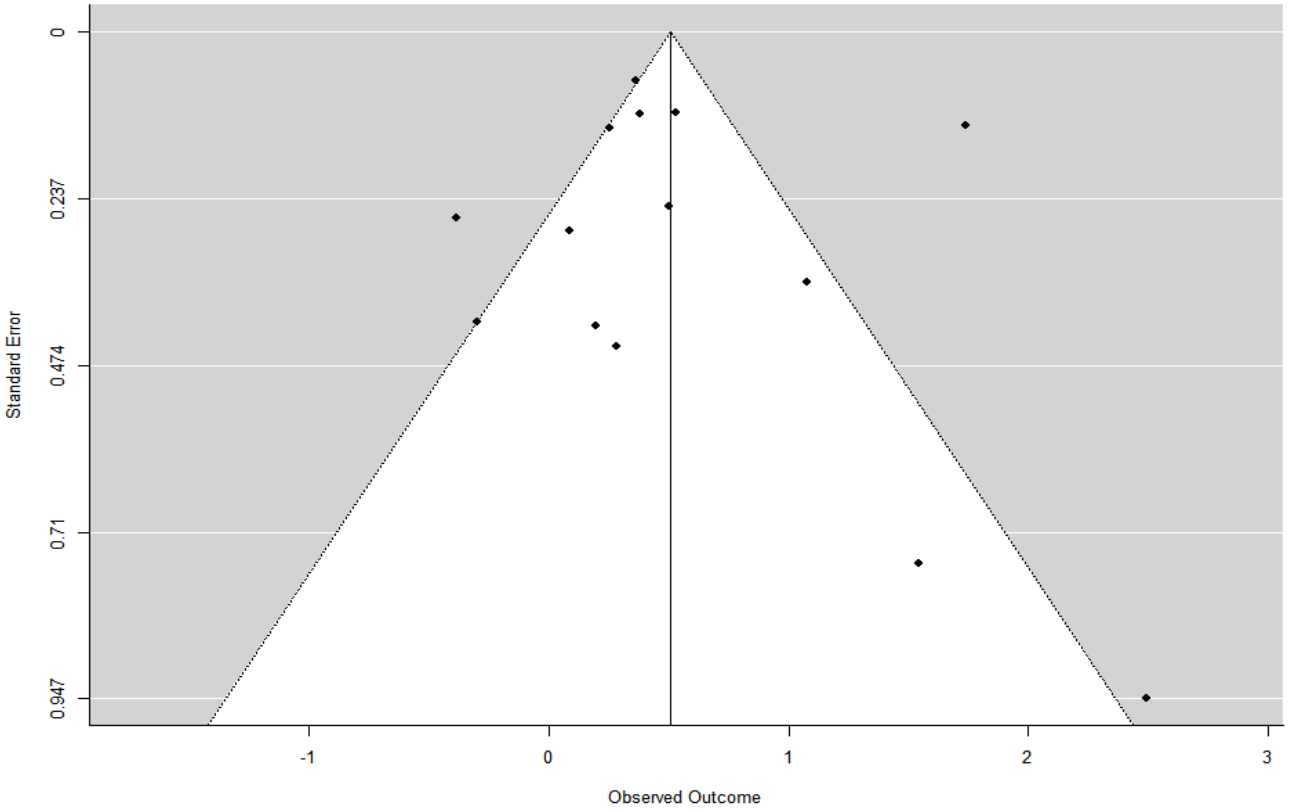
Note: The observed p-curve includes 7 statistically significant ($p < .05$) results, of which 6 are $p < .025$.
There was one additional result entered but excluded from p-curve because it was $p > .05$.

Figure S35. Gestational diabetes (Forest plot, funnel plot, p curve analysis plot)

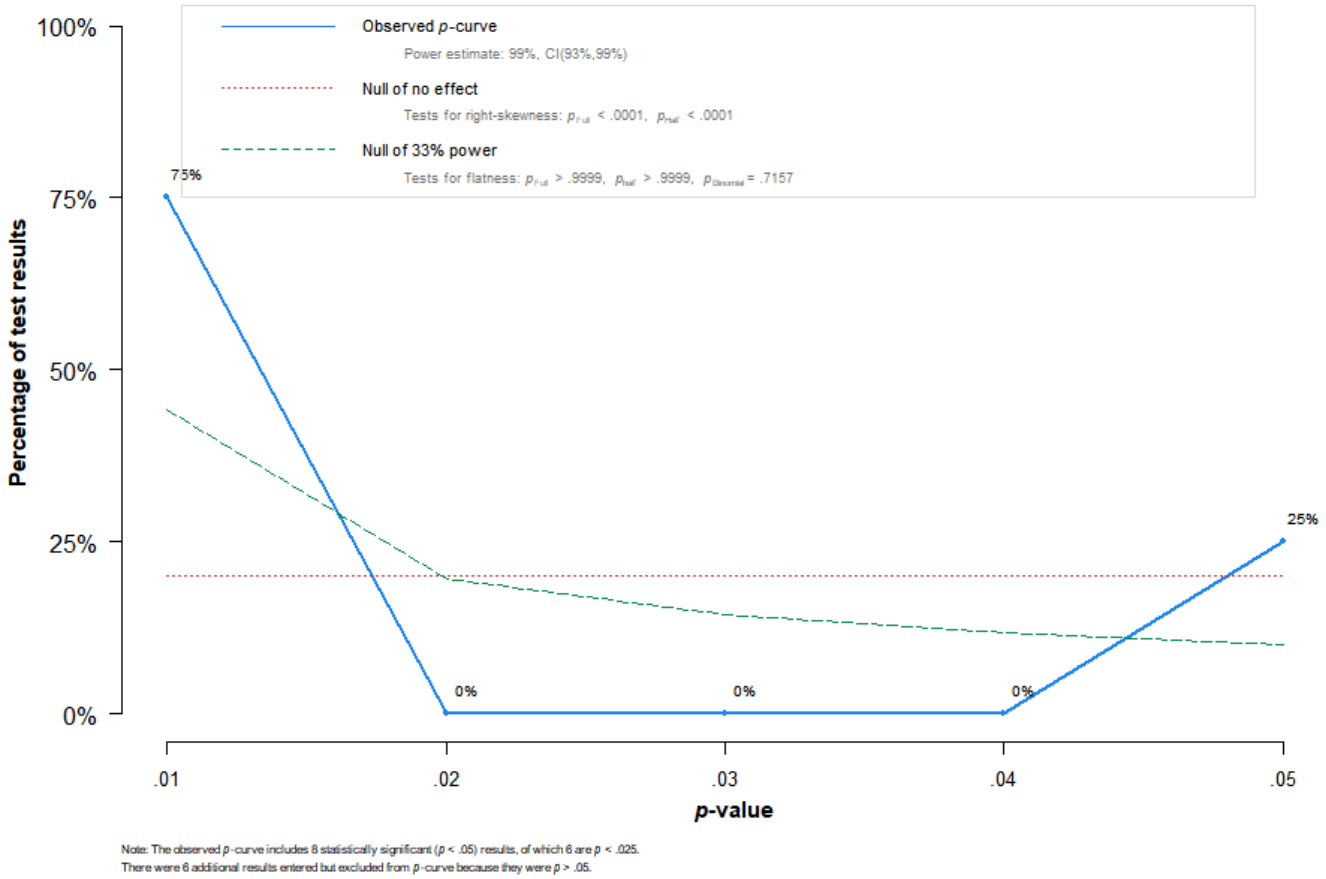
1) Forest plot



2) Funnel plot



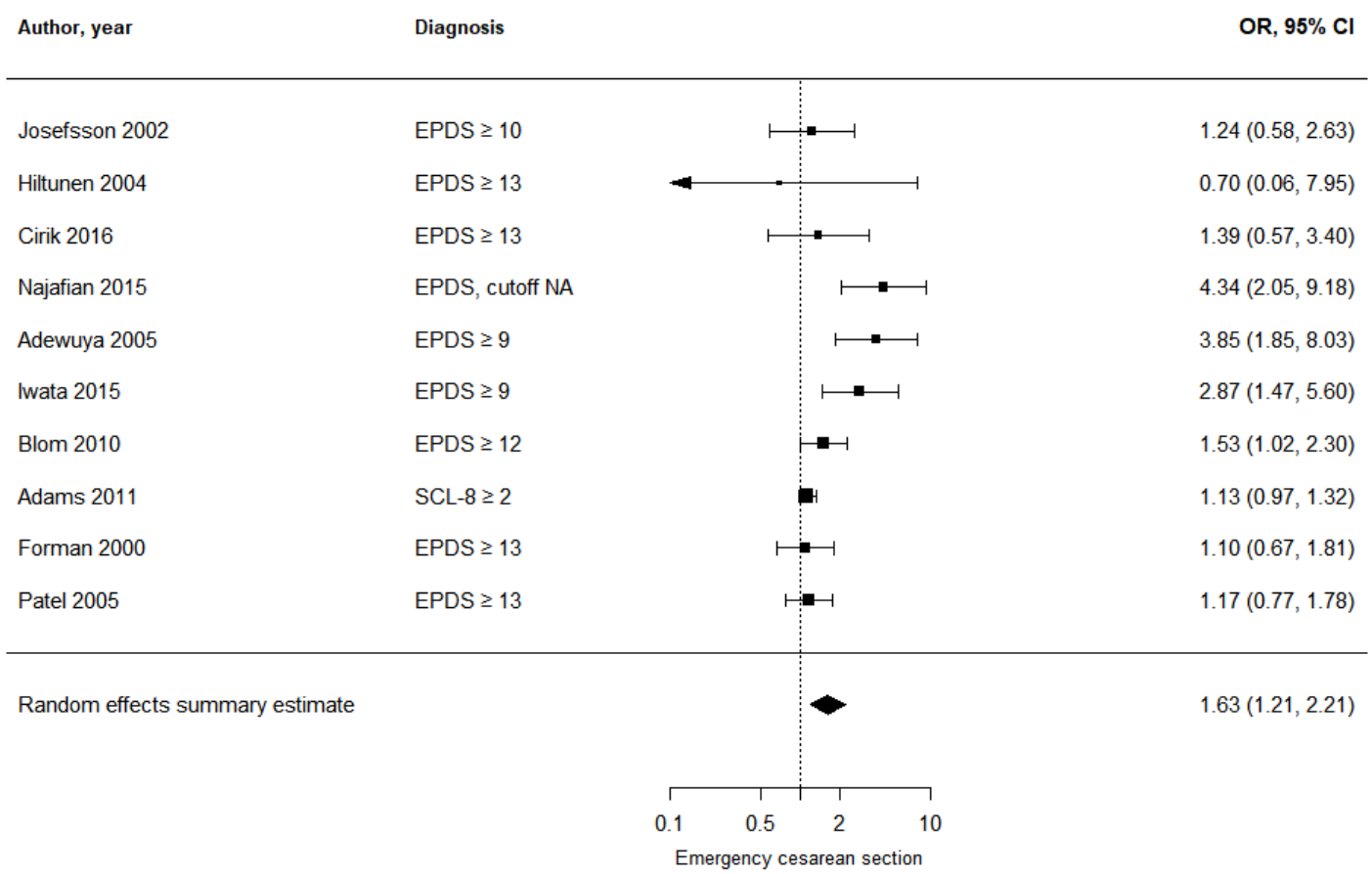
3) P curve analysis plot



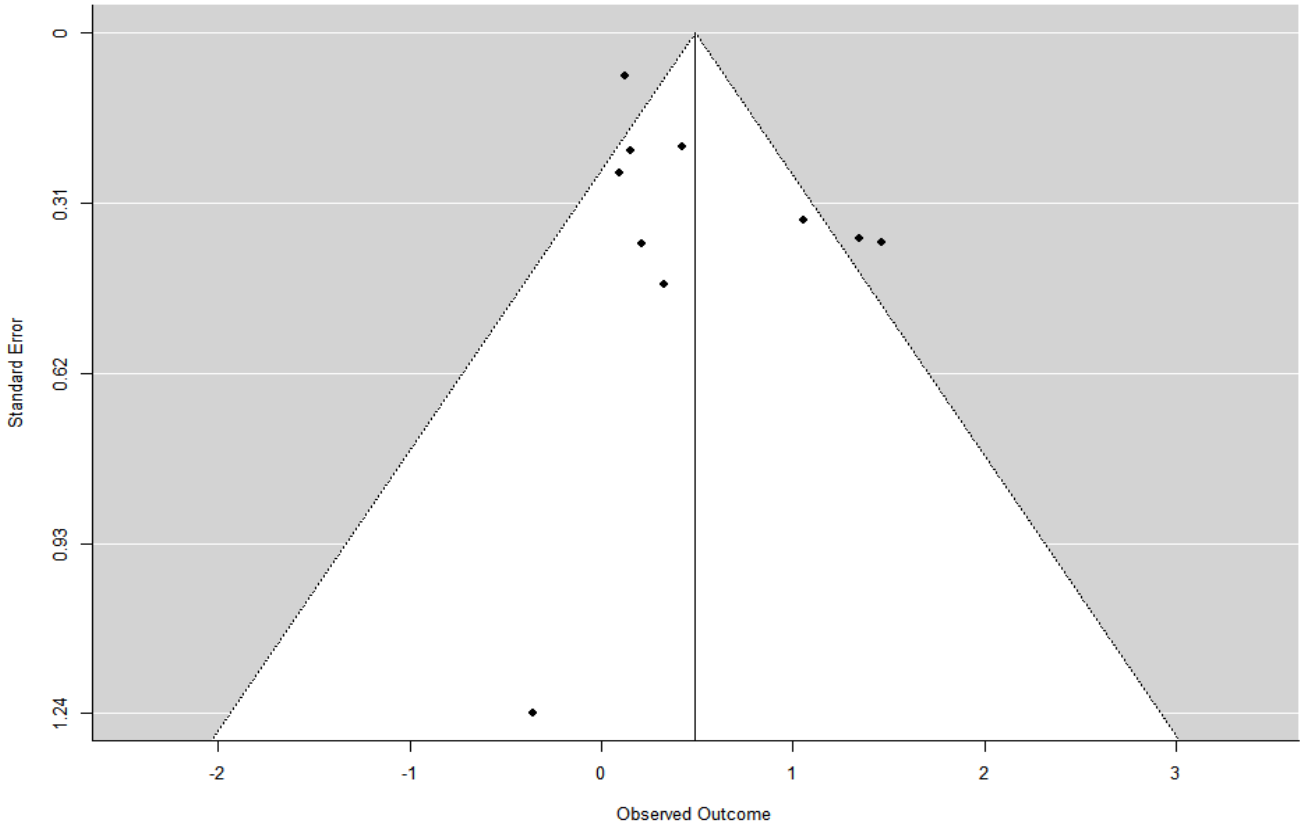
Note: The observed p-curve includes 8 statistically significant ($p < .05$) results, of which 6 are $p < .025$.
There were 6 additional results entered but excluded from p-curve because they were $p > .05$.

Figure S36. Emergency cesarean section (Forest plot, funnel plot, p curve analysis plot)

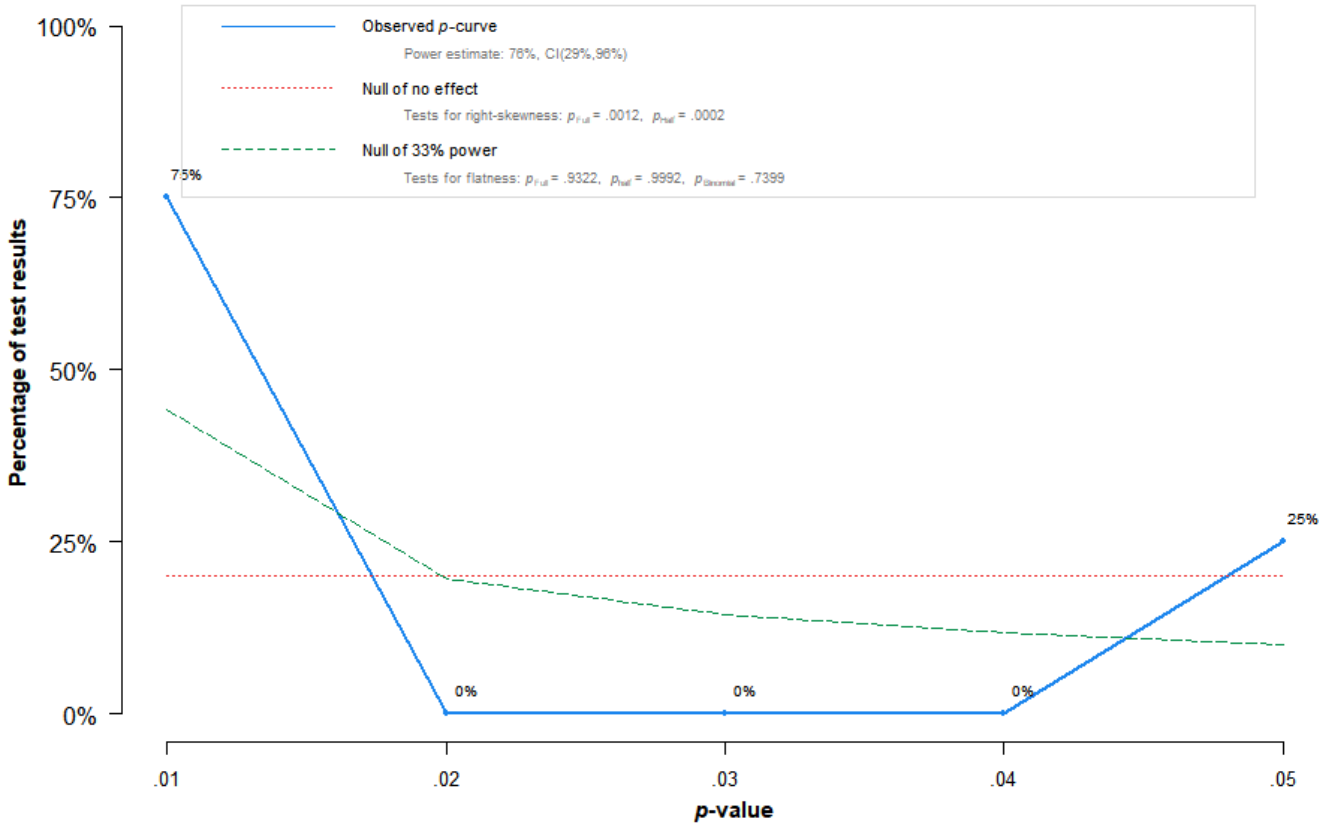
1) Forest plot



2) Funnel plot



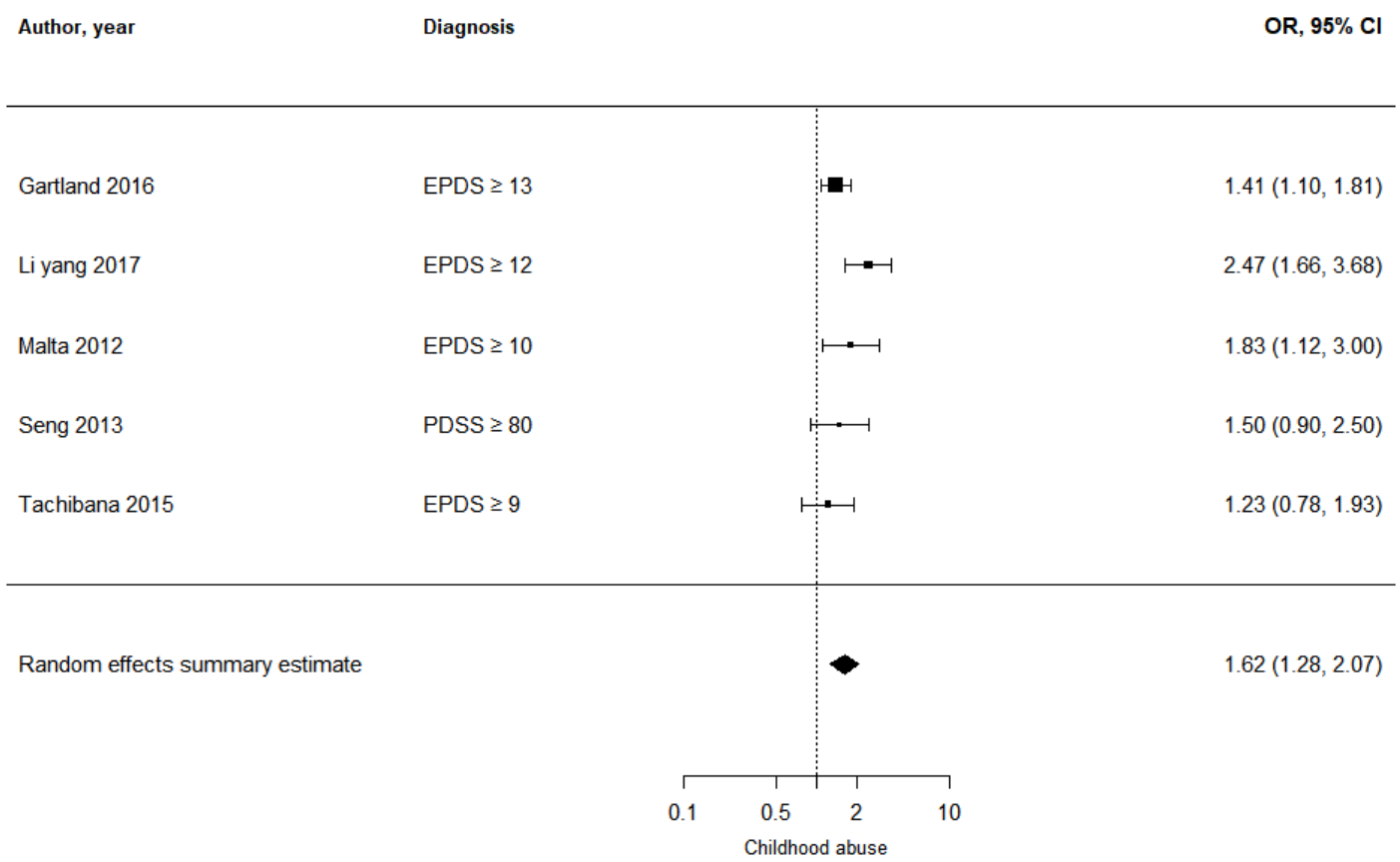
3) P curve analysis plot



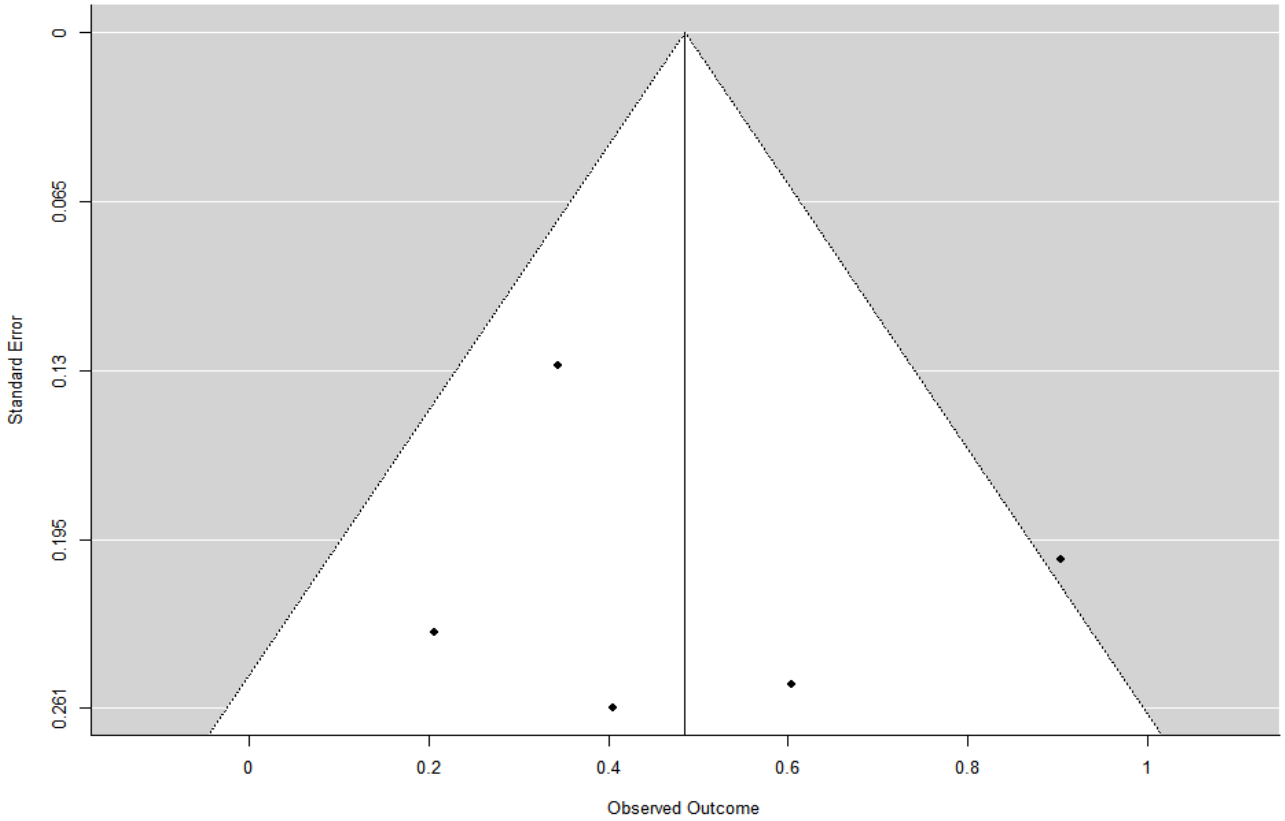
Note: The observed p-curve includes 4 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were 6 additional results entered but excluded from p-curve because they were $p > .05$.

Figure S37. Childhood abuse (Forest plot, funnel plot, p curve analysis plot)

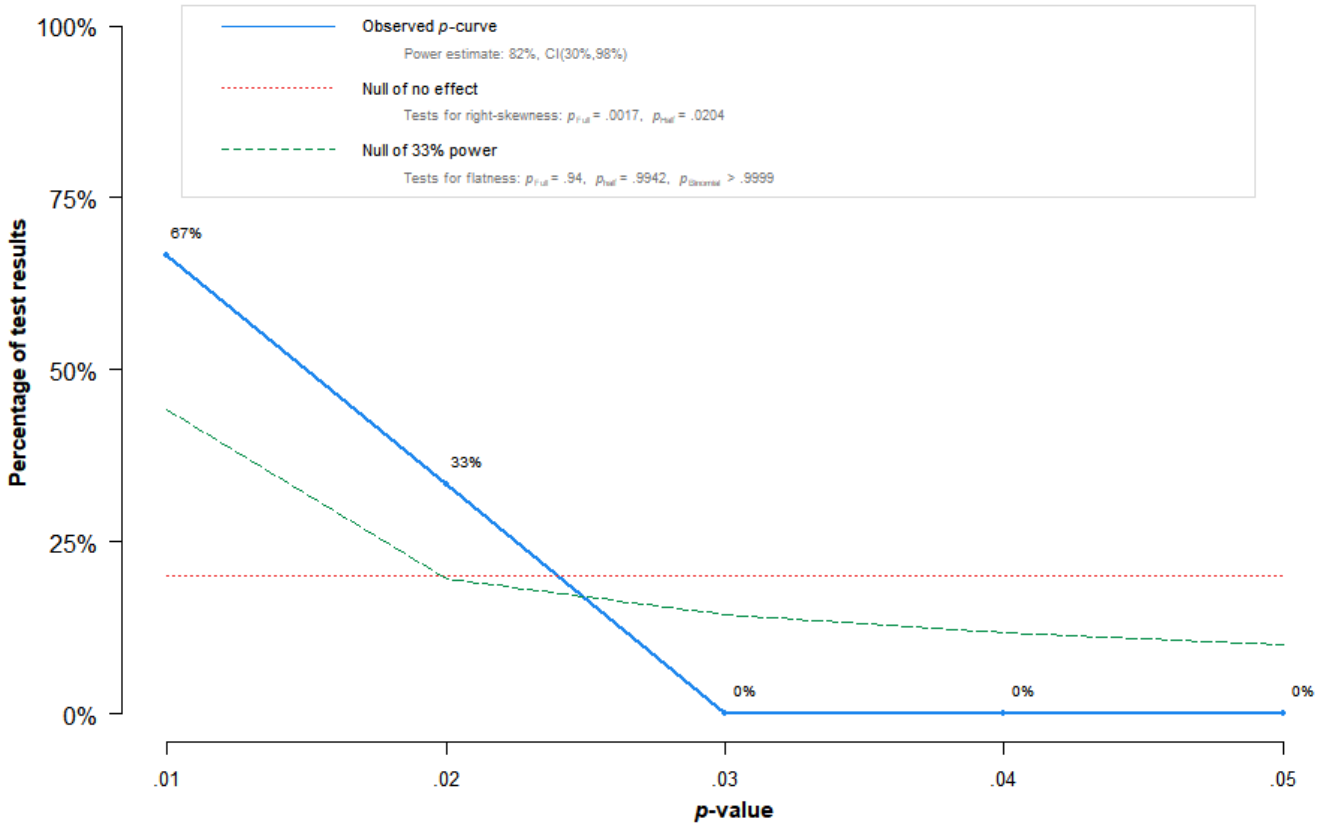
1) Forest plot



2) Funnel plot



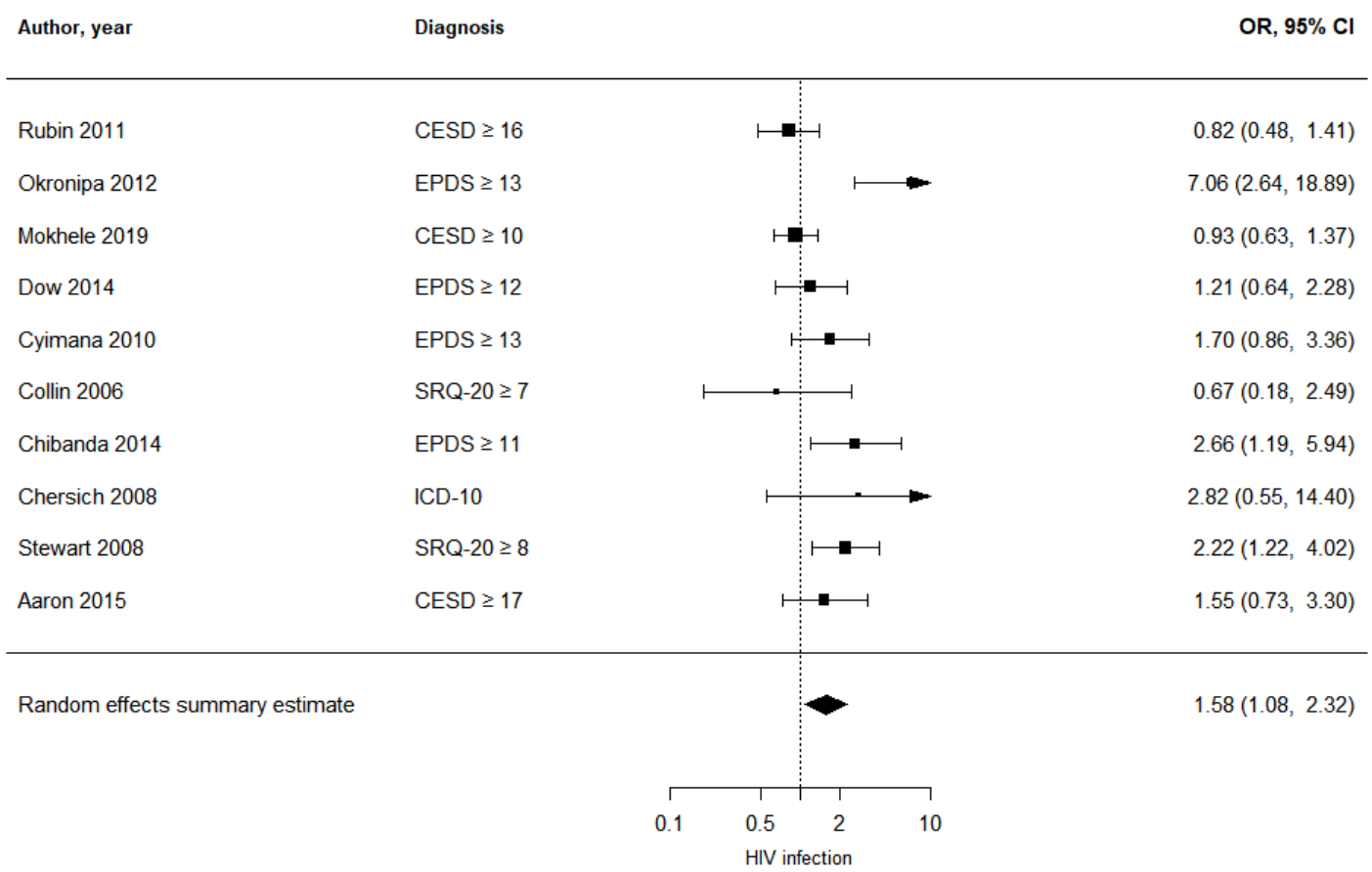
3) P curve analysis plot



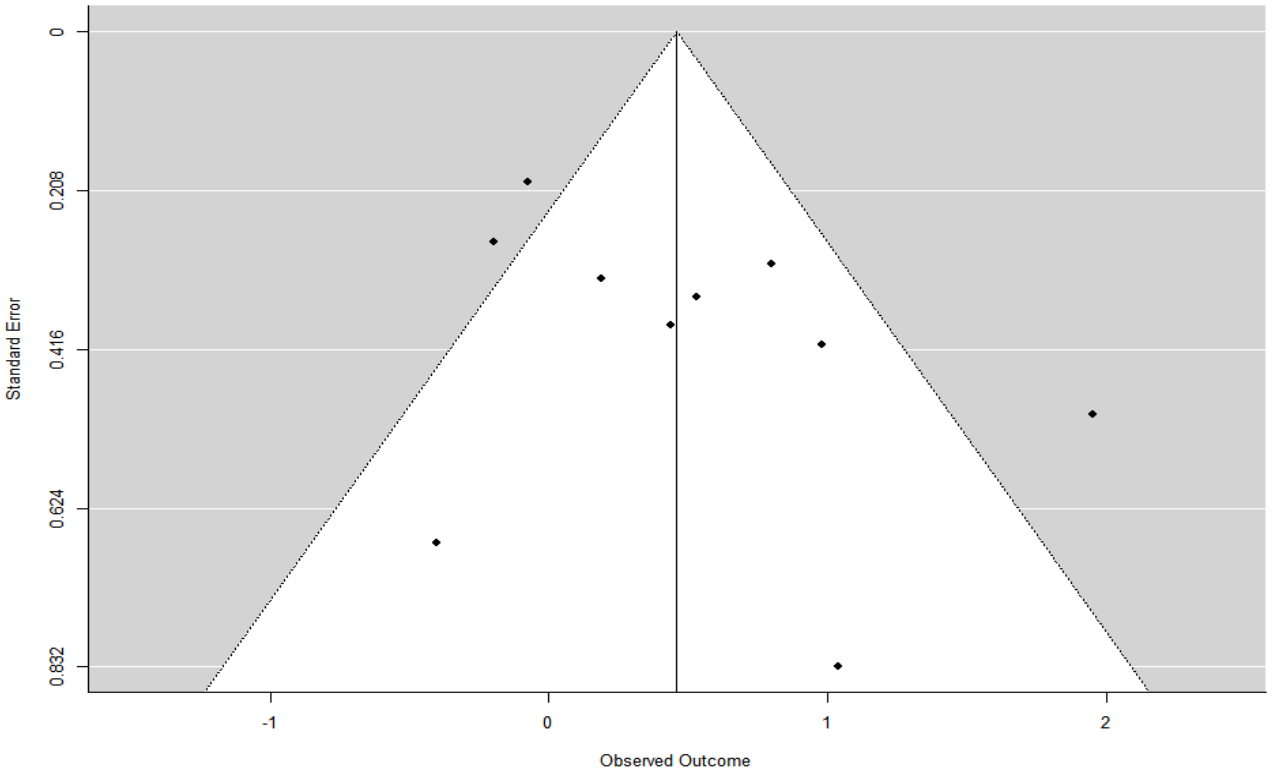
Note: The observed *p*-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were 2 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S38. HIV infection (Forest plot, funnel plot, p curve analysis plot)

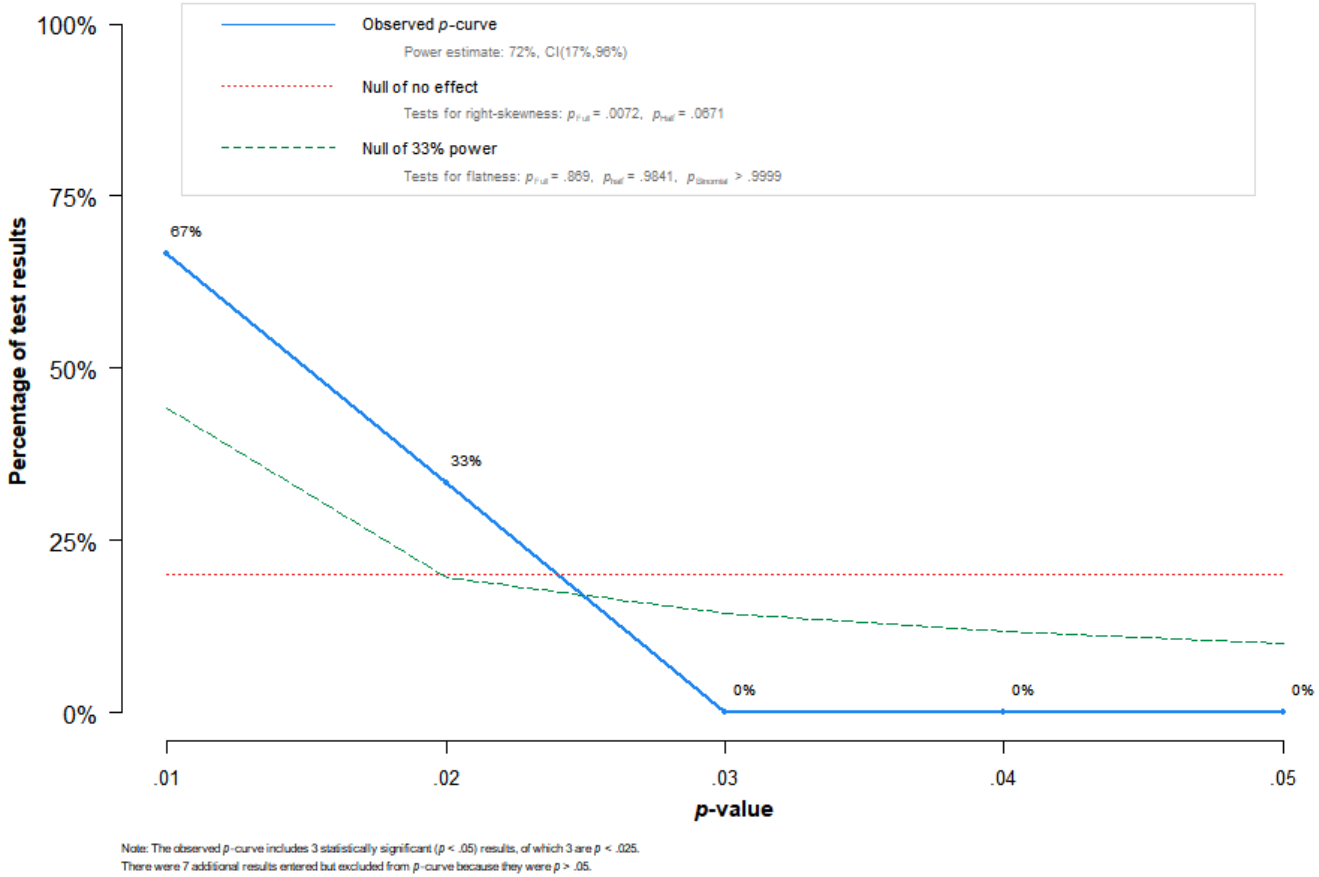
1) Forest plot



2) Funnel plot


Standard Error
0
0.208
0.416
0.624
0.832
-1
0
1
2
Observed Outcome

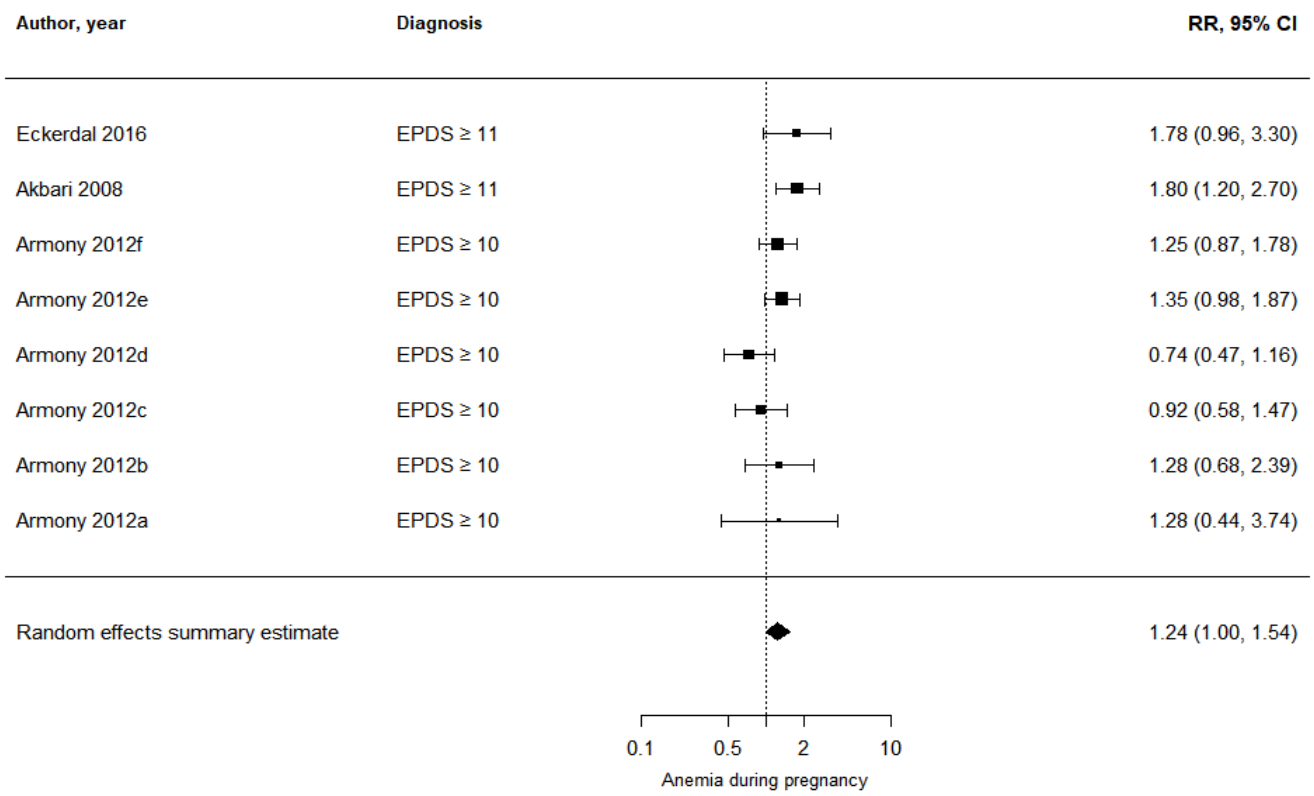
3) P curve analysis plot



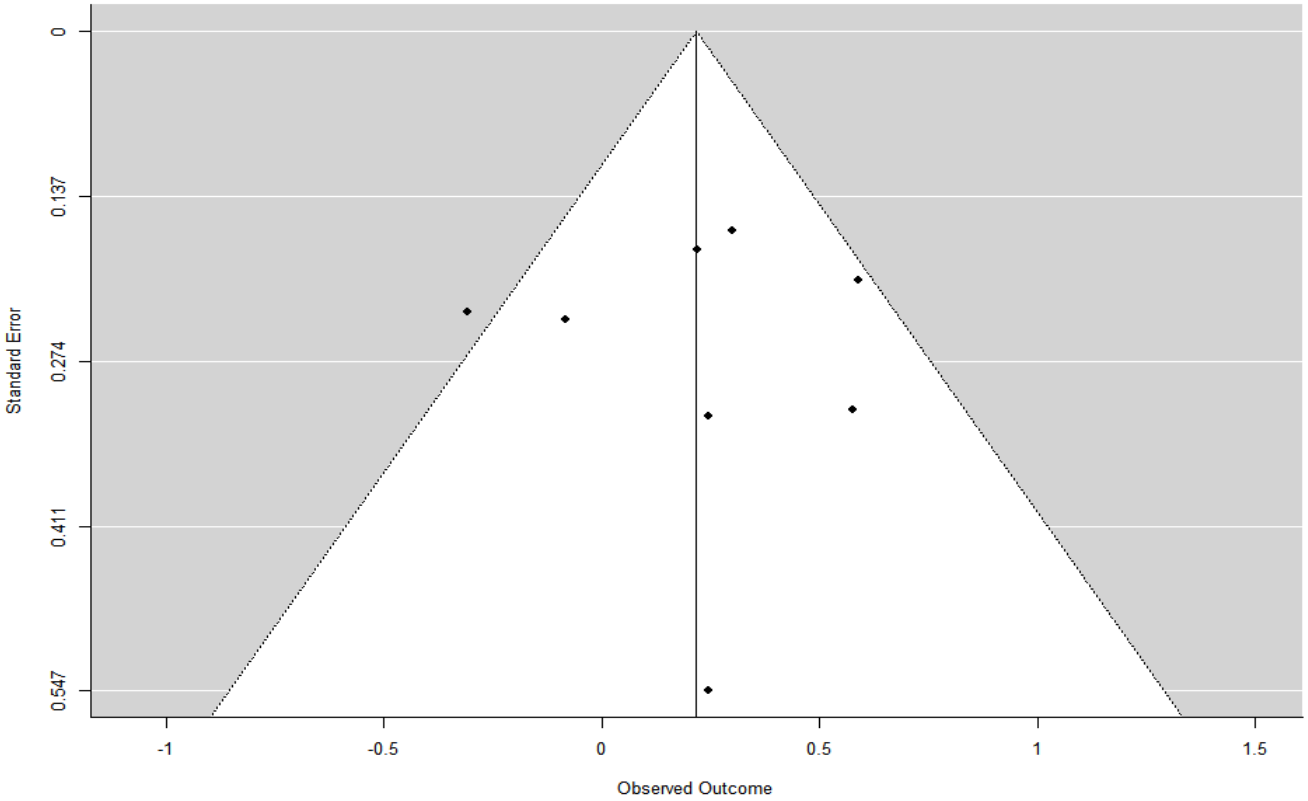
Note: The observed *p*-curve includes 3 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There were 7 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S39. Anemia during pregnancy (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

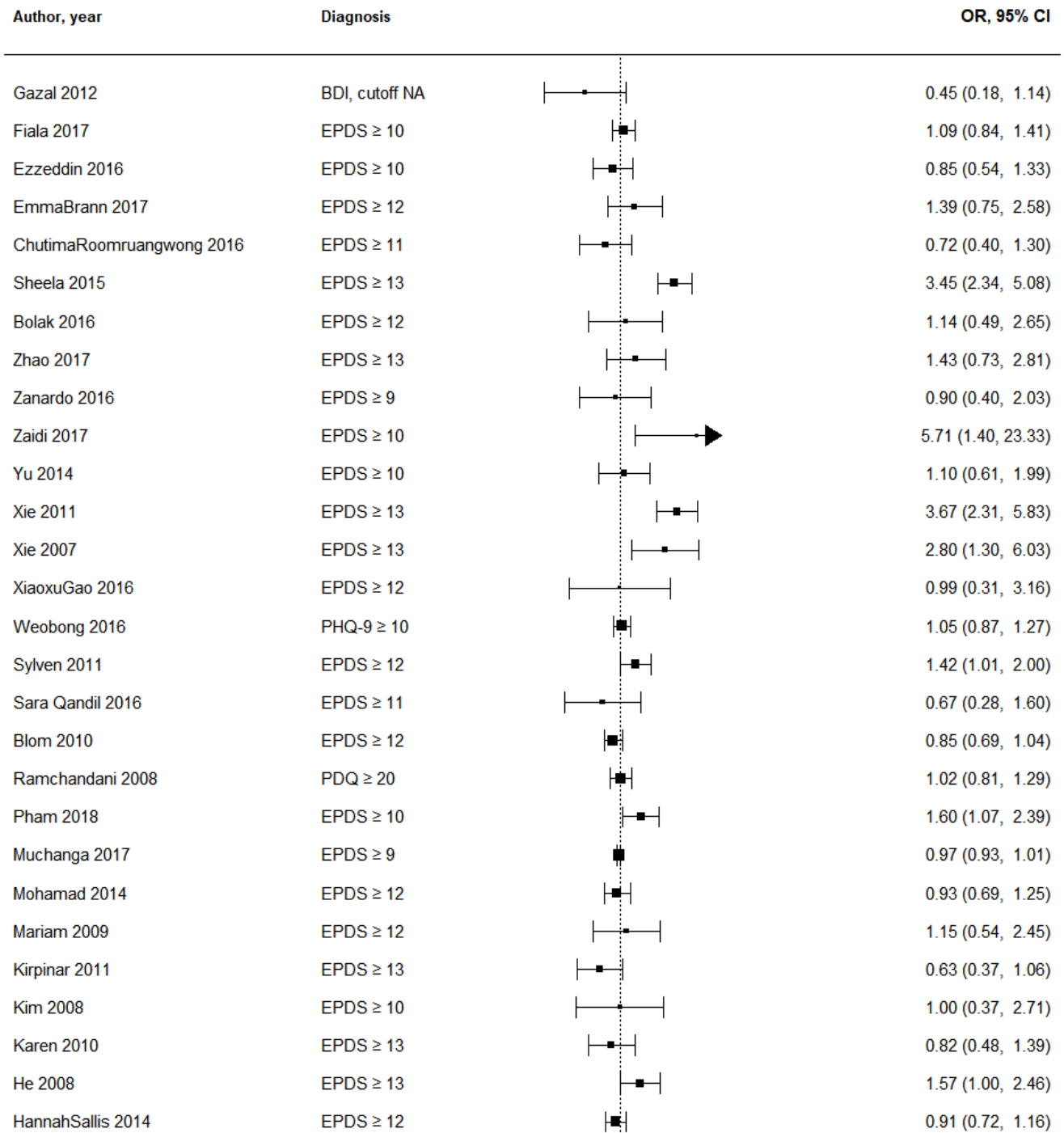


3) P curve analysis plot

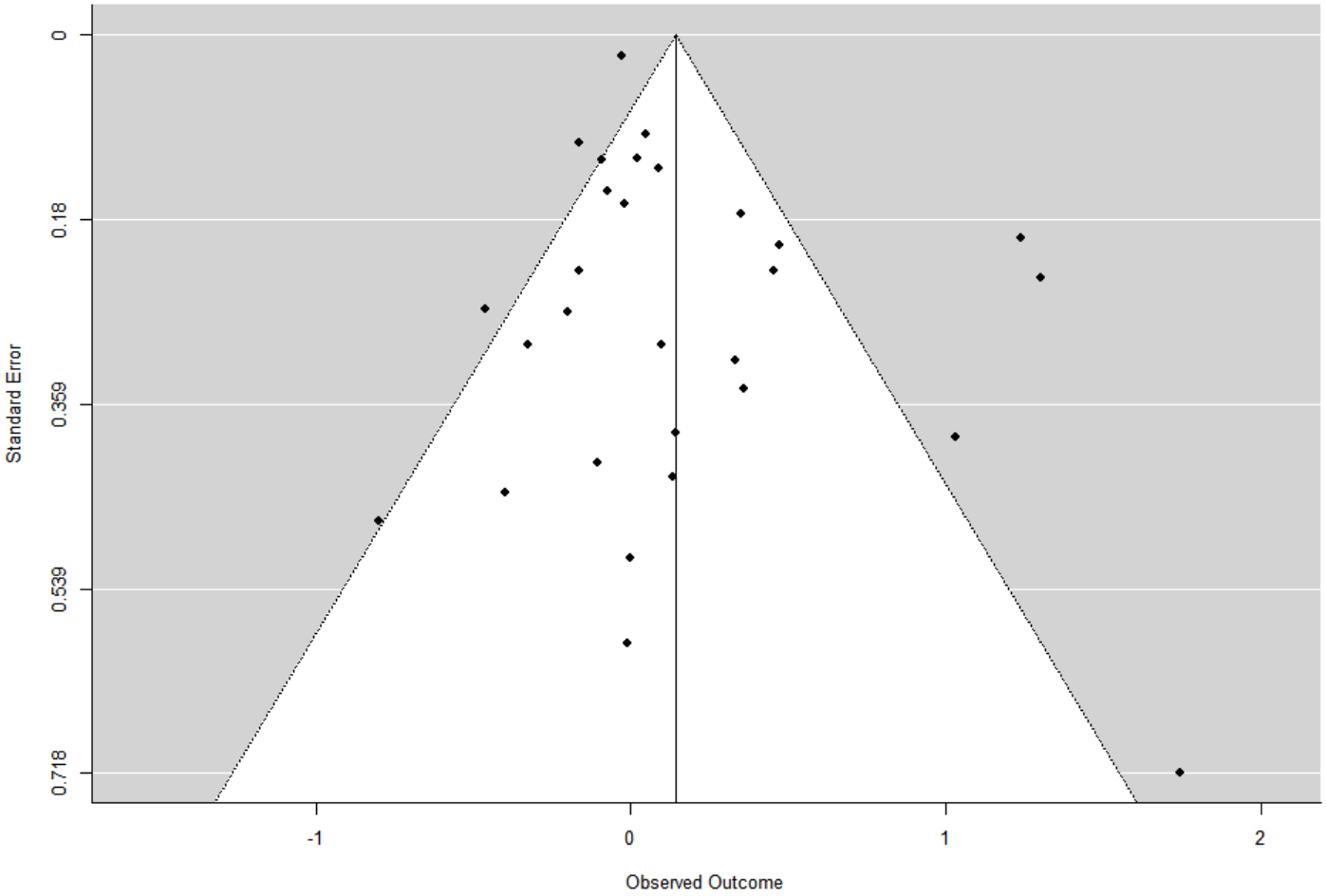
Not available because of the small number of studies

Figure S40. Female infant compared to male infant (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot


Author, year
Diagnosis
OR, 95% CI
Gazal 2012
BDI, cutoff NA
0.45 (0.18, 1.14)
Fiala 2017
EPDS ≥ 10
1.09 (0.84, 1.41)
Ezzeddin 2016
EPDS ≥ 10
0.85 (0.54, 1.33)
EmmaBrann 2017
EPDS ≥ 12
1.39 (0.75, 2.58)
ChutimaRoomruangwong 2016
EPDS ≥ 11
0.72 (0.40, 1.30)
Sheela 2015
EPDS ≥ 13
3.45 (2.34, 5.08)
Bolak 2016
EPDS ≥ 12
1.14 (0.49, 2.65)
Zhao 2017
EPDS ≥ 13
1.43 (0.73, 2.81)
Zanardo 2016
EPDS ≥ 9
0.90 (0.40, 2.03)
Zaidi 2017
EPDS ≥ 10
5.71 (1.40, 23.33)
Yu 2014
EPDS ≥ 10
1.10 (0.61, 1.99)
Xie 2011
EPDS ≥ 13
3.67 (2.31, 5.83)
Xie 2007
EPDS ≥ 13
2.80 (1.30, 6.03)
XiaoxuGao 2016
EPDS ≥ 12
0.99 (0.31, 3.16)
Weobong 2016
PHQ-9 ≥ 10
1.05 (0.87, 1.27)
Sylven 2011
EPDS ≥ 12
1.42 (1.01, 2.00)
Sara Qandil 2016
EPDS ≥ 11
0.67 (0.28, 1.60)
Blom 2010
EPDS ≥ 12
0.85 (0.69, 1.04)
Ramchandani 2008
PDQ ≥ 20
1.02 (0.81, 1.29)
Pham 2018
EPDS ≥ 10
1.60 (1.07, 2.39)
Muchanga 2017
EPDS ≥ 9
0.97 (0.93, 1.01)
Mohamad 2014
EPDS ≥ 12
0.93 (0.69, 1.25)
Mariam 2009
EPDS ≥ 12
1.15 (0.54, 2.45)
Kirpinar 2011
EPDS ≥ 13
0.63 (0.37, 1.06)
Kim 2008
EPDS ≥ 10
1.00 (0.37, 2.71)
Karen 2010
EPDS ≥ 13
0.82 (0.48, 1.39)
He 2008
EPDS ≥ 13
1.57 (1.00, 2.46)
HannahSallis 2014
EPDS ≥ 12
0.91 (0.72, 1.16)

2) Funnel plot



3) P curve analysis plot

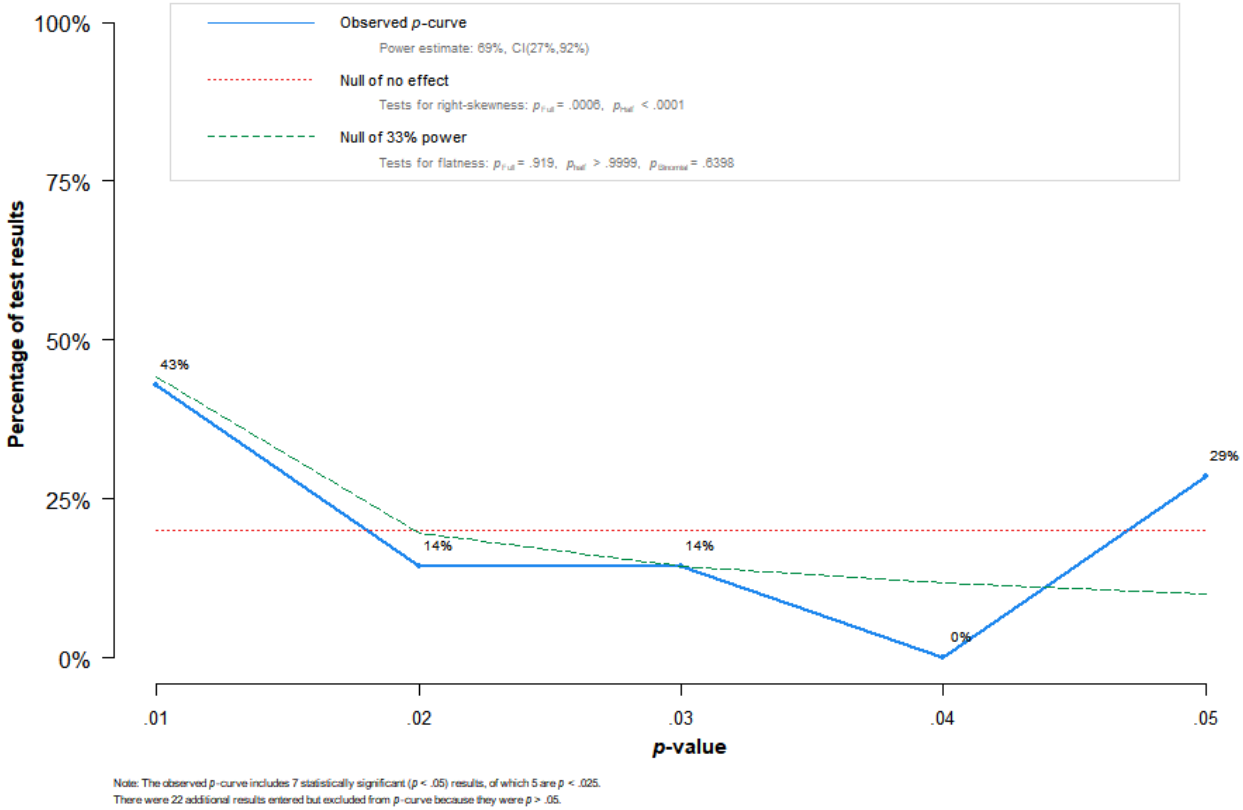
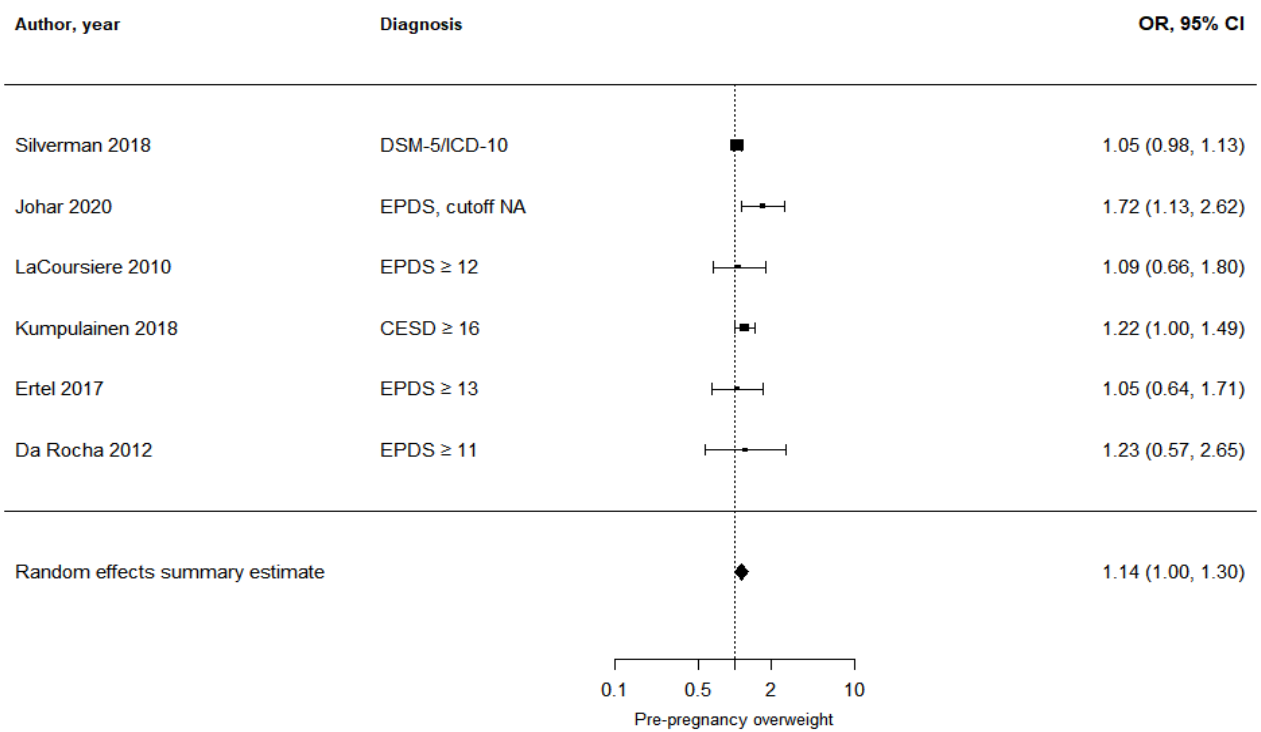
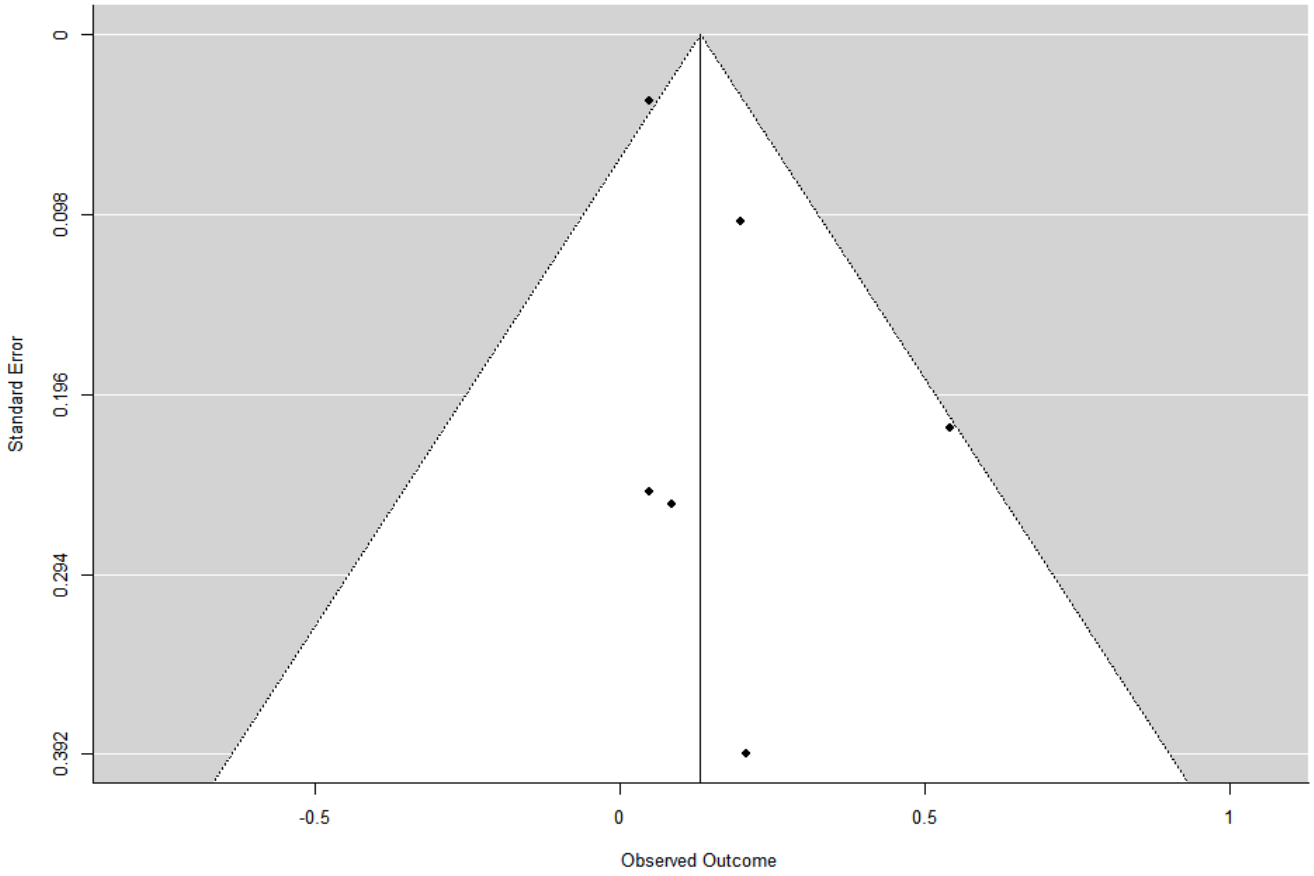


Figure S41. Pre-pregnancy overweight (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

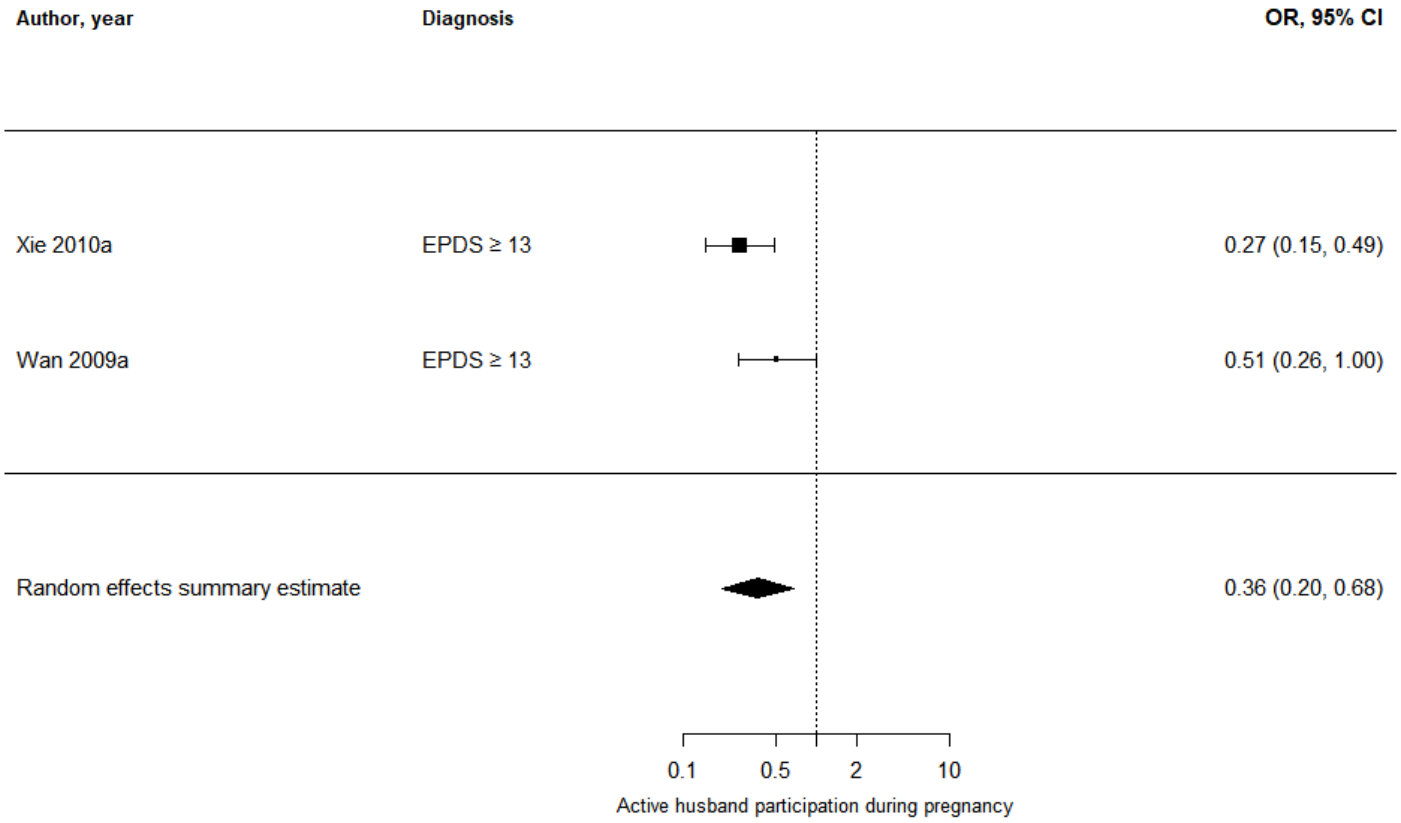


3) P curve analysis plot

Not available because of the small number of studies

Figure S42. Active husband participation in maternal healthcare/services during pregnancy (Forest plot)

1) Forest plot



2) Funnel plot

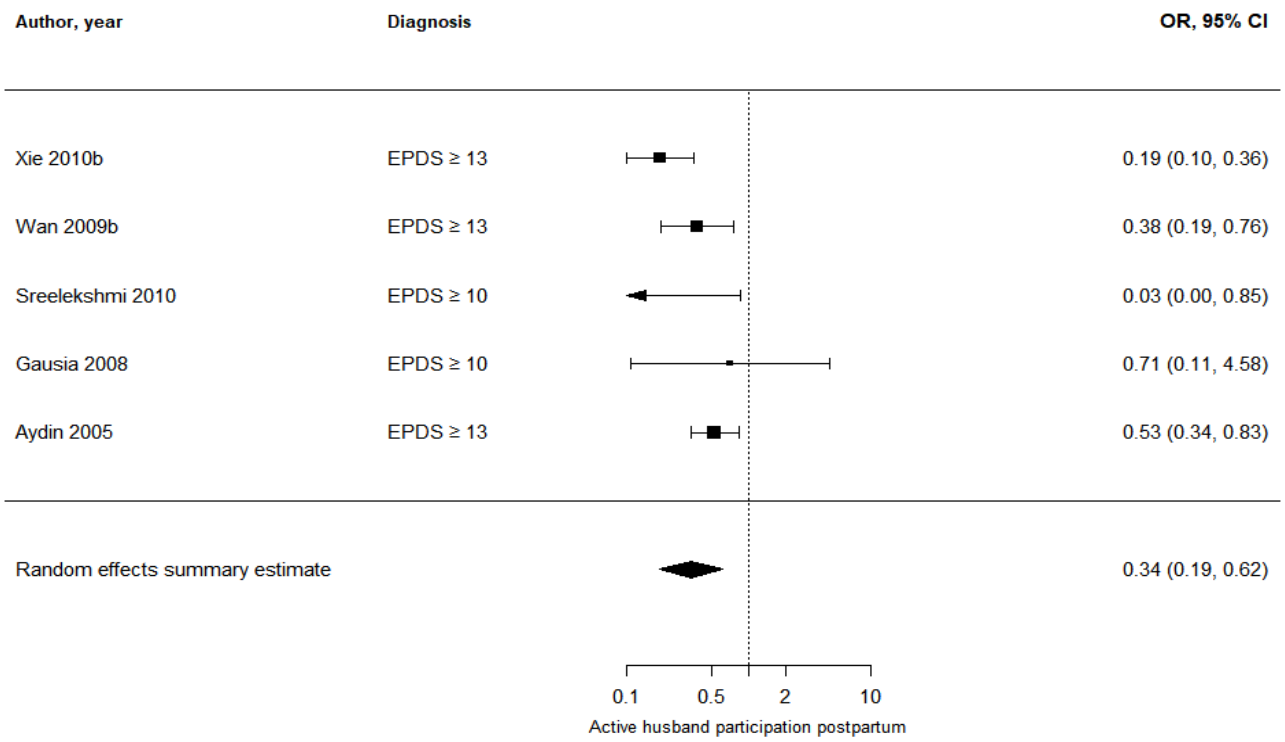
Not available because of the small number of studies

3) P curve analysis plot

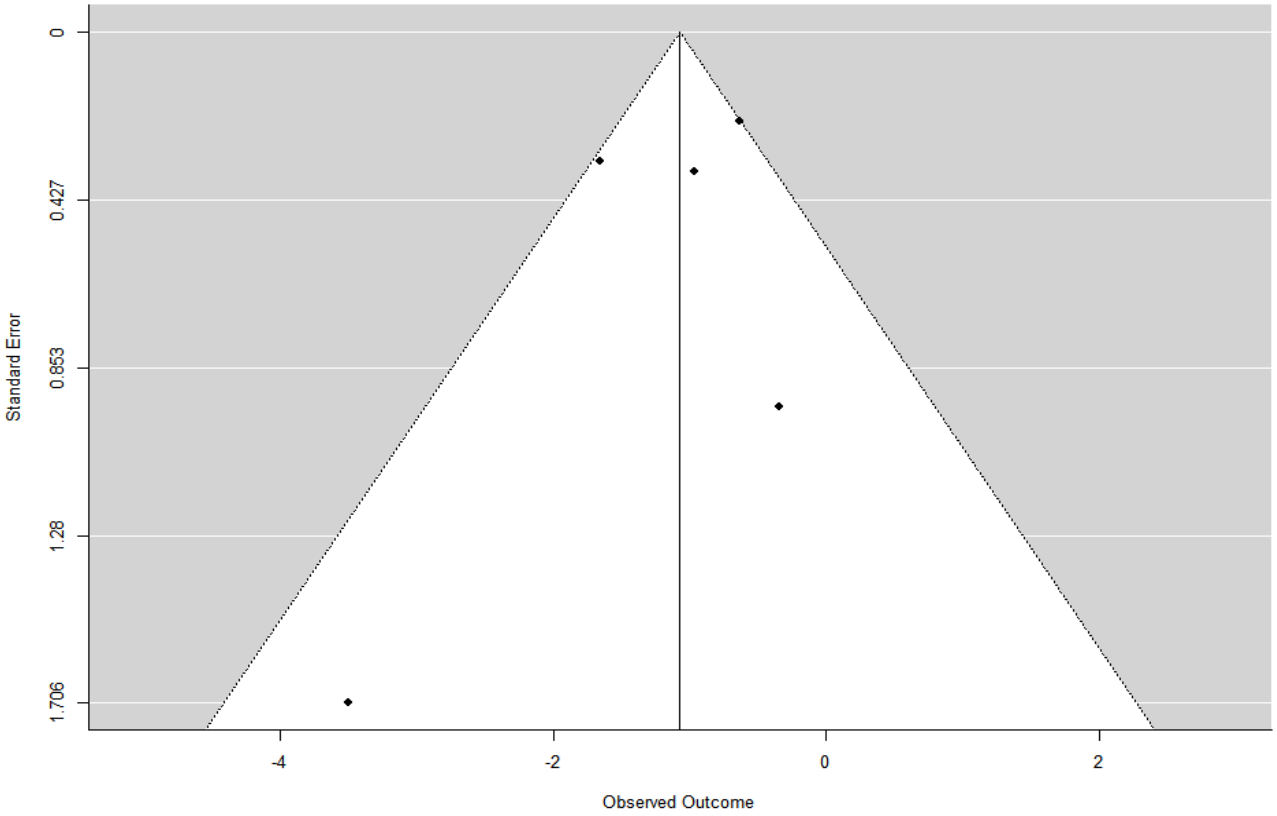
Not available because of the small number of studies

Figure S43. Active husband participation in maternal healthcare/services postpartum (Forest plot, funnel plot, p curve analysis plot)

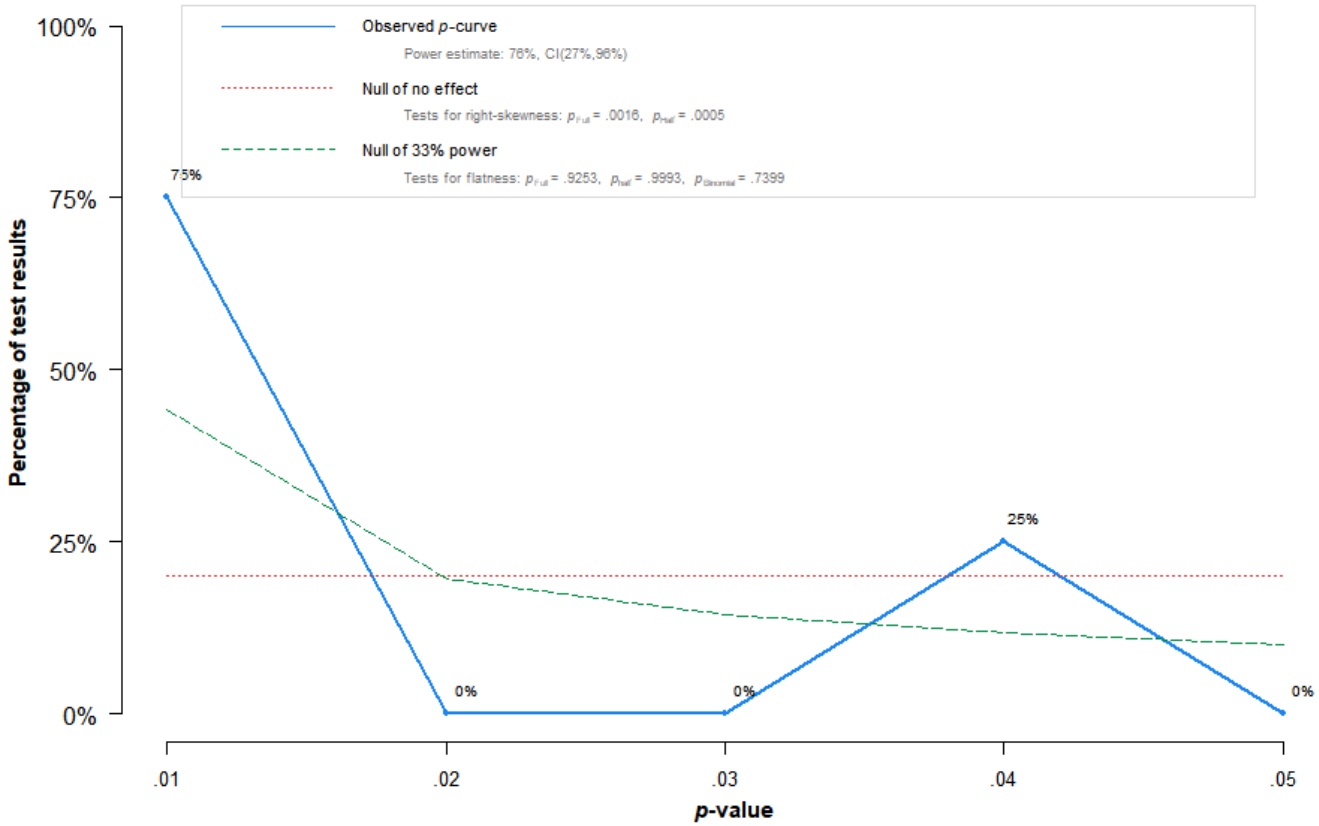
1) Forest plot



2) Funnel plot



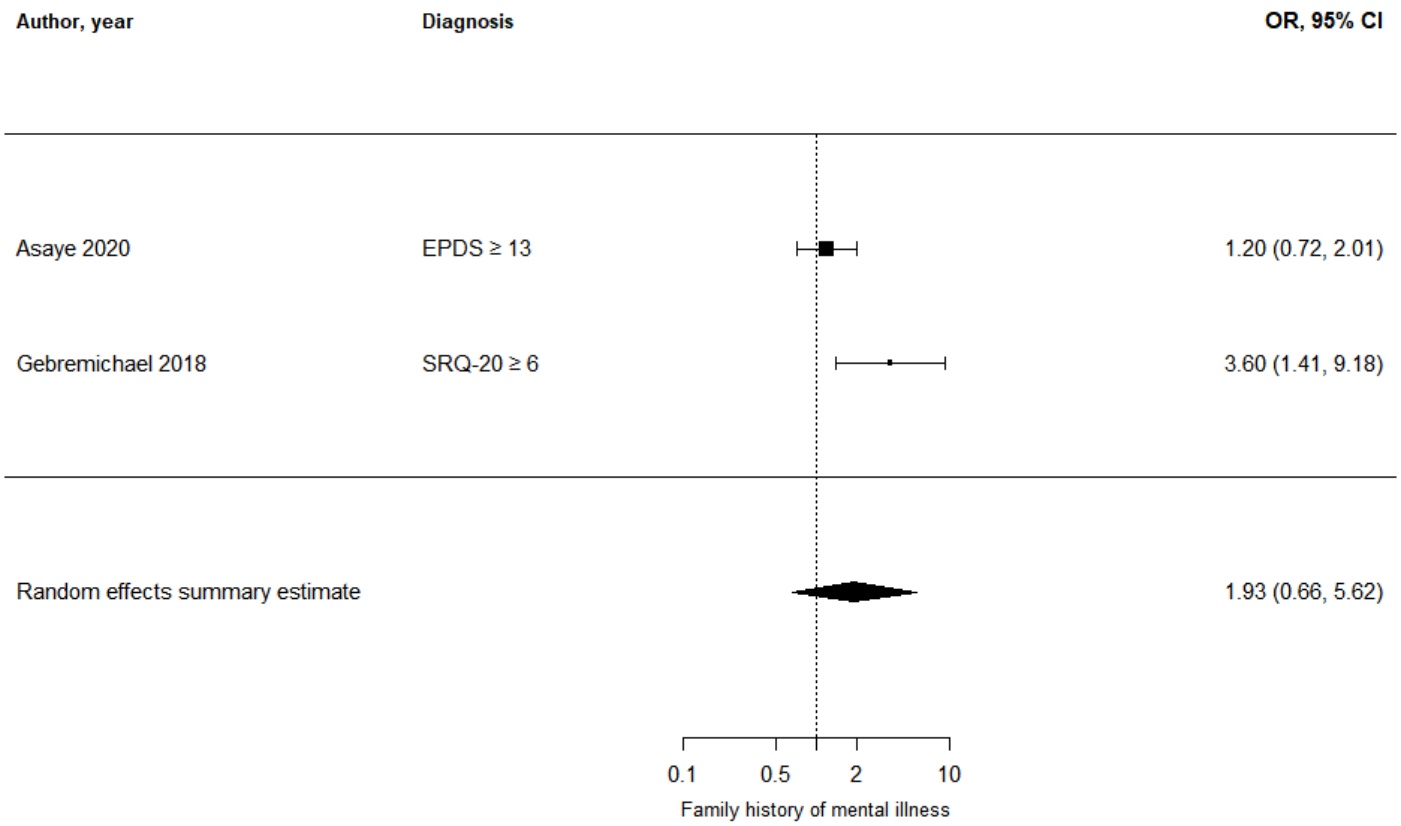
3) P curve analysis plot



Note: The observed p-curve includes 4 statistically significant ($p < .05$) results, of which 3 are $p < .025$.
There was one additional result entered but excluded from p-curve because it was $p > .05$.

Figure S44. Family history of mental illness (Forest plot)

1) Forest plot



2) Funnel plot

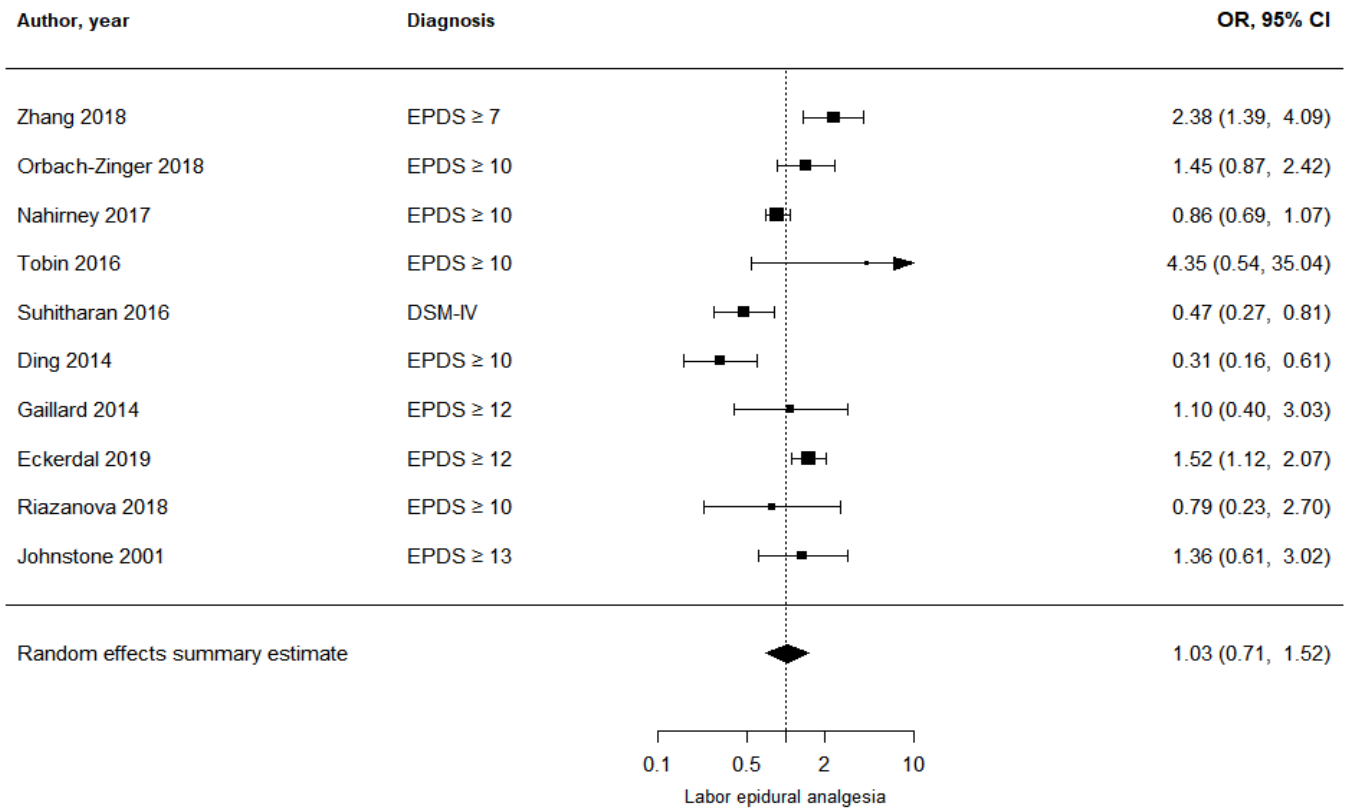
Not available because of the small number of studies

3) P curve analysis plot

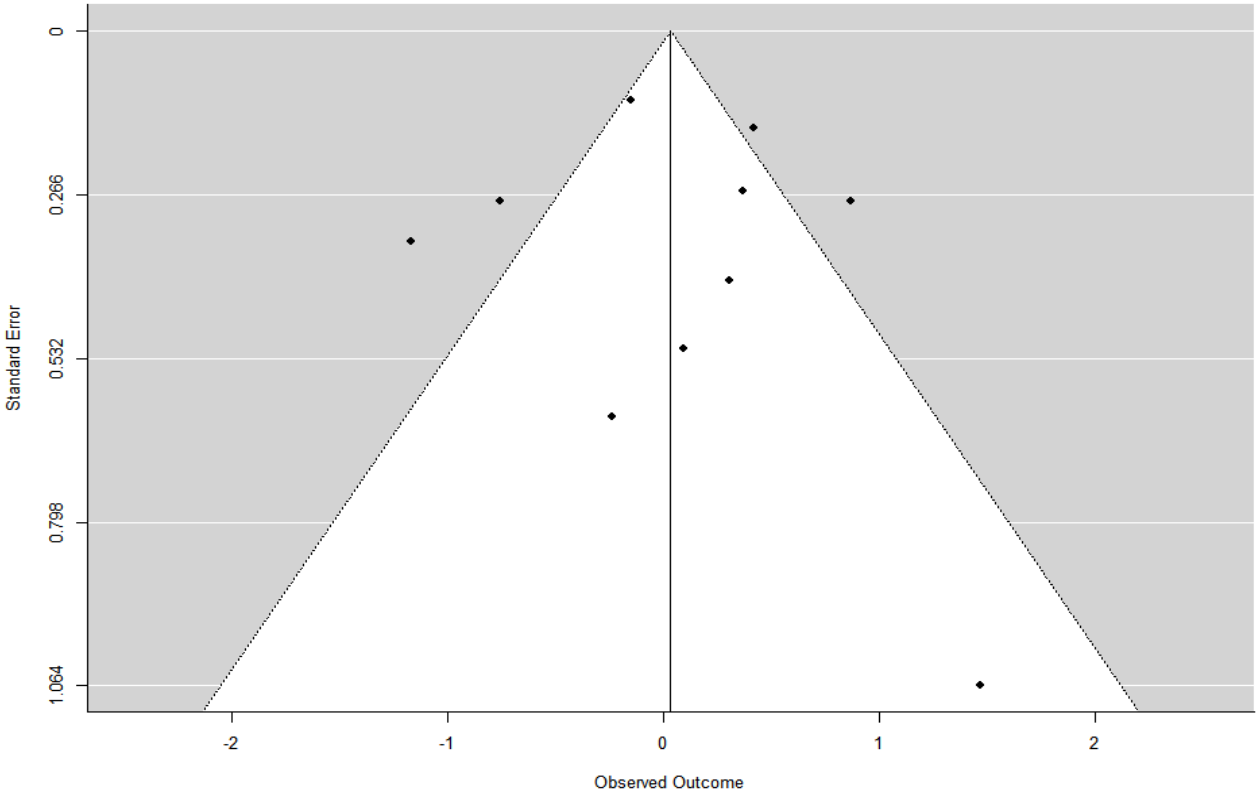
Not available because of the small number of studies

Figure S45. Labor epidural analgesia (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot



2) Funnel plot


Standard Error
0
0.266
0.532
0.798
1.064
-2
-1
0
1
2
Observed Outcome

3) P curve analysis plot

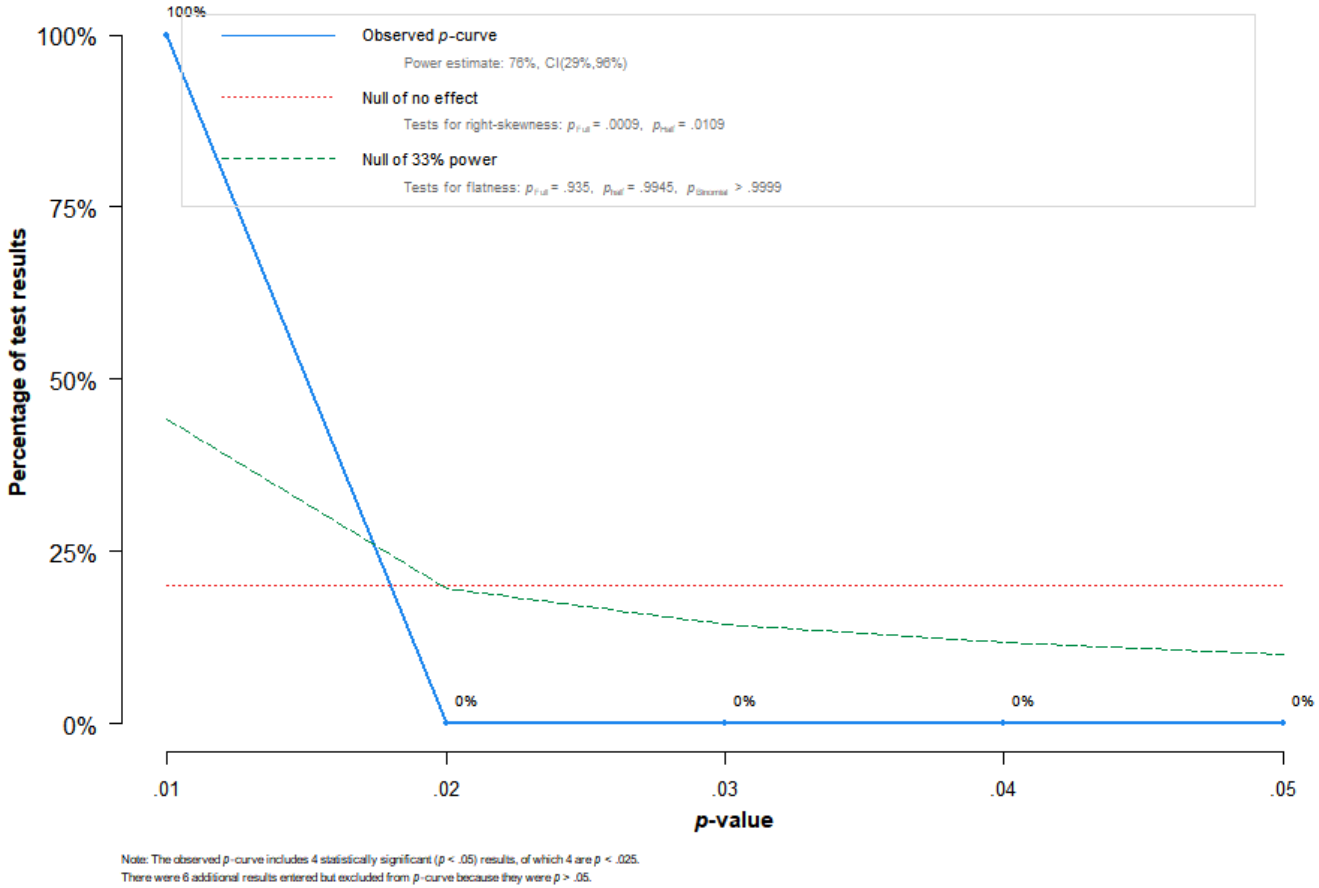
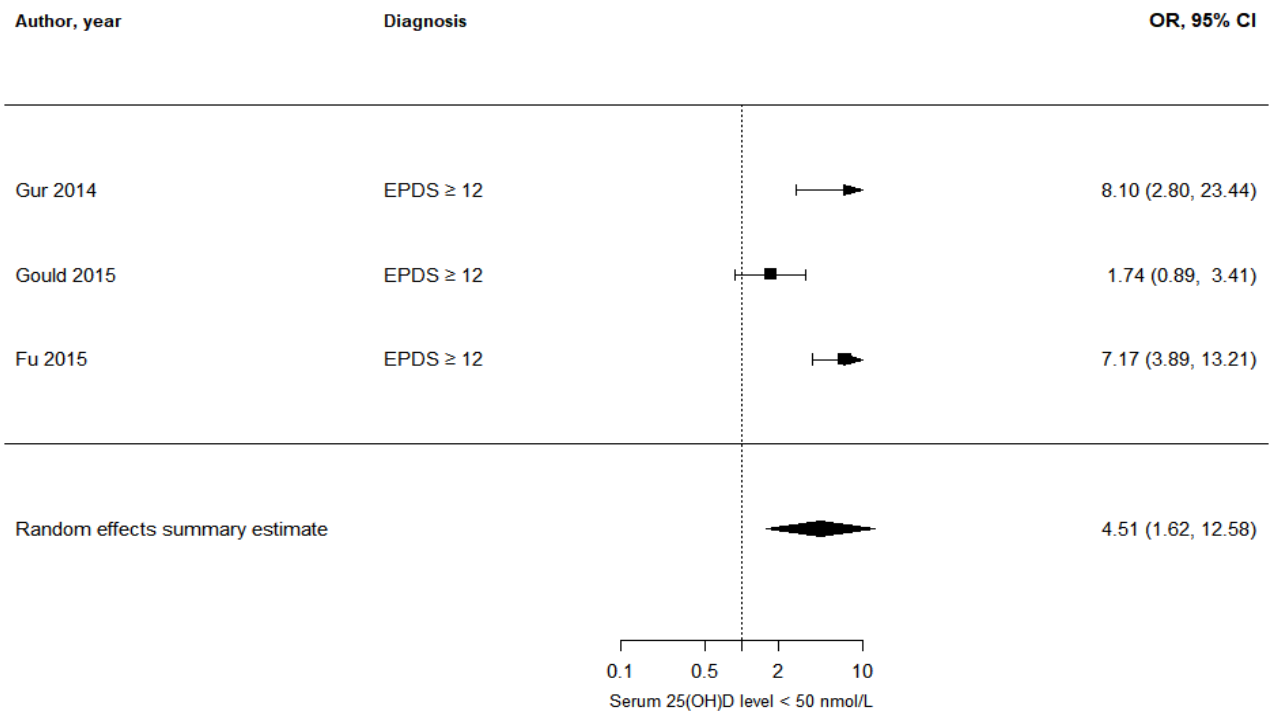
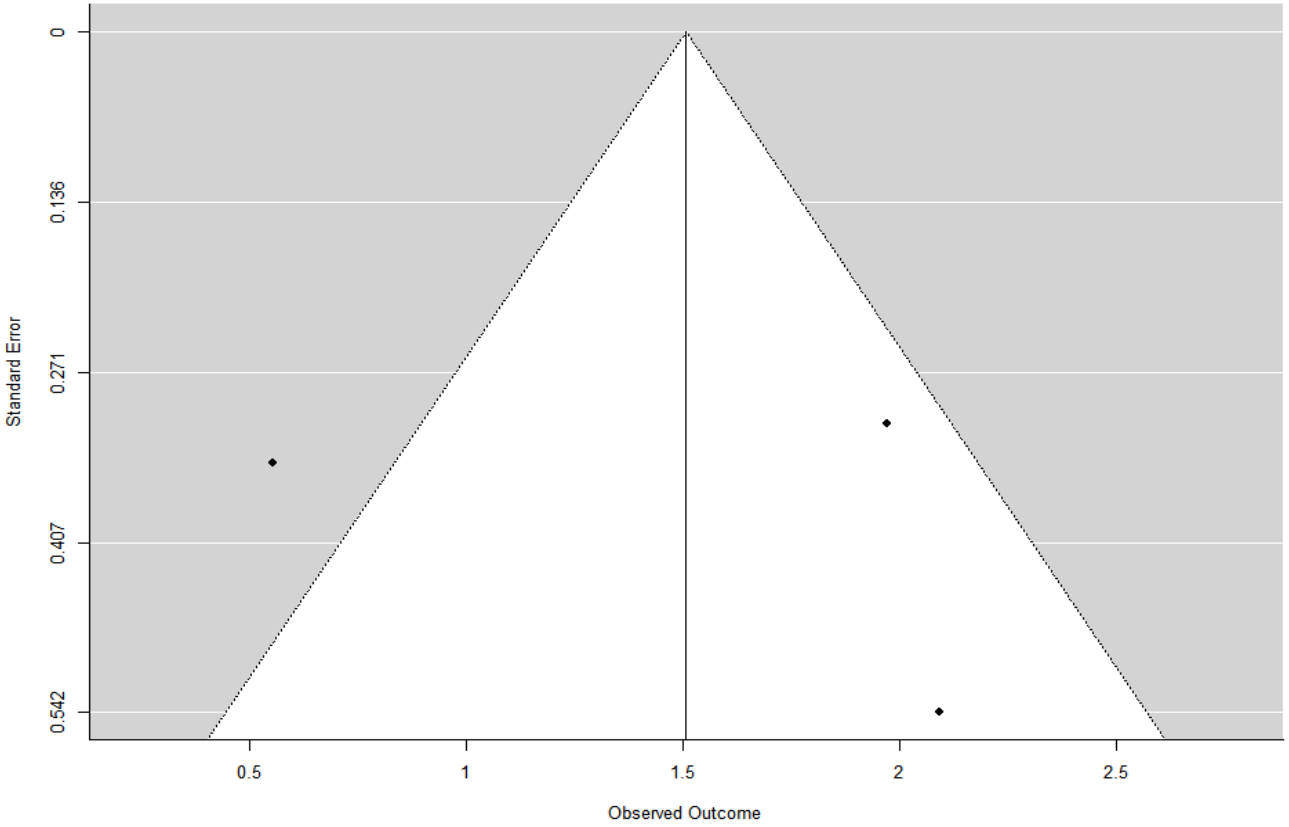


Figure S46. Serum 25(OH)D level < 50 nmol/L (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

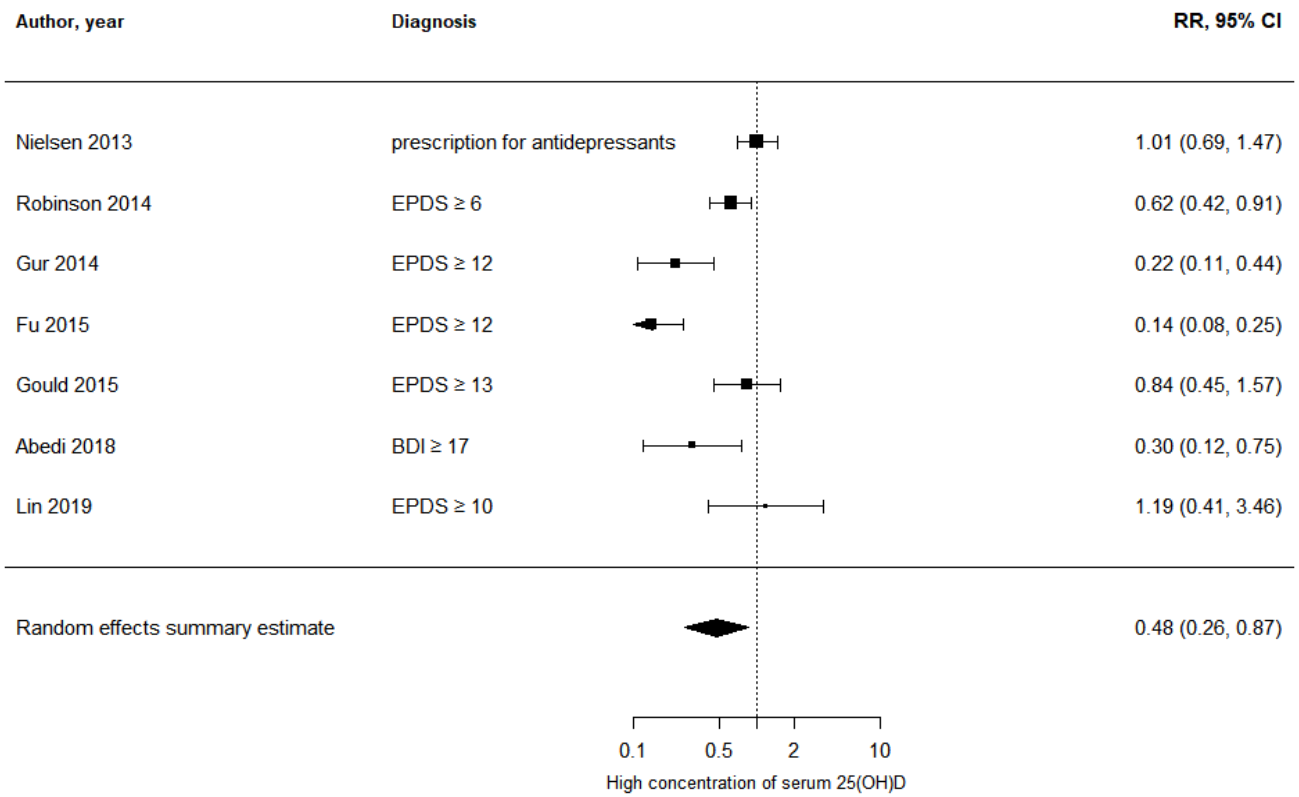


3) P curve analysis plot

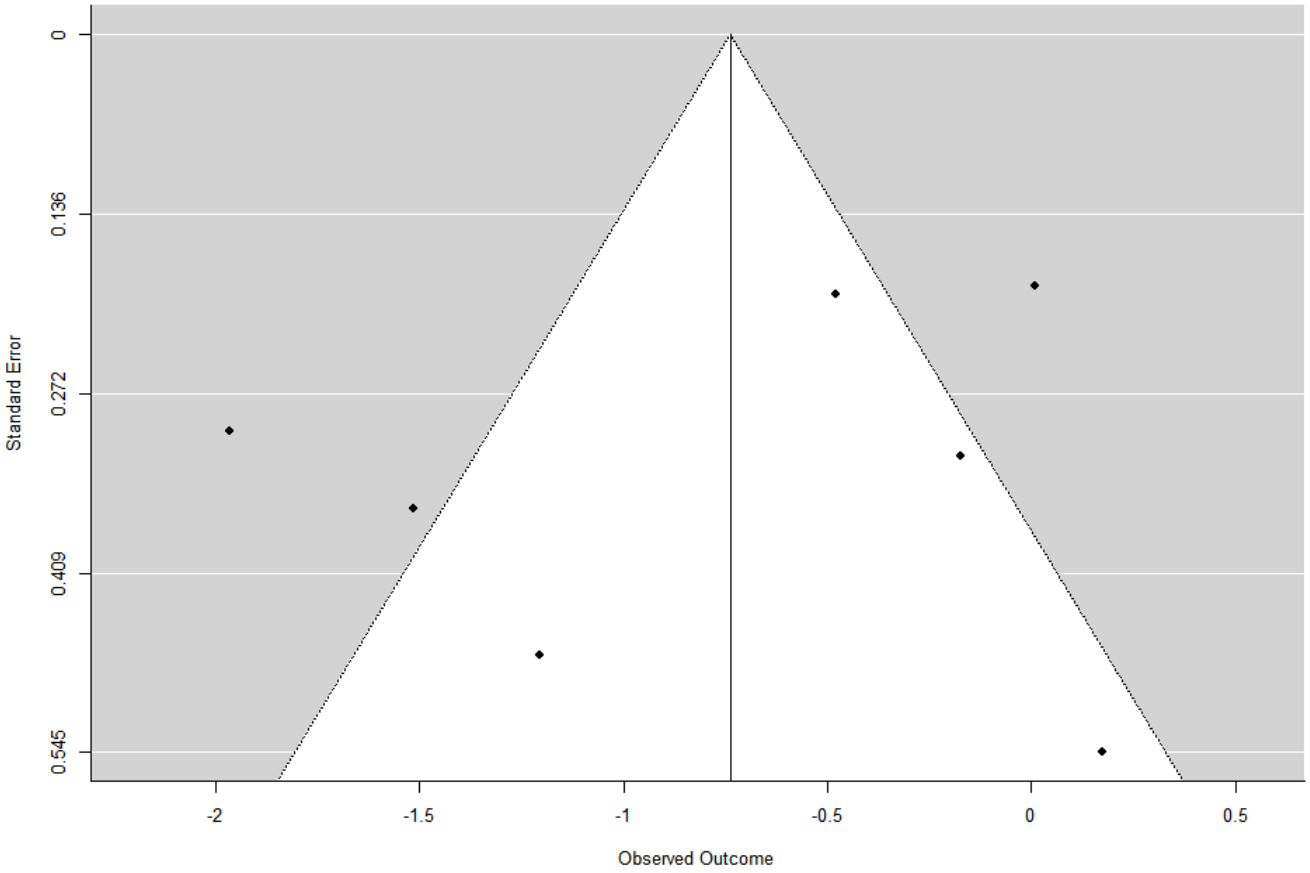
Not available because of the small number of studies

Figure S47. High concentration of serum 25(OH)D (Forest plot, funnel plot, p curve analysis plot)

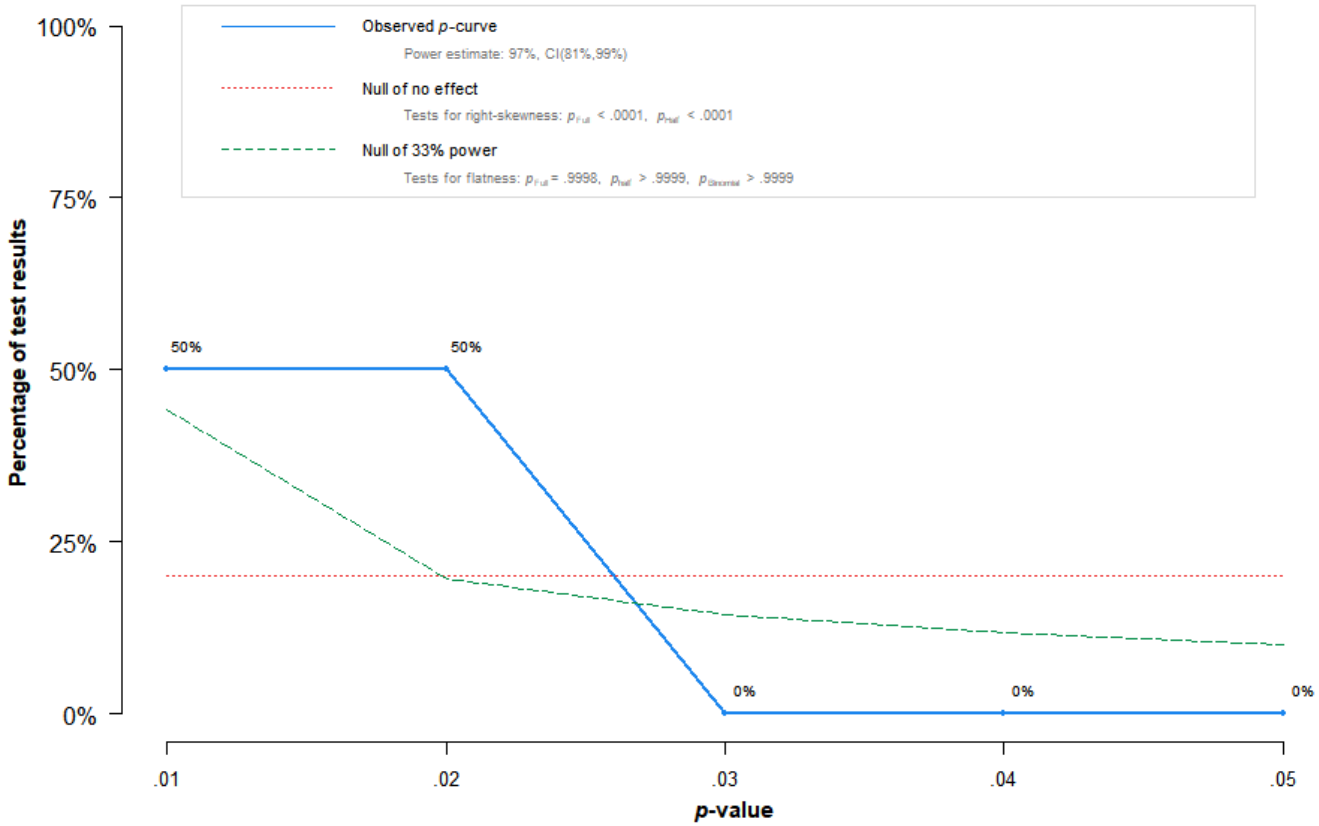
1) Forest plot



2) Funnel plot



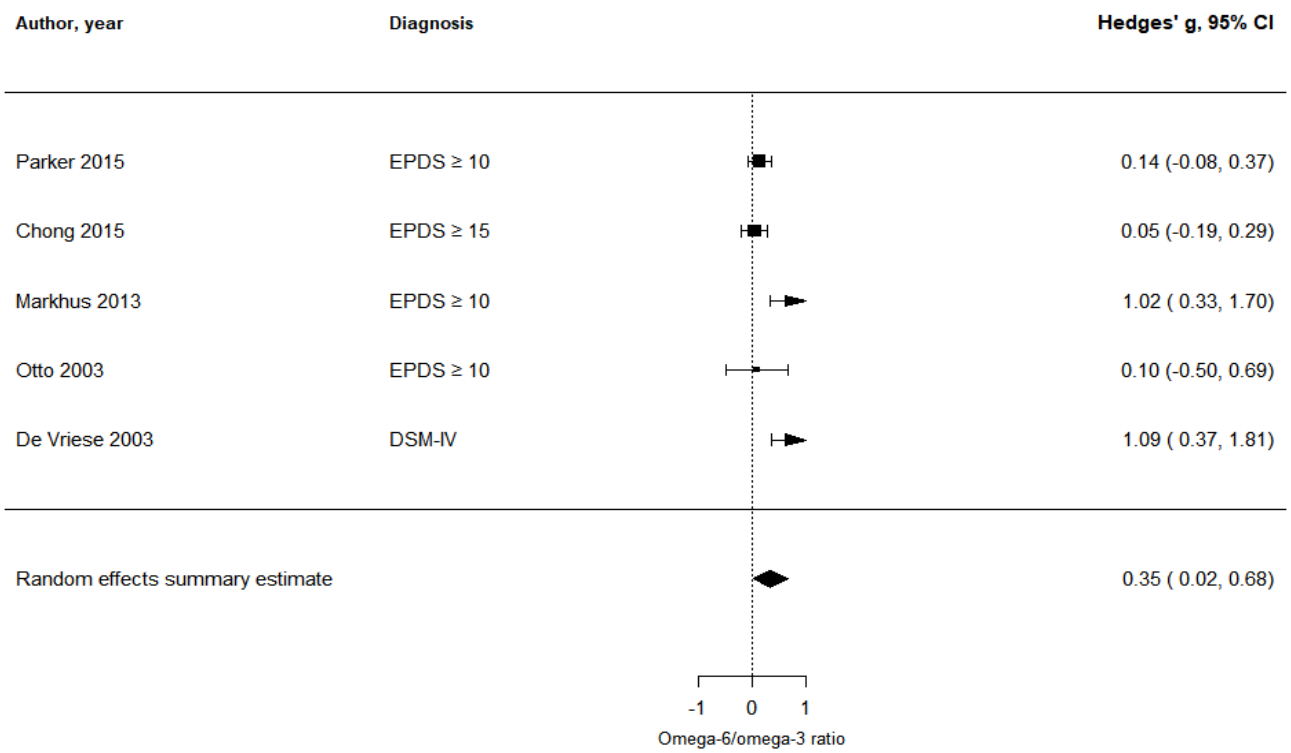
3) P curve analysis plot



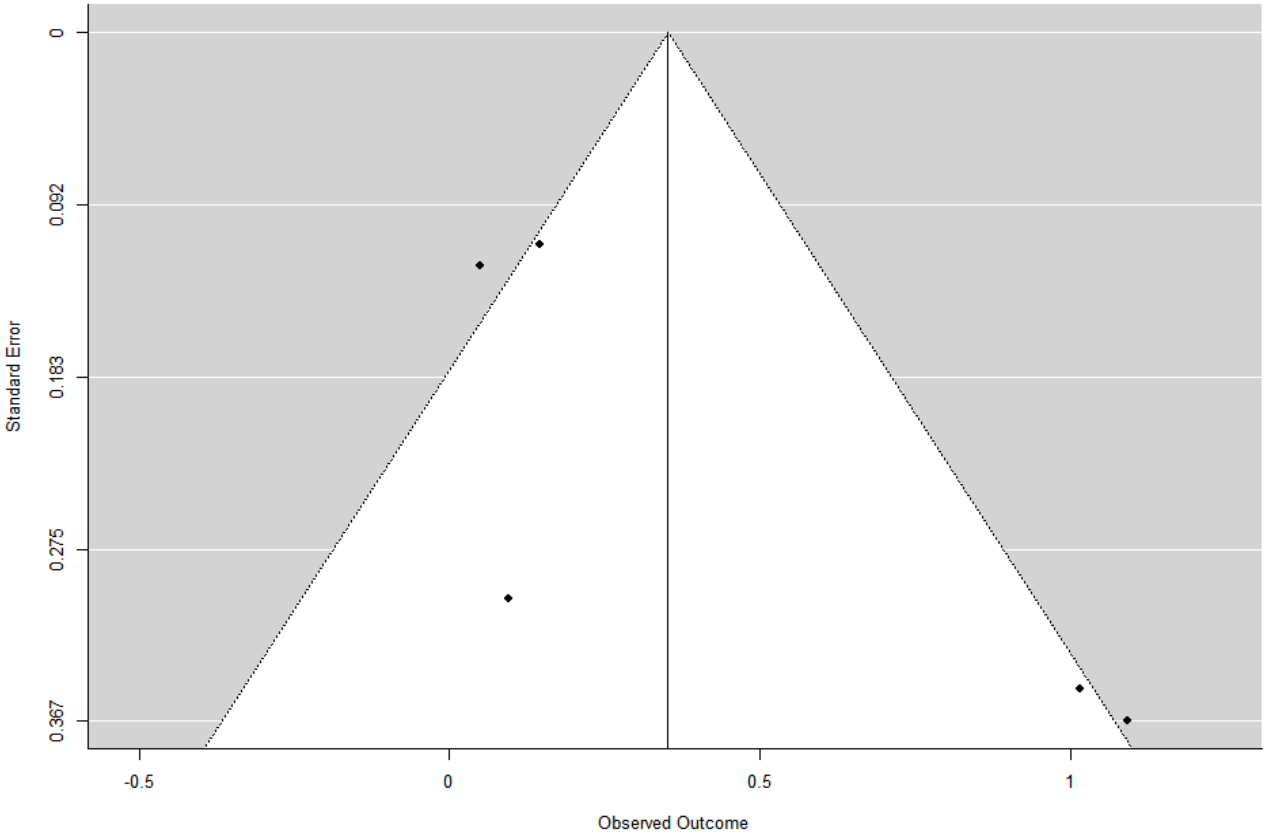
Note: The observed *p*-curve includes 4 statistically significant ($p < .05$) results, of which 4 are $p < .025$.
There were 3 additional results entered but excluded from *p*-curve because they were $p > .05$.

Figure S48. Omega-6/omega-3 ratio (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

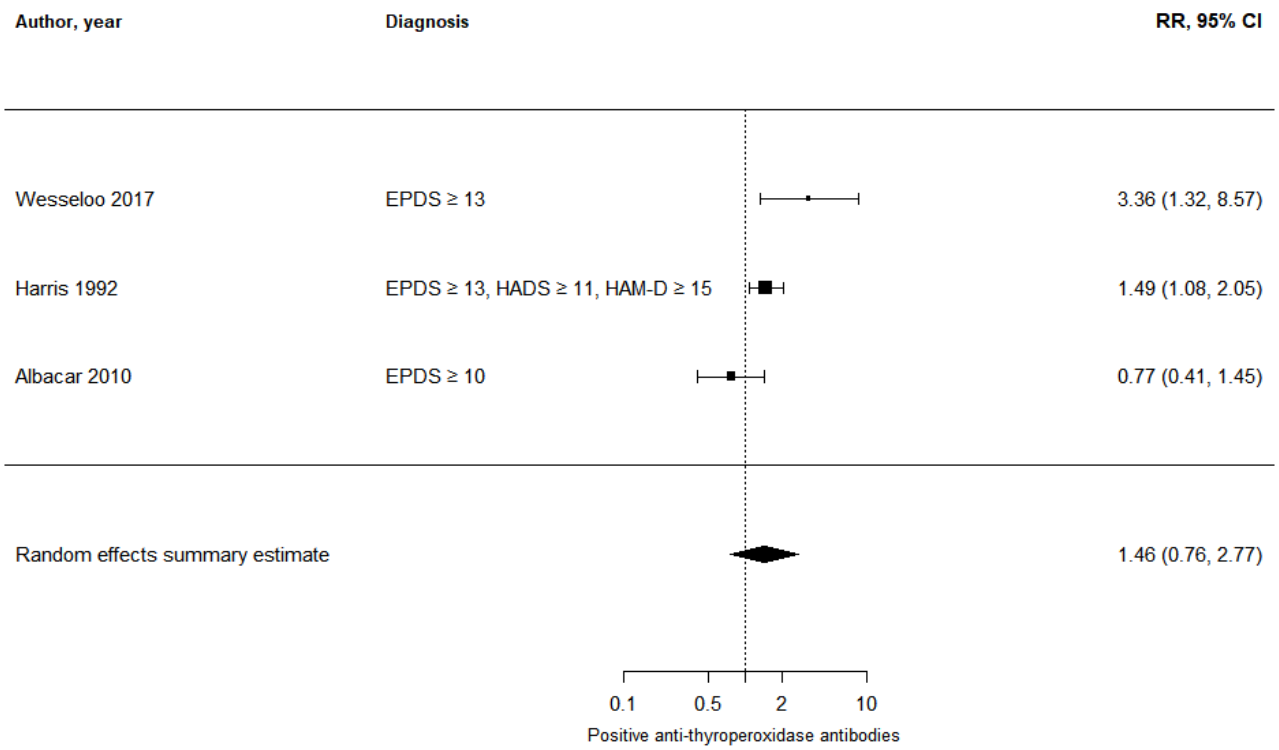


3) P curve analysis plot

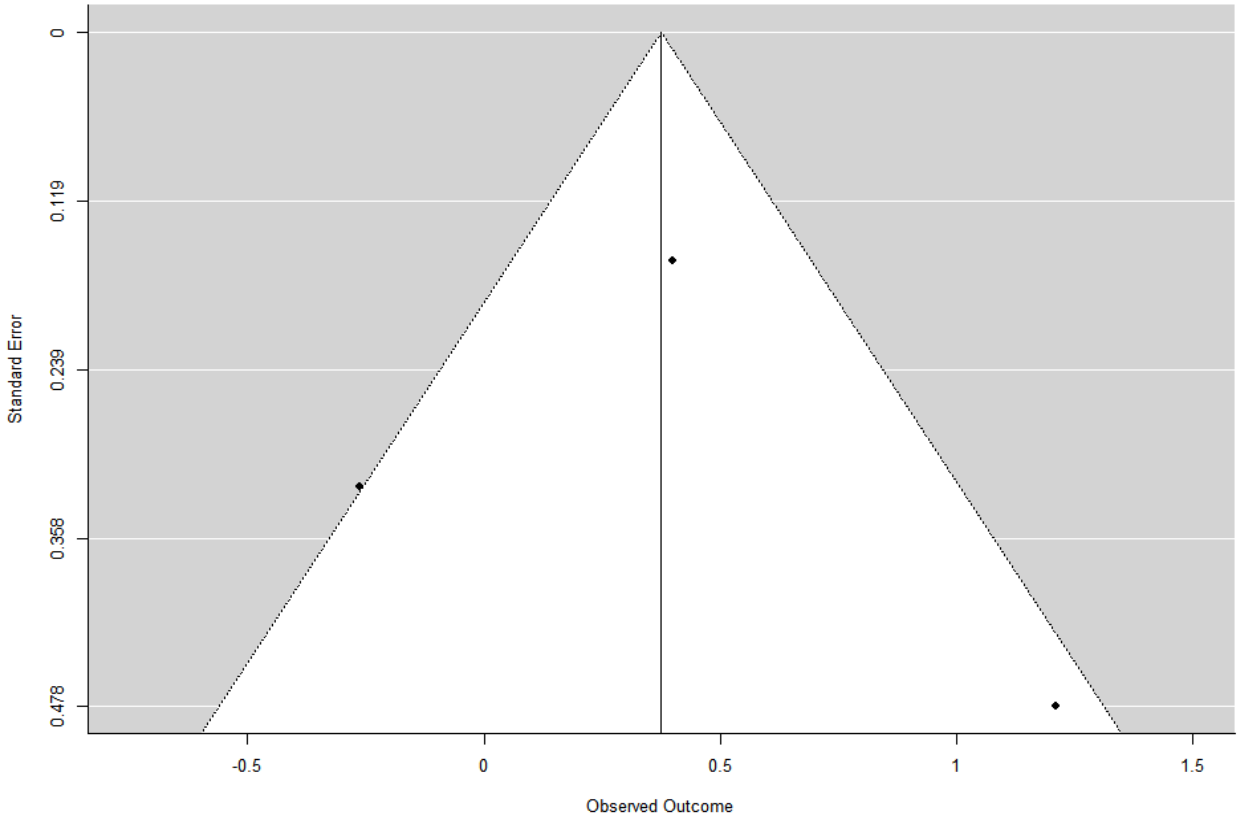
Not available because of the small number of studies

Figure S49. Positive anti-thyroperoxidase antibodies (Forest plot, funnel plot, p curve analysis plot)

1) Forest plot



2) Funnel plot

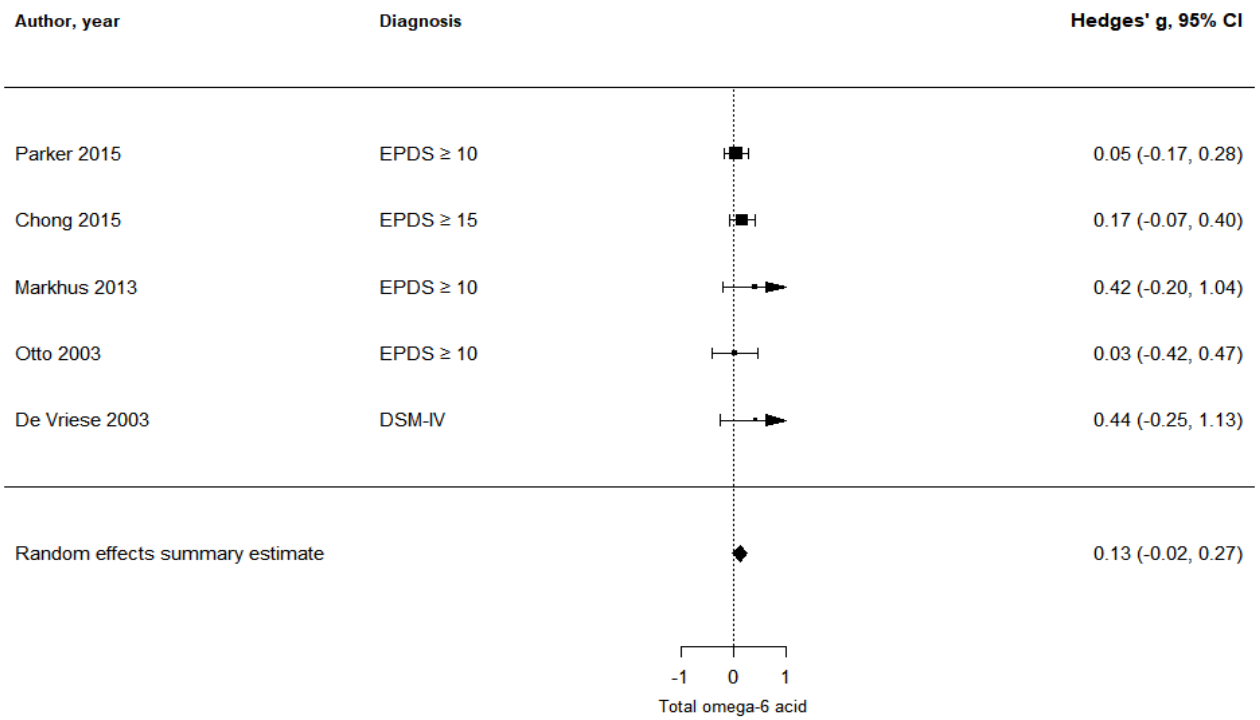


3) P curve analysis plot

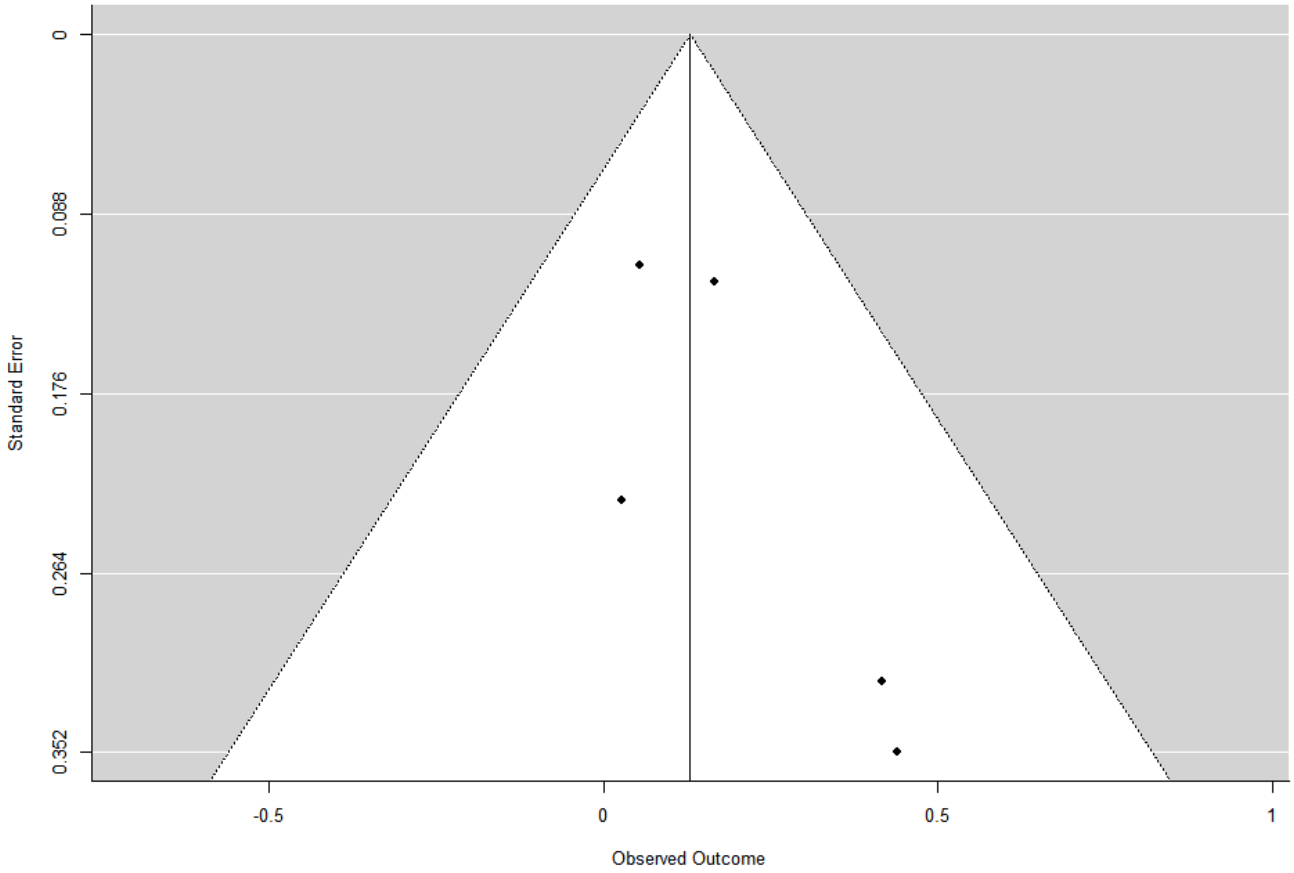
Not available because of the small number of studies

Figure S50. Total omega-6 acid (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

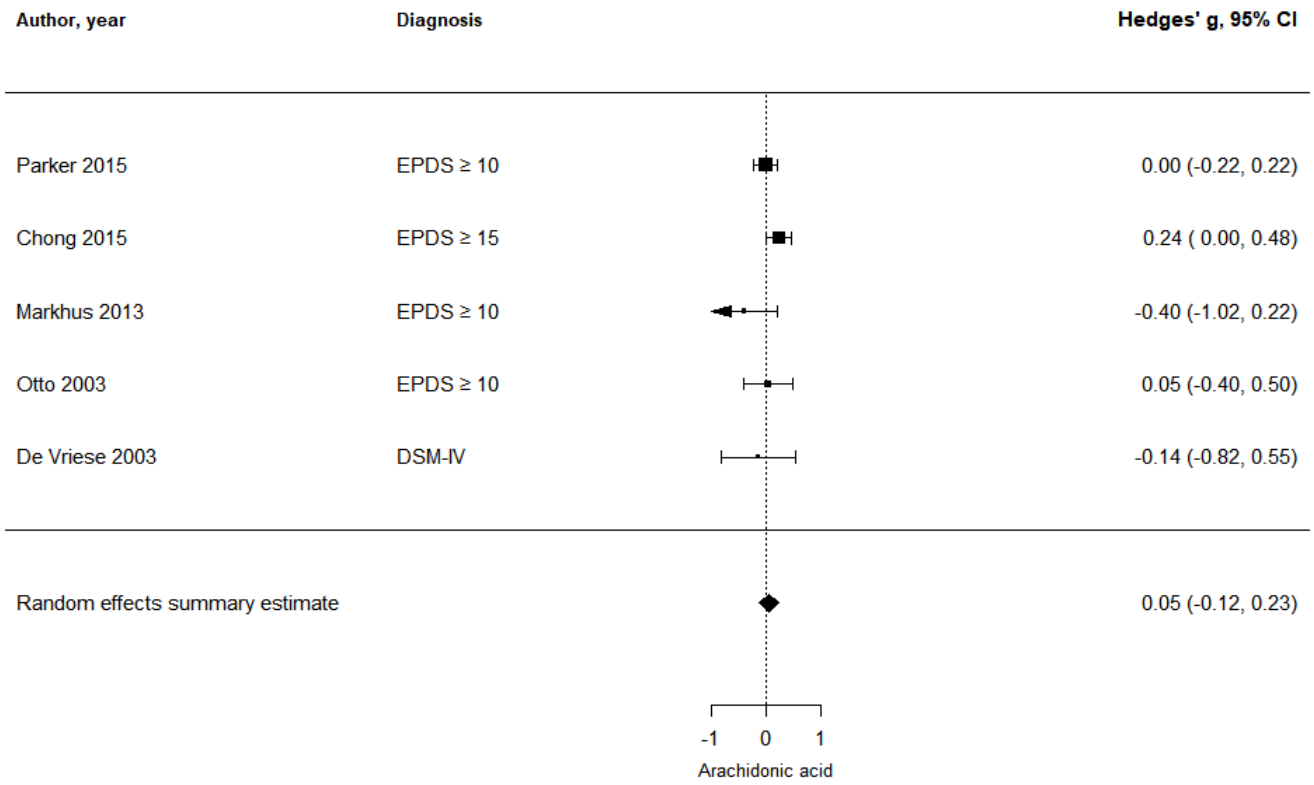


3) P curve analysis plot

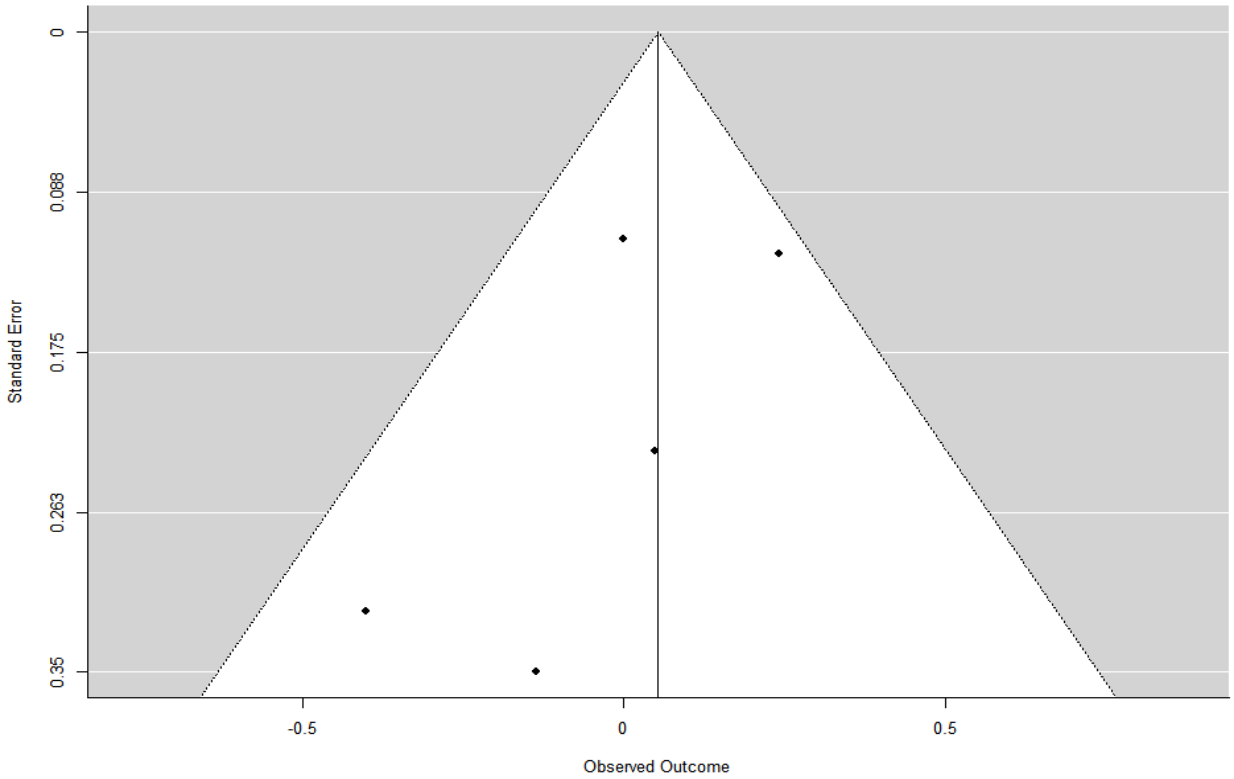
Not available because of the small number of studies

Figure S51. Arachidonic acid (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

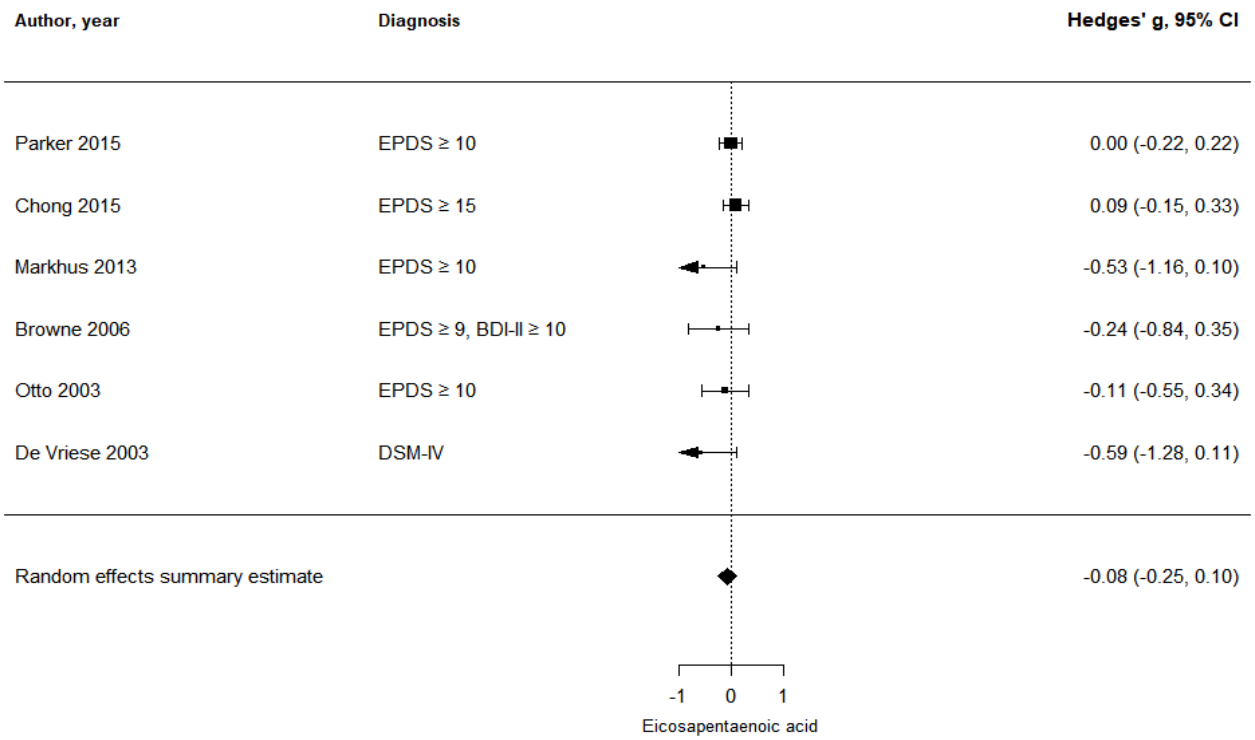


3) P curve analysis plot

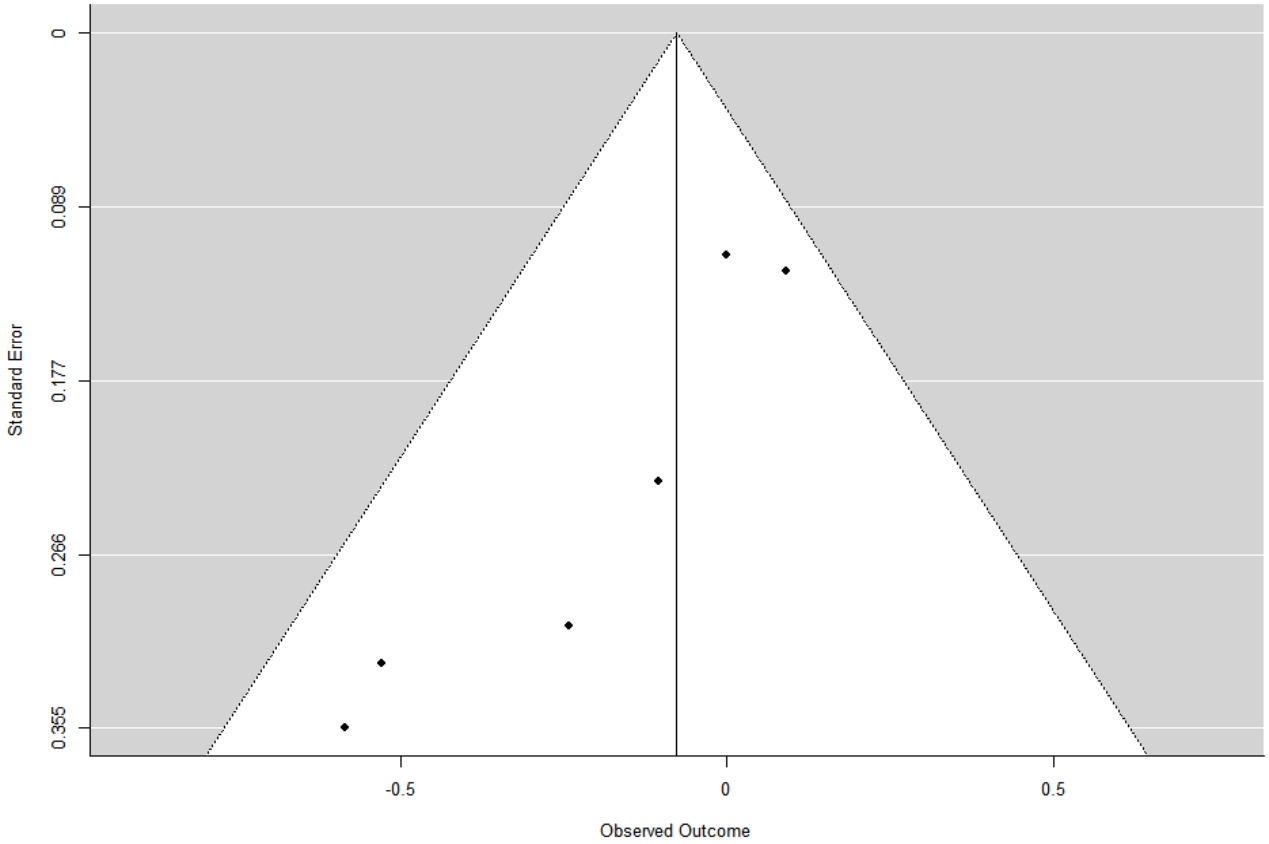
Not available because of the small number of studies

Figure S52. Eicosapentaenoic acid (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

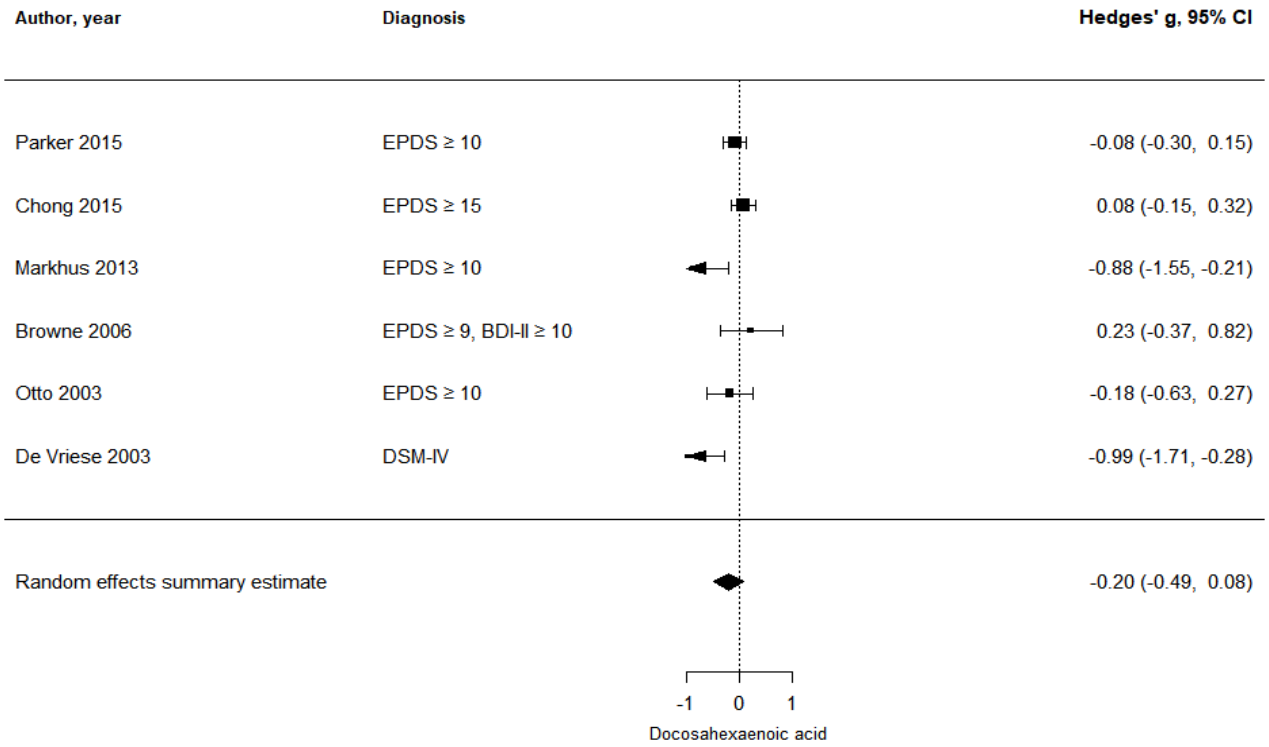


3) P curve analysis plot

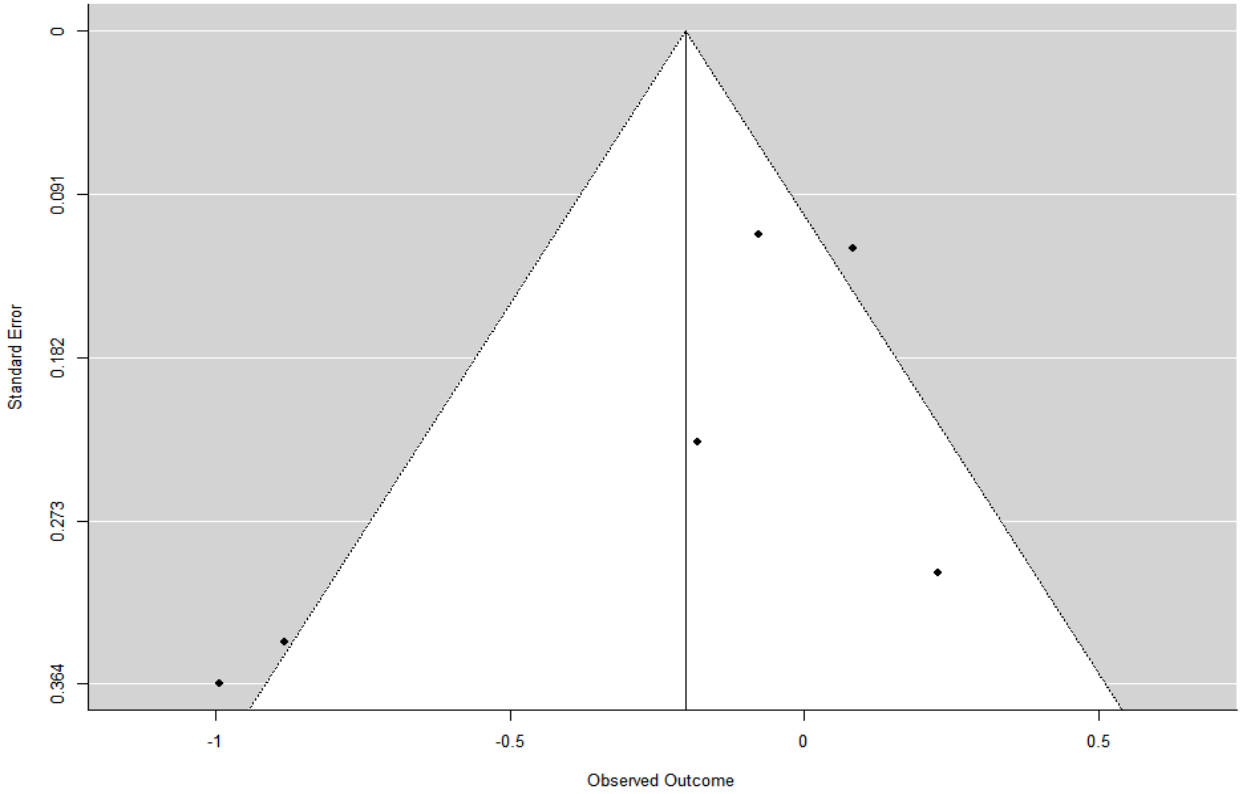
Not available because of the small number of studies

Figure S53. Docosahexaenoic acid (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot

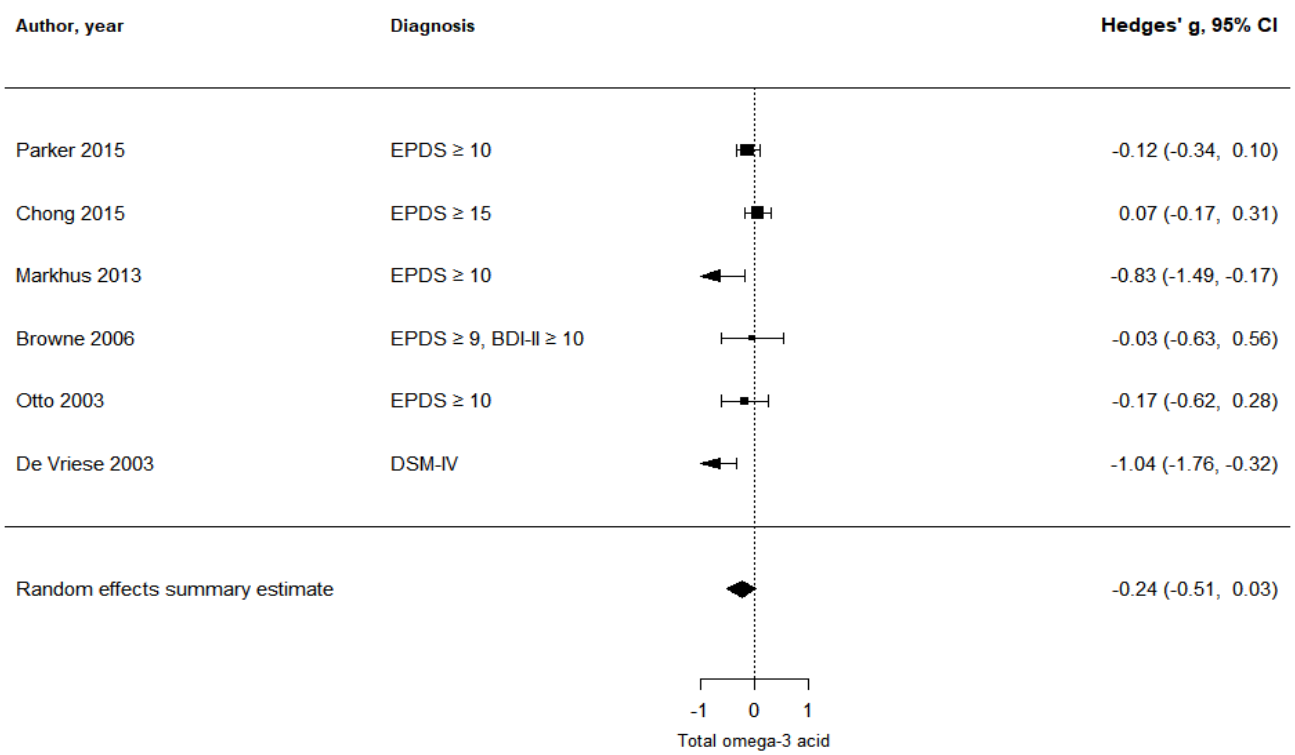


3) P curve analysis plot

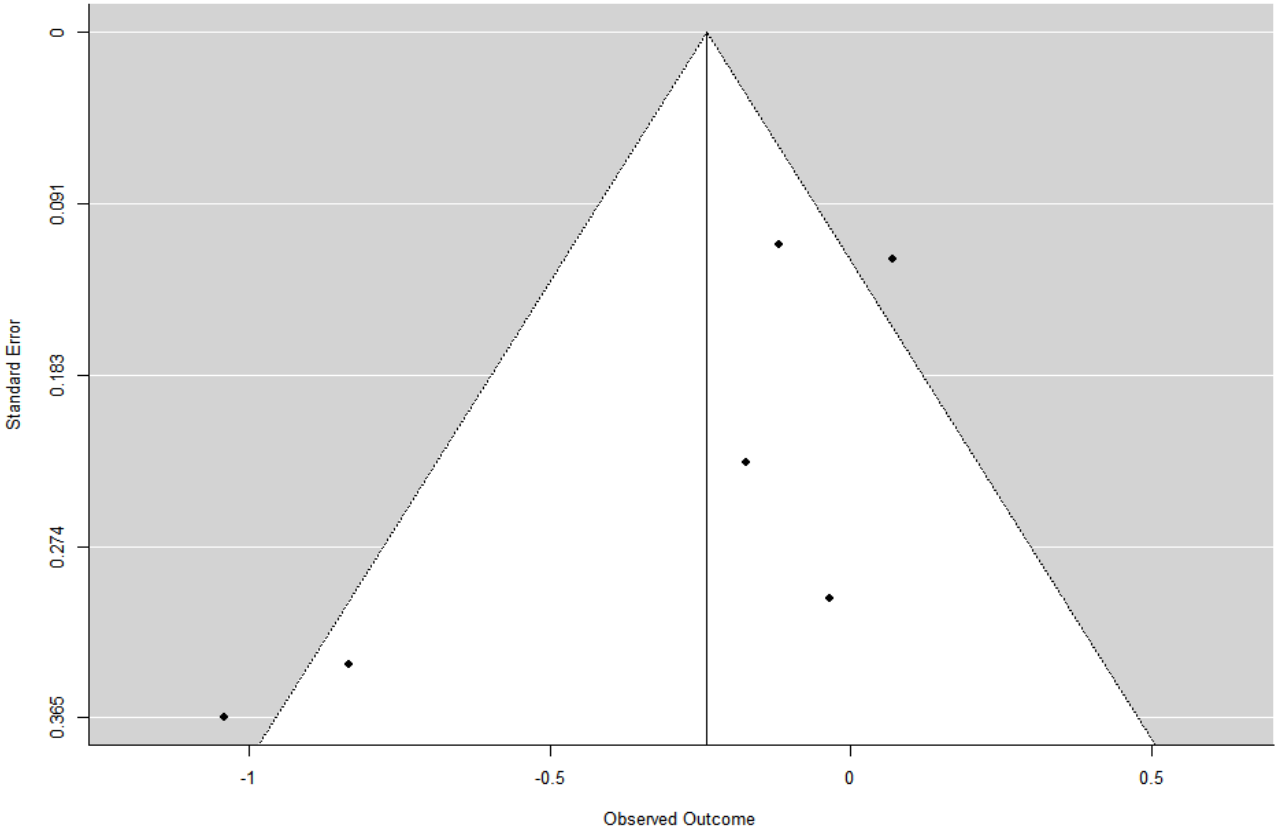
Not available because of the small number of studies

Figure S54. Total omega-3 acid (Forest plot, funnel plot)

1) Forest plot



2) Funnel plot



3) P curve analysis plot

Not available because of the small number of studies