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A Systematic Review and Meta-Analysis

**Dissertação no âmbito do Mestrado em Intervenções Cognitivo-Comportamentais em Psicologia Clínica e da Saúde orientada pelas Professoras Doutora Ana Ganho Ávila Costa e Doutora Maria Cristina Cruz Sousa Portocarrero Canavarro e apresentada à Faculdade de Psicologia e de Ciências da Educação da Universidade de Coimbra.**

setembro 2022

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FACULDADE DE PSICOLOGIA E DE CIÊNCIAS DA EDUCAÇÃO
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**Resumo**

***Revisão da literatura***: No período perinatal, as mulheres reportam frequentemente alterações ao nível da memória, orientação e atenção. No entanto, a investigação com testes neuropsicológicos de memória e atenção tem revelado resultados inconsistentes. A possível influência de mudanças afetivas durante este período tem vindo a ser discutida, sendo que alguns autores defendem uma ligação entre sintomatologia depressiva/ansiosa e funcionamento cognitivo durante a gravidez e o pós-parto. ***Objetivos***: Esta revisão sistemática da literatura pretende caracterizar a associação entre sintomatologia depressiva e ansiosa e o funcionamento cognitivo (memória, atenção e flexibilidade cognitiva) durante o período perinatal. ***Métodos***: Efetuámos pesquisas nas bases de dados eletrónicas PubMed, Web of Knowledge e PsycInfo. Os revisores avaliaram de forma independente os títulos/resumos e os textos completos. Foi efetuada uma avaliação da qualidade dos estudos. Foram realizadas uma síntese qualitativa e uma meta-análise de dados. ***Resultados***: Foram incluídos 44 estudos na revisão sistemática. A análise qualitativa revelou inconsistências entre estudos no que diz respeito à associação entre sintomatologia depressiva/ansiosa e domínios cognitivos específicos (e.g., memória de trabalho, atenção). Deficits ao nível da memória subjetiva parecem estar positivamente associados com sintomatologia depressiva/ansiosa, ao contrário do que se verifica relativamente às memórias de reconhecimento e verbal, que não apresentaram associações com sintomatologia depressiva/ansiosa. A meta-análise não revelou uma associação estatisticamente significativa entre sintomatologia depressiva e atenção no pós-parto. Foi também verificada uma elevada heterogeneidade metodológica entre estudos. No entanto, de acordo com a meta-regressão, o tamanho da amostra, o design do estudo e o controlo de variáveis confundidoras não afetaram significativamente os resultados. ***Conclusões***: A presente revisão sistemática veio confirmar a inconsistência de resultados no que diz respeito à associação entre o estatuto clínico e a performance cognitiva relativamente a certos domínios, em mulheres grávidas e no pós-parto, acentuando a necessidade de uma maior robustez na investigação, que considere metodologias de maior qualidade e uma maior homogeneidade em relação à avaliação cognitiva. Os nossos resultados sugerem ainda que, estudos futuros, devem considerar outras possíveis variáveis na explicação deste fenómeno, nomeadamente a qualidade do sono e a consideração de perspetivas sociais em relação à adaptação da mulher à maternidade.

***Palavras-chave***: cognição, depressão, ansiedade, memória, atenção, flexibilidade cognitiva, memória subjetiva, gravidez, pós-parto, revisão sistemática.

**Abstract**

***Background:*** Women in the perinatal period frequently report forgetfulness, disorientation and short attention span. However, research with neuropsychological tests on memory and attention has yielded inconsistent results. The possible influence of affective changes during this period has been discussed, with some authors defending a linkage between depressive/anxiety symptoms and cognitive functioning during pregnancy and postpartum. ***Objective:*** The present systematic review aims to characterize the association between depression and anxiety symptoms and cognitive functioning (memory, attention and cognitive flexibility) during the perinatal period. ***Methods:*** We searched PubMed, Web of Knowledge and PsycINFO electronic databases. Reviewers independently screened for title/abstract and full text. A risk of bias assessment was independently conducted. Qualitative narrative synthesis and meta-analysis were conducted with enough data available to estimate effect sizes. ***Results:*** We included 44 articles in the present review. Qualitative synthesis reveals inconsistencies among studies regarding the association between depressive/anxiety symptoms and some specific cognitive domains (e.g., working memory, attention). Subjective memory impairments seem to be positively associated with depressive/anxiety symptoms, while no associations have been found for recognition and verbal memory. Meta-analysis does not indicate a statistically significant association between depression symptoms and attention in postpartum. High heterogeneity of data was obtained. According to meta-regression, sample size, type of study, and control for confounding variables did not significantly impact the results. ***Conclusions:*** The present review confirms the inconsistent results regarding the association between clinical status and some specific cognitive domains in pregnant and postpartum women, highlighting the need for more robust research, considering higher quality methodologies and more homogeneity regarding cognitive assessment, and the consideration of other possible variables for the explanation of this phenomenon, namely quality of sleep and the consideration of social perspectives of women's adaptations to this lifespan event.

***Keywords***: cognition, depression, anxiety, memory, attention, cognitive flexibility, subjective memory, pregnancy, postpartum, systematic review.

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**The Role of Depression and Anxiety Symptoms on Cognitive Functioning in Motherhood: A Systematic Review and Meta-Analysis**

The peripartum period is associated with adaptative changes at different levels (e.g., physiological, endocrinological, psychological, behavioral). These changes will prepare women's bodies for healthy growth and delivery of the fetus (Duarte-Guterman et al., 2019; Galea et al., 2018). Moreover, these changes will prepare the future mother to successfully care for her offspring (Barha & Galea, 2017) through the development of new maternal behaviors (Galea et al., 2018) and the necessary adjustments to this remarkable life-span event.

One of the most interesting implications of pregnancy is its impact on the mother's brain functioning (Galea et al., 2018) and what seems to be an impaired cognitive functioning (Barda et al., 2021; Henry & Sherwin, 2012) that seems to be particularly obvious during the third trimester (Davies et al., 2018). Also, such cognitive impairment might be associated with distinct trajectories of psychological adjustment in mothers (Mazor et al., 2018), although this possible association is often unrecognized due to a lack of consistent findings (Liakea et al., 2022). As it is true that a neural adjustment exists, associated with increased developmental brain plasticity allowing for optimal adjustments as needed, doubts remain about the degree of their positive and/or negative impact (Pownall et al., 2022). In the current study, we will systematically review the literature about the cognitive and psychological challenges women face during the transition to motherhood and its underlying mechanisms.

The "baby brain" phenomeon (Christensen et al., 2010) is frequently reported across women in the perinatal period, specifically forgetfulness, disorientation and short attention span (Liakea et al., 2022). This is partially verified by studies with neuropsychological tests that suggest that executive functions seem to be impaired during pregnancy, such as learning, language, attention (Barda et al., 2021), processing speed (Anderson & Rutherford, 2012; Davies et al., 2018), visuospatial abilities (Davies et al., 2018), and memory (Anderson & Rutherford, 2012; Barda et al., 2021, Davies et al., 2018), including verbal recall (Ouellette & Hampson, 2018), prospective memory (Anderson & Rutherford, 2012; Ouellette & Hampson, 2018) and working memory (Anderson & Rutherford, 2012; Cárdenas et al., 2020; Mazor et al., 2018; Ouellette & Hampson, 2018). Moreover, emerging research suggests that cognitive changes during pregnancy in domains such as working memory and free recall may stabilize during the early postpartum period. For example, Pieters et al. (2021) found similar working memory capacities in most mothers from late pregnancy to early postpartum, although a subset (20%) of pregnant women performed worse in the postpartum.

As opposed to these results, other studies revealed no significant changes on cognitive domains such as working memory, immediate recall and delayed recall (Christensen et al., 2010) or even improved cognitive functioning in recognition memory during pregnancy (Anderson & Rutherford, 2012), particularly in third trimester (Christensen et al., 2014). Moreover, the literature suggests that impaired cognitive performance results from a subjective perception of cognitive deficits associated with depressive symptoms that do not translate into significant objective impairment (Mazor et al., 2018).

In sum, literature on the cognitive functioning associated with pregnancy and the postpartum period is characterized by inconsistent results (Davies et al., 2018; Galea et al., 2018; Ouellette & Hampson, 2018) which might be due to methodological bias (e.g., lack of adequate control groups, small sample sizes, heterogeneous methodologies) or the effect of confounding variables (e.g., affective processes) in cognitive functioning, as these have been only anecdotally controlled (Ouellette & Hampson, 2018).

Research suggests that the peripartum is a vulnerable period for developing mental health problems (Cárdenas et al., 2020; Ouellette & Hampson, 2018), such as mood and anxiety disorders. *Peripartum depression* is a mental health disorder that affects approximately 10 to 15% of women and results from genetic, epigenetic, neuroendocrine, environmental, and psychosocial factors. It can lead to consequences for the mother and the child (Schaffir, 2018), interfering with the mother-child bonding necessary for the child's development (Niel & Payne, 2020). Additionally, Fawcett et al. (2019) found that one in five pregnant or postpartum women (up to 12 months after birth) are diagnosed with at least one anxiety disorder. Anxiety is associated with adverse consequences for the mother (e.g., miscarriage, pre-term delivery) and the child (e.g., low birth weight, psychological disorders), besides difficulties regarding mother-child bonding (e.g., communication gaps, insecure attachment) (Fawcett et al., 2019).

There is evidence that pregnant women experiencing depression or anxiety symptoms present a worst cognitive performance (Duarte-Guterman et al., 2019; Ouellette & Hampson, 2018) in domains such as working memory (Kataja et al., 2017). For example, Hampson et al. (2015) found an impaired working memory among pregnant women with depressive symptoms compared with healthy pregnant women, who demonstrated an equal or even significantly better performance when compared to non-pregnant women. These findings led the authors to conclude that memory disturbance during pregnancy can be a specific phenomenon in women experiencing antepartum depressive symptoms (Hampson et al., 2015). The review by Ouellette and Hampson (2018) found a subjective experience of cognitive impairment in women presenting symptoms of depression or anxiety, leading the authors to conclude that the reported cognitive changes may not occur in pregnant women in general but only in a subset of

women experiencing depression or anxiety. However, other studies did not find significant associations between depressive symptoms and cognitive outcomes, such as working memory (Christensen et al., 2010; Liakea et al., 2022), immediate and delayed recall, and cognitive speed (Christensen et al., 2010).

In sum, it remains unclear how clinical symptoms during pregnancy and postpartum are associated with the cognitive changes reported by women during this period. Furthermore, the possible mechanisms underlying these significant changes are still to be unveiled.

## Objectives

The main goal of the present review is to characterize the association between depressive / anxiety symptoms and cognitive functioning (memory, attention and cognitive flexibility) in the transition to motherhood. This review aims to update existing reviews by including new and emerging studies, responding to the following questions: 1) what is the impact of symptoms of depression and/or anxiety on cognitive functioning during pregnancy and the postpartum period? (primary question): and 2) is there a difference in the strength of the associations between symptoms of depression and/or anxiety and cognitive functioning across the perinatal period? (secondary question)

## Methods

### Eligibility Criteria

Selected studies include women over 18 and under 45 years old, with singleton, non-complicated pregnancy and delivery, and a healthy fetus and newborn. The population of interest must have been assessed for depressive and/or anxious symptoms (exposure of interest) and for cognitive performance (outcome of interest) concerning memory (includes neuropsychological tasks evaluating objective memory and subjective reports), attention and cognitive flexibility, at any point during pregnancy and/or up to one year postpartum. Included studies must have had a comparator of interest, namely healthy pregnant and postpartum women not presenting symptoms of depression or anxiety/without a clinical diagnosis and at low risk for depression and anxiety or non-pregnant women who have been assessed for symptoms of depression/anxiety.

We considered validated measures of cognitive ability. Specific domains of memory were considered, considering literature evidence, namely working memory, subjective reports of diminished memory, autobiographical memory, verbal memory, visuospatial memory, recognition memory and prospective memory. Additionally, we accepted all authors'

assumptions considering the domains each measure assessed. Regarding depressive/anxiety symptoms assessment, we considered standardized diagnostic interviews or validated symptoms' questionnaires or screening tools.

Selected studies must report the association between depression and/or anxiety symptoms and cognitive functioning. Whenever this association was not measured by the authors or not reported in the published manuscript, the authors were contacted. If the depressive or anxiety symptoms were assessed at multiple time points or both in prenatal and postnatal symptomatology, these were reviewed separately.

We excluded studies that included women under 18 and over 45 years of age and/or who experienced gestational loss, high-risk pregnancy, and/or pre-term birth. Studies that included women presenting any physical condition or other psychological disorder besides peripartum depression or peripartum anxiety were also excluded. Whenever detailed, we excluded studies that included women diagnosed with bipolar disorder I or II and women presenting suicidal ideation or diagnosed with postpartum psychosis. Whenever studies included any comparator group compatible with our inclusion criteria and whenever these reported results were relevant to our systematic review (even if secondary analysis) the studies were included. However, studies where perinatal depressive and anxiety symptoms were assessed but in which its effect on cognitive performance could not be isolated from other disorders were excluded.

Peer-reviewed and published original papers were included. We included the following study designs: baseline data from prospective randomized control trials (RCTs), prospective cohort, cross-sectional, case-control, case series, and case studies. Prospective RCTs where baseline data was not reported and/or was not made available after our contact with the authors were excluded. Systematic reviews or background articles, viewpoints or opinion papers, letters, guidelines, and protocols were excluded.

Although we aimed for studies that would allow for quantitative analysis of the association between depressive and anxious symptoms and cognitive outcomes, those reporting only qualitative results were considered in the qualitative analysis.

Animal studies were excluded.

**Information sources**

We conducted searches from inception to February 2022 on three electronic databases, which included PubMed (from 1967 to 13th February 2022), Web of Knowledge (from 1990 to 13th February 2022), and PsycINFO, accessed through OVID (from 1806 to 13th February 2022). We also conducted a "snowball" search, where the reference lists from the full texts selected to be included in the systematic review were examined to identify relevant studies to our research.

**Search strategy**

Electronic searches on the three databases were conducted with the following terms, combined with the Boolean operator "AND": (memory OR recall OR (working memory) OR attention OR (cognitive flexibility)); (maternal OR mother OR motherhood OR pregnant OR pregnancy OR perinatal OR peripartum OR antenatal OR antepartum OR postnatal OR postpartum); (depression OR depressive OR anxiety OR mood).

In PubMed and PsycINFO, a Human filter was applied to exclude animal studies. In Web of Knowledge, this filter is unavailable. The investigators excluded animal studies across the screening stages. No date/language limits were applied. Moreover, no filters were applied regarding study designs. The complete search strategies for the three databases are provided in Annex A.

**Selection process**

The rating team comprised five reviewers (AMF, MS, AT, JN, and MC). The exclusion of duplicates and management of references was conducted using Rayyan (Ouzzani et al., 2016). Considering the large number of retrieved articles (> 2,500 after duplicates removal), the title and abstract selection was conducted as follows:

We conducted a pilot screening in the first 25 abstracts to maximize agreement and understanding of the eligibility criteria across the rating team.

Afterward, the five raters screened the title and abstracts of the retrieved articles in bulks of ten until an inter-rater agreement of at least $k = .90$ was achieved. Inter-rater agreement was calculated through Cohen's kappa coefficient, based on the guidelines by Landis and Kich (1977): poor agreement ($k < 0.00$), slight agreement ($0.00 \leq k \leq 0.20$), fair agreement ($0.21 \leq k \leq 0.40$), moderate agreement ($0.41 \leq k \leq 0.60$), substantial agreement ($0.61 \leq k \leq 0.80$) and almost perfect agreement ($0.81 \leq k \leq 1.00$). Inter-rater disagreements were solved through discussion until consensus. After reaching the desired inter-rater agreement, the reviewers worked independently (i.e., unaware of each other's decisions) on the title/abstract screening of the remaining articles. If it was not possible to screen the study based solely on the title and abstract (e.g., inaccessibility of the abstract), the study was retained for full-text screening. AMF and MS performed independently the full-text screening and solved inter-rater disagreements through discussion until consensus.

**Data collection process**

AMF, MS, and AGA developed the data extraction sheet in excel. Data extraction from eligible studies was performed by AMF and MS independently that reviewed each other's extraction. Disagreements were solved through discussion until consensus between reviewers and a third reviewer (AGA) was reached whenever necessary.

To enable the statistical analysis, whenever the association between depression and/or anxiety symptoms and cognitive functioning was not directly reported in the published manuscript, we contacted the authors via e-mail requesting the results or the raw data (e.g., Edinburgh Postnatal Depression Scale [EPDS] scores and reaction times on the attention task). Studies were excluded in the absence of qualitative and quantitative data (e.g., due to confidentiality concerns; inaccessibility to the data; absence of response from the authors within the defined deadline - 14 days upon the first contact).

**Data items**

For each cognitive domain of interest, we extracted the qualitative and/or quantitative data according to the instrument used by the original study. For longitudinal studies (i.e., two or more assessment time points), we considered all time points where the outcomes of interest were assessed.

Additionally, we extracted data concerning the characteristics of the studies (reference, funding sources, country, design, objectives), participants (sample size, age, perinatal stage, comorbid disorders and treatment), comparison groups (sample size, age, other relevant characteristics), depression and/or anxiety scores in the peripartum period (domain, measure), cognitive functioning assessment in the peripartum period (domain, measure), confounding variables (e.g., age, education, parity, previous clinical history, ethnicity, Intelligence quotient (IQ), socioeconomic status), assessment time points, main results (e.g., correlation coefficient) and the original authors' conclusions.

**Risk of bias assessment**

We conducted the risk of bias assessment of the included articles using different tools according to the study design. For Randomized Controlled Trials (RCT) and cross-sectional studies, the risk of bias was assessed with Joanna Briggs Institute (JBI) critical appraisal checklist for RCT (Tufanaru et al., 2020) and analytical cross-sectional studies (Moola et al., 2020). These are composed of 13 and 8 items, respectively, with "Yes", "No", "Unclear" and "NA" as answer options. For cohort and case-control studies, the Newcastle-Ottawa Scale (NOS) for cohort and case-control studies (Wells et al., 2006) was used, respectively. The NOS for cohort and case-

control studies are composed of 8 items each, distributed in 3 categories: selection, comparability, outcome (exclusive for NOS applied to cohort studies) and exposure (exclusive for NOS applied to case-control studies). Scale scores range between 0 and 9 stars. However, Newcastle-Ottawa Scale (NOS) for cohort was modified, with scores ranging between 0 and 8 stars, because item 4 ("demonstration that outcome of interest was not present at start of study") was non-applicable. That is, for most studies' first assessment occurs in the first trimester, when cognitive impairment (outcome of interest) is expected to be present. Risk of bias assessment allowed for a critical appraisal of each article based on a predetermined cut-off score but did not lead to article exclusion from the analysis.

Before conducting the risk of bias assessment, the reviewers AMF, MS, and AGA discussed the assessment tools. They adapted the instruments to the current review, considering the defined exposure (i.e., depression and/or anxiety symptoms), the outcome (i.e., cognitive functioning), and the condition (i.e., pregnancy/postpartum; cf. Annex B). AMF and MS worked independently (i.e., reviewing each other's assessment), and disagreements were solved until consensus.

In the absence of specific guidelines concerning assessments of high or low quality (Harrison et al., 2017) and considering the recommendations by Aromataris & Munn (2020), the risk of bias scoring system and cut-offs for each instrument were pre-defined based on previous literature and upon raters' agreement. The cut-offs are detailed in Table 1.

***Table 1:*** *Cut-offs Scores for the Risk of Bias Assessment*

| **Risk of bias assessment tool** | **Score** | **Appraisal** |
|---|---|---|
| JBI critical appraisal checklist for RCT | 0 - 6 | Low quality study |
| | 7 - 9 | Moderate quality study |
| | 10 - 13 | High quality study |
| JBI critical appraisal checklist for analytical cross-sectional studies | 0 - 3 | Low quality study |
| | 4 - 5 | Moderate quality study |
| | 6 - 8 | High quality study |
| NOS | 0 - 2 | Low quality study |
| | 3 - 5 | Moderate quality study |
| | 6 – 8 or 9 | High-quality study |

JBI: Joanna Briggs Institute; NOS: Newcastle-Ottawa Scale.

**Effect measures**

We extracted estimates of correlation (effect sizes, z-values), allowing between-group comparisons (women with vs. without clinical symptoms) and within-group comparisons

(comparisons between all periods: first trimester pregnancy vs second trimester pregnancy vs third trimester pregnancy vs three months postpartum vs six months postpartum vs 12 months postpartum).

**Synthesis methods**

A qualitative narrative synthesis was conducted, structured around the exposure condition (depression or anxiety symptoms or comorbidity between the two) and cognitive outcome (memory, cognitive flexibility, and attention) according to the following subgroups:

- Memory outcomes (working memory, recognition memory, autobiographical memory, prospective memory, verbal memory and subjective memory) in pregnant women who presented anxiety symptoms;
- Memory outcomes (working memory, recognition memory, autobiographical memory, prospective memory, verbal memory and subjective memory) in pregnant women who presented depressive symptoms;
- Memory outcomes (working memory, recognition memory, autobiographical memory, prospective memory, verbal memory and subjective memory) in women in the postpartum period who presented anxiety symptoms;
- Memory outcomes (working memory, recognition memory, autobiographical memory, prospective memory, verbal memory and subjective memory) in women in the postpartum period who presented depressive symptoms;
- Attention outcomes in pregnant women who presented anxiety symptoms;
- Attention outcomes in pregnant women who presented depressive symptoms;
- Attention outcomes in women in the postpartum period who presented anxiety symptoms;
- Attention outcomes in women in the postpartum period who presented depressive symptoms;
- Cognitive flexibility outcomes in pregnant women who presented anxiety symptoms;
- Cognitive flexibility outcomes in pregnant women who presented depressive symptoms;
- Cognitive flexibility outcomes in women in the postpartum period who presented anxiety symptoms;
- Cognitive flexibility outcomes in women in the postpartum period who presented depressive symptoms.

The analytic approach was conducted per subgroup when enough data was available to estimate effect sizes. When the available data for a particular subgroup was insufficient, the analytic approach was not conducted. The correlation coefficient *r* was used as the effect size metric. Other effect sizes were converted to *r*. Meta-analysis was conducted with

Comprehensive Meta-Analysis software (CMA; Borenstein et al., 2005), in which the correlation coefficient is converted to Fisher's z, so that the sampling distribution of Pearson's *r* becomes normally distributed. The transformed values were used to conduct the meta-analysis.

Heterogeneity was assessed using the Q and $I^2$ statistics: 0% indicates no observed heterogeneity, 25% low heterogeneity, 50% moderate heterogeneity, and 75% high heterogeneity (Higgins & Thompson, 2002; Higgins et al., 2003). Regardless of heterogeneity estimates results, heterogeneity was always assumed. Therefore, we used a random-effects model that considers differences among studies being caused by not only random error but also between-study variability, due to the different designs and methodologies used across studies (Ahn & Kang, 2018).

To evaluate the contribution of each study characteristics to variability (e.g., type of study, sample size, control for confounding variables), meta-regression was applied.

## Results

### Study Selection

We retrieved 14080 articles from the database search. After the removal of duplicates, 10051 articles were screened for title and abstract. Besides the 25 abstracts from the pilot test stage, three bulks of 10 articles were selected until we reached the desirable inter-rater agreement. The first two bulks of articles were selected ordering them by the author (from A to Z) and the third in the reverse order (from Z to A). From the first bulk, an inter-rater agreement of $k = 1$ was obtained. Still, the process was repeated with the second bulk of articles, reaching an inter-rater agreement of *k=.83,* with conflict in four articles. Finally, an inter-rater agreement of k = .944 was obtained in the third bulk of articles, with only one conflicting result.

The five reviewers excluded 9739 articles. Of the remaining 313 articles, 272 were excluded in the full-text screening. The inter-rater agreement for the selection of reports in the full-text phase was moderate: κ = .593 (95% CI, .300 to .886), $p < .001$ (Landis & Koch, 1977). Additional data regarding Hoekzema et al. (2017) was requested and included in the analysis.

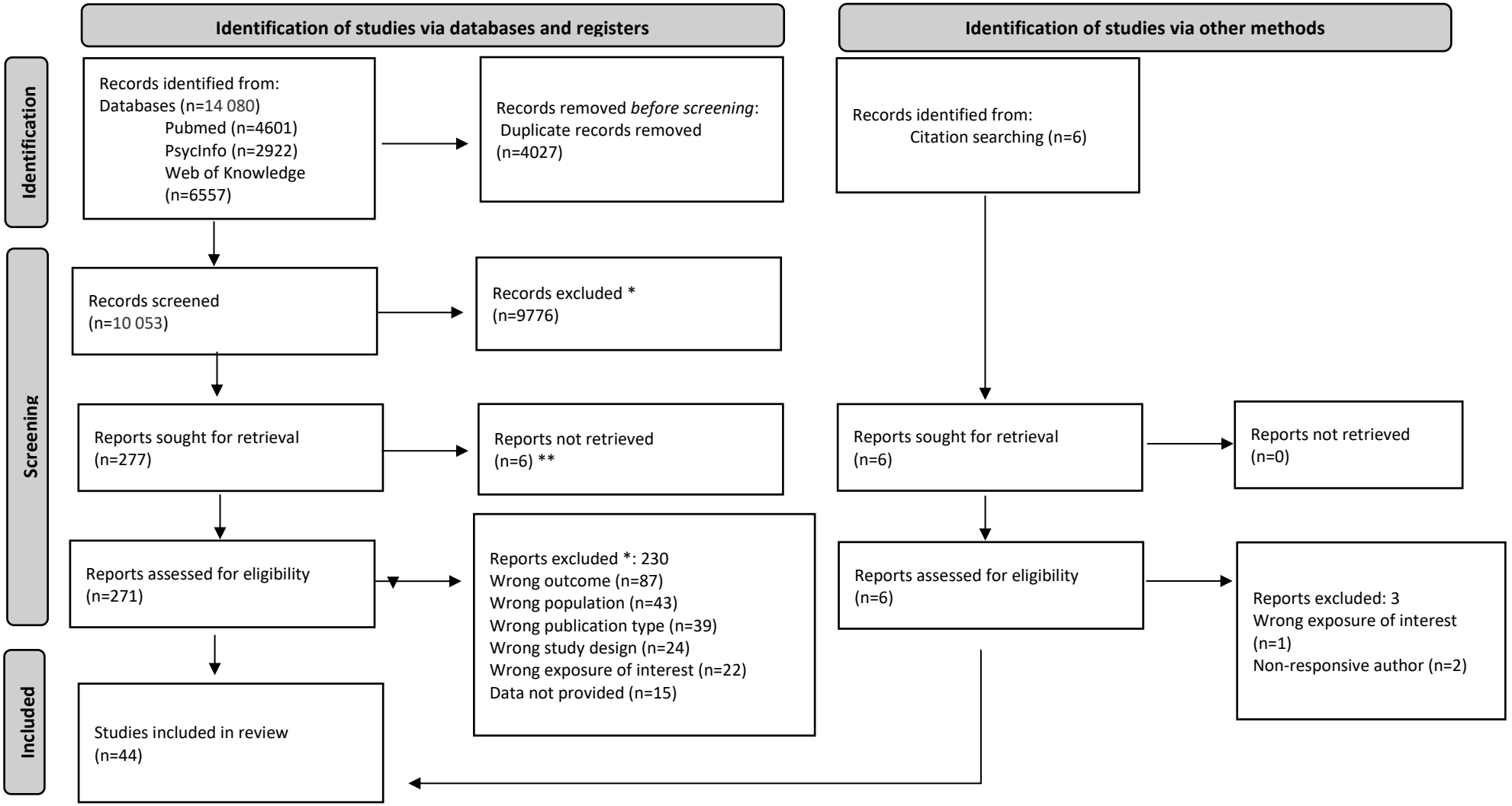
Additionally, from the "snowball" search, we identified and assessed six articles for eligibility, of which three were excluded due to unavailable data in the published manuscript (n = 2) and wrong exposure of interest (n = 1).

Forty-four articles were included in the present systematic review (cf. figure 1).

### Study characteristics

A detailed description of the included studies is presented in Table 2 and Table 3.

***Figure 1**: Flow-chart of the Selection of Sources of Evidence*




*All records were excluded manually.
** Full text not available.

***Table 2:*** *Characteristics of the included studies (n = 44)*

| Authors | Study Design | **Pregnant** group | | Comparison group/s | | Assessment timepoints* |
|---|---|---|---|---|---|---|
| | | **Sample size** | **Age (M, SD)** | **Sample size** | **Age (M, SD)** | |
| **Almanza-Sepulveda et al. (2018)** | Cross-sectional | 30 | T1: 25.5, 2.36<br>T2: 27.5, 3.44<br>T3: 26.0, 2.74 | 10 never pregnant women | 24.1, 1.53 | First, second or third trimester |
| **Atkinson et al. (2009)** | Longitudinal | 47 | 31.89, 3.65 | n.a. | n.a. | Third trimester and six and 12 months postpartum |
| **Barda et al. (2021)** | Prospective cohort | 40 | 31.9, 4.1 | 40 non-pregnant women | 31.7, 5.2 | Second or third trimester |
| **Brussé et al. (2008)** | Case-control | 10 women with normotensive pregnancies (control group) | 33.8<br>Range: 29.4 - 37.2 | 10 former severely preeclamptic patients (case group) | 34.4<br>Range: 29.2 - 37.4 | Three - seven months postpartum |
| **Buckwalter et al. (1999)** | Longitudinal | 25 | 33.1, 4.7 | n.a. | n.a. | Third trimester and 26.5 days postpartum |
| **Callaghan et al. (2021)** | Longitudinal | 40 for object-recognition memory (Wave 1), 36 for object-recognition memory (Wave 2), 23 for associative memory (Wave 1), and 23 for associative memory (Wave 2) (collection in person) | 28.92<br>Range: 18 - 40 | 82 never pregnant for object-recognition memory (Wave 1), 49 never pregnant for object-recognition memory (Wave 2), 78 never pregnant for associative memory (Wave 1), 38 never pregnant for associative memory (Wave 2) | 30.58<br>Range: 18 - 44 | Third trimester and 36 weeks pregnant |
| **Castro et al. (2021)** | Prospective cohort from a longitudinal main study | 216 | 31.3, 4.50 | n.a. | n.a. | Third trimester |
| **Casey (2000)** | Longitudinal | 18 | 28.2, 5.0 | 10 nonpregnant women who were planning a pregnancy; 24 nonpregnant women | 30.9, 4.2; 32.5, 7.2 | Second and third trimester and nine, 23 and 36 weeks postpartum |

*Assessment timepoints considering review question.
n.a.: not applicable

***Table 2*** *(continued)*

| Authors | Design | Pregnant group | | Comparison group/s | | Assessment timepoints* |
|---|---|---|---|---|---|---|
| | | Sample size | Age (M, SD) | Sample size | Age (M, SD) | |
| **Cheng et al. (2013)** | Merged data from two studies with a cross-sectional correlational design | 389 | US: 33.7, 3.69; Taiwan: 30.78, 3.86 | n.a. | n.a. | Three months (*n* = 80), three to six months (*n* = 111), six to nine months (*n* = 101), and over nine months postpartum (*n* = 97) |
| **Choi et al. (2017)** | Prospective cohort (from a longitudinal main study) | 33 | 25, 5.8 | n.a. | n.a. | Six weeks postpartum |
| **Christensen et al. (2010)** | Prospective cohort longitudinal | 76 pregnant women at follow-up (2003 or 2007) and 188 became mothers (but were not pregnant at the time of the interview). All participants included in analyses were not pregnant at Time 1 | 20-24 at baseline | 542 never pregnant | 20-24 at baseline. | Baseline measurement (1999), first follow-up (2003) and second follow-up (2007) |
| **Croll & Bryant (2000)** | Cohort | 13 | 31.85, 4.61 | 13 non-depressed new mothers | 31.85, 4.18 | Depressed group: 9.38 (8.97) months postpartum; control group: 6.23 (3.35) months postpartum |
| **Cuttler et al. (2011)** | Cross-sectional | 61 (13 in first trimester; 24 in second trimester; 24 in third trimester) | Not available | 24 non-pregnant | Not available | First, second or third trimester |
| **Dale-Hewitt et al. (2012)** | Cross-sectional | 50 | 28<br>Range: 18 – 40 | n.a. | n.a. | 6 weeks postpartum |
| **Dennis-Tiwary et al. (2017)** | Pilot double-blind, randomized, placebo-controlled trial | 29 (ABMT [*n* = 15] and placebo [PT, *n* = 14] groups) | 32.97, 5.52<br>Range: 23 - 45 | n.a. | n.a. | Second trimester |
| **Dudek & Haley (2020)** | Longitudinal | 36 (25 primiparous and 11 multiparous) | 30.5, 4.8<br>Range: 22 - 39 | n.a. | n.a. | Third trimester |
| **Edvinsson et al. (2017)** | Cross-sectional from a longitudinal cohort main study | 73 pregnant (*n* = 40) and postpartum (*n* = 33) women | Pregnant: 29.1, 5.3<br>Postpartum: 30.4, 4.9 | 137 pregnant and 124 postpartum women without depressive disorder | Pregnant: 31.8, 4.1; postpartum: 32.0, 4.5 | Third trimester or 6–14 weeks postpartum |
| **England-Mason et al. (2017)**<br>**England-Mason et al. (2018)** | Prospective | 140 | 32.3, 4.4;<br>range: 22 - 41 | n.a. | n.a. | 7 months postpartum |
| **Farrar et al. (2014)** | Longitudinal | 23 | 30, 6.2 | 24 non-pregnant women | 32, 6.1 years | First, second and third trimesters and 3 months postpartum |
| **Fiterman & Raz (2019)** | Cross-sectional | 23 | 33.74, 4.80 | 22 non-pregnant women | 31.50, 6.53 | Third trimester |

*Assessment timepoints considering review question.

n.a.: not applicable.

***Table 2*** *(continued)*

| Authors | Design | Pregnant group | | Comparison group/s | | |
|---|---|---|---|---|---|---|
| | | **Sample size** | **Age (M, SD)** | **Sample size** | **Age (M, SD)** | **Assessment timepoints*** |
| **Hampson et al. (2015)** | Repeated-measures | 28 pregnant women (10 Preg+ and 18 Preg−) and 10 postpartum controls | Pregnant women: 29.96, 5.41; postpartum controls: 31.30; 3.92 | 26 non-pregnant controls | 27.35, 3.37 | Pregnant group: third trimester and 3-4 months postpartum. Postpartum group: 4-12 (M = 9) weeks and 3-4 months postpartum |
| **Harris et al. (1996)** | Longitudinal | 20 | 29.0, 4.6 | 20 non-pregnant women | 29.1, 4.7 | Third trimester and 48h and four weeks postpartum |
| **Hipwell et al. (2004)** | Prospective cohort | 94 | 30.3, 4.4<br>Range: 17 – 39 | n.a. | n.a. | Third trimester of pregnancy, seven – 10 days postpartum and six – eight weeks postpartum |
| **Hoekzema et al. (2017)** | Prospective cohort | 25 primiparous women | Not available | 20 nulliparous control women, 19 first-time fathers and 17 control men without children | Not available | 73.56 (47.83) days postpartum |
| **Kataja et al. (2017)** | Nested case-control Focus Cohort | 143 (High symptom level group [*n* = 46]; Moderate symptom level group [*n* = 97]) | High symptom level group: 30.6, 4.4; Moderate symptom level group: 31.7, 4.4 | 87 (low symptom level group) | 31.5, 4.6 | Second and third trimester |
| **Keenan et al. (1998)** | Longitudinal | 10 | 32.5, 4.3 | 10 non-pregnant women | 34.9, 4.7 | First, second and third trimesters of pregnancy and postpartum |
| **Liakea et al. (2022)** | Nested case–control group within a longitudinal population-based cohort (BASIC) | 283 | 31.40, 4.31 | n.a. | n.a. | Third trimester (cognitive and depression assessment) and 6 weeks postpartum (depression assessment) |
| **Logan et al. (2014)** | Longitudinal controlled | 21 | 25.14, 3.80<br>Range: 21 - 33 | 21 never pregnant | 21.90, 2.79<br>Range: 19 - 29 | Third trimester of pregnancy and three - six months postpartum |
| **Mazor (2019)** | Cross-sectional | 40 (high risk for PPD) | 28.23, 5.0 | 80 (low PPD risk) | 28.24, 5.1 years | One - three days postpartum |
| **Messinis et al. (2010)** | Cross-sectional | 21 postpartum depressed women; 22 postpartum nondepressed women | 33.43, 5.32; 33.27, 3.70 | 24 non-depressed non-postpartum women | 34.29, 3.53 years | 30 - 58 days postpartum |
| **Miranda et al. (2021)** | Cross-sectional | 305 | 30.51, 5.65 | n.a. | n.a. | ≤ six months postpartum (73%) or > six months postpartum (27%)) |
| **Nah et al. (2018)** | Cross-sectional | 25 | 32.36, 2.96 | 27 controls | 30.81, 4.08 | Three months postpartum |

*Assessment timepoints considering review question.

n.a.: not applicable;"; Preg+: pregnant women with diagnosis of depression; Preg-: pregnant women without diagnosis of depression; PPD: postpartum depression (symptoms)

***Table 2*** *(continued)*

| Authors | Design | Pregnant group | | Comparison group/s | | Assessment timepoints |
|---|---|---|---|---|---|---|
| | | Sample size | Age (M, SD) | Sample size | Age (M, SD) | |
| **O'Toole & Berntsen (2020)** | Longitudinal | 59 | 28.3, 4.8 | 59 nonpregnant women | 24.3, 2.2 | Third trimester |
| **Pearson et al. (2010)** | Cross-sectional | 31 (depressive symptom group) | 28<br>Range: 18 - 41 | Non-symptom group (*n* = 70) | 30<br>Range 18 - 43 | First trimester |
| **Pearson et al. (2011)** | longitudinal | 75 in late pregnancy; 51 later in postpartum | 29.5 (range 18 – 41); 30 (range 19 – 37) | n.a. | n.a. | Third trimester and 18 weeks (9-33) postpartum |
| **Pearson et al. (2013)** | Pilot randomised control trial (RCT) | 24 depressed pregnant women | CBT group: 28, 5.1; Usual care: 30, 6.2 | 51 non-depressed pregnant women | Not available | First trimester |
| **Raz (2014)** | Cross-sectional | 17 | 30.35, 6.33<br>Range: 22 - 41 | 19 non-pregnant | 30.53, 6.05<br>Range: 23 - 42 | Third trimester |
| **Roos, A., et al. (2012)** | Longitudinal | 44 | 26.57, 5.76 | 25 never pregnant | 28.84, 6.09 | Second and third trimester |
| **Shin (2018)** | Prospective | 25 | 30.9, 3.0<br>Range: 20 - 40 | 26 nulligravid women | 29.8, 4.0 | Two – four months postpartum |
| **Skowron et al. (2014)** | Prospective cohort | 118 third trimester; 45 postpartum women | Third trimester: 26.3, 5.6; Postpartum: 28.3, 6.6<br>Range: 18 – 43 | n.a. | n.a. | Third trimester (cognitive and depression assessment) and eight weeks postpartum (depression assessment) |
| **Sun et al. (2020)** | Longitudinal | 682 pregnant and 89 postpartum women | 30.1, 4.3 | 2504 controls | 30.7, 4.3 | Second and third trimesters and 19 weeks (12.55) postpartum |
| **Tang et al. (2019)** | Cohort | 46: MDS group (*n* = 22) and SDS group (*n* = 24) | MDS: 29.8, 4.50<br>SDS: 28.5, 3.60 | 43 (NDS group) | 28.3, 3.60 | Third trimester |
| **Wilson et al. (2011)** | Cross-sectional | 46 (20 first and 26 third trimester women) | First-trimester: 29.4, 3.3, third-trimester: 32.2, = 3.6) | 24 nonpregnant women (control group) | 29.3, 5.9 | First or third trimester |

*Assessment timepoints considering review question.
n.a.: not applicable; MDS: major depression symptoms, SDS: suspicious depressive symptoms, NDS: non-depressive symptoms.

***Table 3:*** *Outcomes and results of the included studies (n = 44)*

| Authors | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depressive symptoms | Measures to assess anxiety symptoms | Measures to assess cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Almanza-Sepulveda et al. (2018)** | BDI | BAI | Verbal working memory, visuospatial working memory | DST, CBT | Demographic characteristics (age, education, health, and other details) | No significant differences between groups for anxiety and depression levels [results of the association not provided]. |
| **Atkinson et al. (2009)** | SCL-90-R*, BDI and EPDS | SCL-90-R* | Selective attention to social information | Emotional Stroop task | n.a. | No significant differences between six and 12-month Stroop outcomes and mental health variables [no quantitative data provided]. |
| **Barda et al. (2021)** | Depression test (taken from the GDS) | n.a. | Verbal and learning memory, working memory and short-term working memory | DST, word recall task, verbal paired associates test | n.a. | None of the women were depressed and no difference was found on the depression test between pregnant and non-pregnant women [results of the association not provided]. |
| **Brussé et al. (2008)** | CES-D | STAI | Auditory verbal memory, delayed free recall, recognition; verbal recall, attention, working memory; attention | Dutch version of the Rey auditory verbal learning test; DST; TMT, the Stroop Color Word test | Age, educational level, mode of delivery, and method of anesthesia | Although former severely preeclamptic patients had higher scores on depression and levels of anxiety, the differences did not reach significance [results of the association not provided]. |
| **Buckwalter et al. (1999)** | BDI, POMS* and SCL* | POMS* and SCL* | Episodic verbal memory, short- and long-term delayed memory; semantic memory; verbal attention | CVLT; Boston Naming Test,; DST Forward and Backward | n.a. | No association between mood and cognitive changes [no quantitative data provided]. |
| **Callaghan et al. (2021)** | EPDS | n.a. | Recognition memory (object-recognition memory and object-scene associative recognition memory) | Test of learning and retention of spatial associative memory for parenting-relevant and non-parenting-relevant stimuli (baby and adult objects) | n.a. | Depression was not a significant predictor of cognitive performance, comparing pregnant participants to never pregnant online participants. |
| **Castro et al. (2021)** | EPDS | n.a. | Working memory | DST | n.a. | Depressive symptoms were not associated with the DST subscales. Maternal depressive symptoms did not significantly predict scores on the DST Forward ($B$ = -.00, $p$ = n.s.), DST Backward ($B$ = .02, $p$ = n.s.) or DST Total ($B$ = -.01, $p$ = n.s.). |

*We considered this instrument whenever anxiety/depression scores alone were extracted for the analysis and/or the instrument was combined with other specific measures of depressive/anxiety symptoms.
n.a.: not applicable; BDI: Beck Depression Inventory; BAI: Beck Anxiety Inventory; SCL-90-R: Symptom Checklist 90-R; EPDS: Edinburgh Postnatal Depression Scale; GDS: Geriatric Depression Scale; CES-D: Center for Epidemiological Studies Depression Scale; STAI: State-Trait Anxiety Inventory; POMS: Profile of Mood States; DST: Wechsler Digit Span Test; WAIS-III: Wechsler Adult Intelligence Scale – 3rd edition; CBT: Corsi Block-tapping task; TMT: Trail Making Test; CVLT: California Verbal Learning Test

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Casey (2000)** | DASS-21 | DASS-21 | Subjective memory impairment; working memory | Part F of the Short Inventory of Memory Experience; DST Forward and Backward | Age and education level | Correlations at 23 weeks postpartum: significant association between anxiety and reported absentmindedness level ($r$ = 0.32, $p$ < 0.05), reported level of forgetting on errands (r = 0.34, $p$ < 0.05) (measures of subjective memory impairment). No differences between groups on objective test results at any time phase. |
| **Cheng et al. (2013)** | CES-ND | n.a. | Subjective decrease in memory | PHC | Age, employment, educational level, and whether they had received postpartum care | Depressive symptoms were correlated to a decrease in memory ($r$ = .30, $p$ < .01). Mothers who experienced depressive symptoms had high rates of experiencing a decrease in memory ($p$ < 0.01). |
| **Choi et al. (2017)** | EPDS | n.a. | Attention bias | Modified Stroop task | Maternal age and education | Selective attention to masked (unconscious) fear stimuli inversely predicted postpartum depression scores through six months ($B$ = −.47, $p$ = .001): ↓ response latencies predicted ↑ levels of depression. Selective attention to unmasked (conscious) fear stimuli did not predict postpartum depression. |
| **Christensen et al. (2010)** | Goldberg Depression Scale | Goldberg Anxiety Scale | Working memory; immediate and delayed recall of verbal memory | DST Backwards; first trial of the CVLT | n.a. | Symptoms of depression and anxiety were not significant covariates for the cognitive factors [no quantitative data provided]. |
| **Croll & Bryant (2000)** | EPDS and BDI | n.a. | Autobiographical memory | AMT | Age, number of years of education, time since the birth of their last child, and number of children | EPDS scores were negatively correlated with recall of specific neutral ($r$ = .43, $p$ < .05) and negative memories ($r$ = .59, $p$ < .01) and positively correlated with latency to retrieve positive memories ($r$ = .55, $p$ < .01). EPDS correlated negatively with recall of positive parent-related memories ($r$ = .47, $p$ < .05). |
| **Cuttler et al. (2011)** | BDI | STAI | Self-reported memory impairment; explicit episodic memory (verbal memory); working memory; prospective memory | PMQ, PRMQ, CFQ; AVLT; DST Backward; Fruit Prospective Memory Task, Phone Prospective Memory Task, Call-In Prospective Memory Tasks, Mail Prospective Memory Task | n.a. | Depressed mood associated with greater subjective problems on PMQ episodic prospective memory ($r$ = .41, $p$ < .001), PMQ habitual prospective memory ($r$ = .36, $p$ < 0.01), PMQ internally-cued prospective memory ($r$ = .42, $p$ < .001), PRMQ prospective memory ($r$ = .37, $p$ < .001), PRMQ retrospective memory ($r$ = .44, $p$ < .001), CFQ memory ($r$ = .44, $p$ < .001), CFQ distractibility ($r$ = .41, $p$ < .001), CFQ blunders ($r$ = .48, $p$ < .001). Depressed mood was not significantly correlated with performance on objectively assessed prospective memory. |
| **Dale-Hewitt et al. (2012)** | EPDS | n.a. | Attentional bias in relation to childbirth | Stroop task with labour-related words | n.a. | No significant relationship ($r$ = −0.98, $p$ = 0.49) between depressive symptoms and attentional bias. Symptoms of depression did not significantly contribute to the prediction of variance of an attentional bias towards labour words. |

n.a.: not applicable; DASS-21: Depression, Anxiety, and Stress Scale; CES-D: Center for Epidemiological Studies Depression Scale; EPDS: Edinburgh Postnatal Depression Scale; STAI: State-Trait Anxiety Inventory; BDI: Beck Depression Inventory; PHC: Physical Health Condition checklist; DST: Wechsler Digit Span Test; CVLT: California Verbal Learning Test; PMQ: Prospective Memory Questionnaire; PRMQ: Prospective and Retrospective Memory Questionnaire; CFQ: Cognitive Failures Questionnaire; AVLT: Rey Auditory Verbal Learning Test; AMT: Autobiographical Memory Test

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Dennis-Tiwary et al. (2017)** | DASS-21 | DASS-21 and HAM-A | Attention bias (selective attention) | Baseline dot probe task | n.a. | No significant correlation between self-report measures of depression and anxiety and attention bias scores [no quantitative data provided]. |
| **Dudek & Haley (2020)** | EPDS | STAI - Trait Version | Attention bias to infant and adult facial cues | Attentional bias task (Go/No-go) | n.a. | Depression and anxiety scores unrelated to the attention bias index, both in high-sensitivity mothers, as derived from RT data ($r$ = -.20, $p$ = .39; $r$ = -.08, $p$ = .74) or ERP data ($r$ = -.21, $p$ = .37; $r$ = 0.10, $p$ = .67) and in low–sensitivity mothers ($r$ = -.17, $p$ = .54; $r$ =.05, $p$ = .85; $r$ = -.02, $p$ = .95; $r$ = -.01, $p$ = .96). |
| **Edvinsson et al. (2017)** | Swedish version of the MINI*, MADRS-S and EPDS | Swedish version of the MINI* | Attentional bias to emotional information | Emotional stroop task | Age | In pregnancy, no significant difference in emotional interference scores was noted. Women with postpartum depression displayed shorter reaction times to positive and negative stimuli than to neutral words. In postpartum, depression severity was significantly negatively correlated with the emotional interference scores by positive (MADRS: ρ = −.29, $p$ < .001; EPDS: ρ = −.25, $p$ < .01) and negative (MADRS: ρ = −.20, $p$ < .05) stimuli. No interaction between word category and anxiety was found. |
| **England-Mason et al. (2017) England-Mason et al. (2018)** | EPDS | n.a. | Selective attention to emotional stimuli | Emotional Stroop | n.a. | **England-Mason et al. (2017)**: Pearson correlation between EPDS score and attention bias score non-significant (ρ = -0.11, p > .05). Depression as a non-significant covariate in the moderation effect of maternal difficulties with emotion regulation in the impact of exposure to child maltreatment on time-dependent cortisol reactivity to an Emotional Stroop task. **England-Mason et al. (2018)**: No significant correlation between EPDS score and average neutral word reaction time ($r$ = 0.02, $p$ > .05), average negative word reaction time ($r$ = -0.01, $p$ > .05), average attachment word reaction time ($r$ = 0.02, $p$ > .05), negative attention bias ($r$ = -0.14, $p$ > .05) and attachment attention bias ($r$ = 0.02, $p$ > .05). |
| **Farrar et al. (2014)** | EPDS | n.a. | Visual-spatial recognition memory; short-term visual recognition memory; spatial working memory; attentional set shifting ability/executive functioning | CANTAB: SRM; DMS; SOC; IED shift | n.a. | Although the pregnant group reported more symptoms of anxiety and depression than controls, a regression analysis indicated that these differences did not account for the SRM differences [no quantitative data provided]. After controlling for the confounders verbal intelligence (NART), parity, anxiety, and depression, the differences between groups on the SRM test were strengthened (second assessment, $p$ = 0.002; third assessment, $p$ = 0.06 and fourth assessment, $p$ = 0.002). |
| **Fiterman & Raz (2019)** | n.a. | STAI | Attention | Digit-symbol coding test | Age, ethnicity, socioeconomic status, educational level and number of children | No differences in trait or state anxiety were found between pregnant and non-pregnant women ($p$ = 0.598; $p$ = 0.116, respectively) [results of the association not provided]. |
| **Hampson et al. (2015)** | EPDS, MADRS and MINI* | n.a. | Verbal memory; working memory | Paragraph Recall; SPWM; SOP; CBT | Age, education and ethnicity, number of weeks post-delivery, minor individual differences across participants in the number of days prior to parturition | Significant correlation between EPDS and SOP and SPWM errors ($p$ < .10, $r$ = .34); and between MADRS and SOP ($p$ < 0.05; $r$ = .48) and SPWM errors ($p$ < .10; $r$ = .36). ↑ depression and ↓ estradiol concentrations associated with ↑ WM errors. Preg+ showed a substantial decrease in WM errors from Visit 1 to Visit 2 ($p$ < .01). At postpartum there were no significant differences in WM performance. |

*We considered this instrument whenever anxiety/depression scores alone were extracted for the analysis and/or the instrument was combined with other specific measures of depressive/anxiety symptoms.
n.a.: not applicable; DASS-21: Depression, Anxiety, and Stress Scale; HAM-A: The Hamilton Anxiety Scale; EPDS: Edinburgh Postnatal Depression Scale; STAI: State-Trait Anxiety Inventory; MINI: Mini International Neuropsychiatric Interview; MADRS: Montgomery–Åsberg Depression Rating Scale; SRM: Spatial Recognition Memory Test; DMS: Delayed Matching to Sample test; SOC: Stockings of Cambridge test; IED shift: Intra/extra dimensional shift test; SPWM: Spatial Working Memory; SOP: Self-Ordered Pointing; CBT: Corsi Block-tapping task; WM: Working Memory; Preg+: pregnant women with clinical depression.

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Harris et al. (1996)** | HAD | HAD | Verbal memory; attention; subjective impairment of memory | Delayed form of Logical memory; Digit symbol, PASAT; Memory questionnaire by Taylor (1990) | Age and intellectual level | Third trimester: non-significant correlations between HAD-D and digit symbol ($r$ = -.10), PASAT 4s ($r$ = -10) and PASAT2S ($r$ = -.06); 48h postpartum: significant correlations between HAD-D and digit symbol ($r$ = -.38, $p$ < .02), PASAT 4s ($r$ = -.66, $p$ < .001) and PASAT2S ($r$ = -.26. $p$ < .05); Four weeks postpartum: significant correlations between HAD-D and PASAT 4s ($r$ = -.30, $p$ < .05), but not for PASAT2S ($r$ = -.13) and digit symbol ($r$ = -.20). |
| **Hipwell et al. (2004)** | BDI (Time 1) and EPDS (Times 2 and 3) | n.a. | Autobiographical memory | AMT | Educational level, variations in antenatal dysphoria, previous emotional difficulties, neuroticism and the woman's own experience of mothering | Depressive symptomatology during the immediate postpartum period was not predicted by cognitive variables examined during pregnancy. However, low specificity of autobiographical recall to positively valenced cues ($r$ = -0.29, $p$ =< .05) predicted depressive symptoms more distally at 2 months post-delivery. Type of recall to negative cues was not found to be predictive. |
| **Hoekzema et al. (2017)** | EPDS | n.a. | Working memory | DST, two-back working memory test | n.a. | Non-significant correlations between postpartum EPDS scores in the mothers and digit span task (correct responses) ($r$ = -.077, $p$ = .715) and Nback (correct responses) ($r$ = .394, $p$ = .057). ** |
| **Kataja et al. (2017)** | EPDS | Anxiety subscale of SCL-90*; PRAQ-R2 | Verbal learning and memory; visual attention/vigilance; visual working memory; visual recognition memory; visuospatial working memory | Cogstate (test battery): International Shopping List Task + recall; Identification Task; One Back Task; One Card Learning Task; Continuous Paired Associate Learning Task; GML | Maternal age and parity | Visuospatial working memory errors correlated positively and significantly with depressive symptom in all three assessments during pregnancy (ranging between 0.15 and 0.16, $p$ values 0.009 – 0.013) and with pregnancy-related anxiety ($r$ = 0.151, $p$ = 0.012), especially concerns related to the well-being of the child ($r$ = 0.216, $p$ = 0.001). No correlation was found between the GML performance and general anxiety symptoms (SCL-90). ↑ scores in PRAQ-R2, factor 2, ↑ EPDS score and ↑ maternal age all positively predicted the number of GML errors. |
| **Keenan et al. (1998)** | BDI | SAS | Explicit memory; subjective memory decline | Wechsler Memory Scale-Revised Logical Memory, California Discourse Memory Test; Subjective Memory Questionnaire | Age, education, estimated IQ, and socioeconomic variables | Correlation between degree of somatic complaints on the BDI and recall not significant. These complaints continued into the postpartum period while recall scores improved dramatically. Reports of cognitive symptoms of depression were negligible. Fluctuations in mood and memory did not coincide [quantitative data not provided]. |
| **Liakea et al. (2022)** | EPDS | n.a. | Working memory; attention | DST (DSB; DSF) | Maternal education and feeling rested at assessment | No association between antepartum depression and performance on memory tasks (ρ = 16.0, $p$ = 0.789). Women who scored higher on EPDS at 6 weeks postpartum performed better on DSF than those who scored lower on EPDS ($p$ = 0.047), but not for DSB ($p$ = 0.856) or DST ($p$ = 0.184); Spearman correlations between memory performance score and EPDS score at six weeks postpartum were not statistically significant. DSF in pregnancy was a significant predictor of postpartum depression (PPD) symptoms and remained a significant predictor when adjusted for confounders, only for women without a pre-pregnancy history of depression and also those without antepartum depression (APD) symptoms. |

*We considered this instrument whenever anxiety/depression scores alone were extracted for the analysis and/or the instrument was combined with other specific measures of depressive/anxiety symptoms.

**Additional data not reported in the published manuscript but requested by the research team.

n.a.: not applicable; EPDS: Edinburgh Postnatal Depression Scale; HAD: Hospital Anxiety and Depression scale; BDI: Beck Depression; SCL-90: Symptom Checklist 90; PRAQ-R2: Pregnancy-Related Anxiety Questionnaire Revised 2; SAS: Zung Anxiety Scale; SPWM: Spatial Working Memory Inventory; SOP: Self-Ordered Pointing; PASAT: Paced Auditory Serial Addition Test; AMT: Autobiographical Memory Test; DST: Wechsler Digit Span Test; GML: Groton Maze Learning Test

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Logan et al. (2014)** | BDI–II | STAI | Verbal memory; visuospatial memory; working memory and divided attention; selective attention | CVLT–II; BVMT–R; DST, PASAT; Stroop Color–Word Test | n.a. | No differences on any of the neuropsychological measures between the seven participants with BDI–II scores above 13 at third trimester and the other pregnant women ($t < 1.59$, $p > .13$) or the control participants ($t < 1.73$, $p > .10$). No significant result of either BDI–II-measured depression or STAI-measured anxiety scores as moderators for all the neuropsychological domains. |
| **Mazor (2019)** | EPDS | n.a. | Subjective cognitive function (working memory); memory | AFI; SDMT | Maternal age, gestational age, and ethnicity | Depressed mothers scored significantly lower in the subjective AFI test ($p < 0.001$), nearly significantly lower in the objective SDMT90 test ($p = 0.057$) and not significantly lower in the objective cognitive test SDMT4 ($p = 0.485$). Maternal depression (EPDS score) was independently and significantly associated with the subjective (AFI) score ($\beta = –13.71$, $p < 0.001$), but not with objective cognitive test score (SDMT90) ($\beta = –3.48$, $p = 0.15$). |
| **Messinis et al. (2010)** | QIDS–SR | n.a. | Verbal memory; visual selective and sustained attention | RAVLT; Ruff 2 and 7 Selective Attention Test | Age and education level | Postpartum depressed women were found to present lower performance on the initial verbal learning trial of the RAVLT (Trial1) ($p = .011$) and recall of List B (interference trial) ($p = .010$) than did the healthy control group. However, the verbal learning/memory performance of the two postpartum groups did not differ significantly. Groups did not differ in their performance regarding visual selective and sustained attention. |
| **Miranda et al. (2021)** | Spanish version of PDSS-SF | n.a. | Memory complaints | Spanish version of MCS-P | n.a. | Significant positive correlation between the scores of postpartum depression and memory complaints ($p < 0.0001$). Social isolation had significant indirect effects on cognition ($B = -0.02$, $p = 0.048$), mediated by depression. Depression had direct effects on cognition ($B = -0.33$, $p < 0.0001$). Cognition received indirect effects from depression ($p < 0.0001$) through insomnia. |
| **Nah et al. (2018)** | BDI and Subjective Discomfort Survey* | Subjective Discomfort Survey* | Cognitive dysfunction, cognitive failures, attention, working memory, verbal and learning memory, short term and long-term memory | Subjective discomfort survey, CFQ, TMT, DST, Word List Recall and Recognition, and Word List Memory, N-back task, R/K procedure. | Age | Subjective discomfort in daily life due to sleep deprivation, insomnia, anxiety, and depression did not differ between groups, indicating that subjective degradation in cognitive function found in the PP group could not be due to poor emotional state or circumstances [results of the association not provided]. |

*We considered this instrument whenever anxiety/depression scores alone were extracted for the analysis and/or the instrument was combined with other specific measures of depressive/anxiety symptoms.
n.a.: not applicable; BDI: Beck Depression Inventory; STAI: State-Trait Anxiety Inventory; EPDS: Edinburgh Postnatal Depression Scale; QIDS-SR: Quick Inventory of Depressive Symptomatology–Self-Report (QIDS–SR); PDSS-SF: Postpartum Depression Screening Scale-Short Form; CVLT-II: California Verbal Learning Test–II; BVMT-R: Brief Visuospatial Memory Test–Revised; DST: Wechsler Digit Span Test; PASAT: Paced Auditory Serial Addition Test; AFI: Attention Function Index; SDMT: Symbol Digit Modalities Test; RAVLT: The Rey Auditory Verbal Learning Test; MCS-P: Memory Complaint Scale for patients; CFQ: Cognitive Failures Questionnaire; , TMT: Trail Making Test; DST: Wechsler Digit Span Test;

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **O'Toole & Berntsen (2020)** | HAD | HAD | Autobiographical memory | FREE and FORCED condition | Education | The total number of birth-related events recalled or predicted was negatively associated with psychological distress. However, the number of specific events ($r$ = .33, $p$ = .011) and specific birth-related events ($r$ = 0.34, $p$ = .005) was positively associated with levels of psychological distress. |
| **Pearson et al. (2010)** | CIS-R* and EPDS | CIS-R* | Attentional bias | Go/no-go with adult and infant faces of distressed, neutral and happy expressions | General reaction times, social class, gestation, fatigue scores, desire to have children, ability to recognize emotions and previous loss, parity, age, mental health history, planned pregnancy, marital status | Non-depressed pregnant women showed an attentional bias toward distressed infant faces, since reaction times following distressed infant trials were slower than trials featuring happy infant ($t$ = 3.8, $p$ < 0.01) or neutral infant faces ($t$ = 2.8, $p$ < 0.01), whereas women with depressive symptoms did not. Depressed women were quicker to disengage their attention from distressed compared with non-distressed infant faces. |
| **Pearson et al. (2011)** | EPDS | n.a. | Attentional bias towards distressed infant faces | Go/no-go | n.a. | Women's attentional bias index towards infant distress after birth was not found to be associated with maternal mood after birth [no quantitative data provided]. |
| **Pearson et al. (2013)** | CIS-R* and EPDS | n.a. | Attentional bias for infant distress | Attentional bias task (Go/No-go) | n.a. | At baseline, depressed women in both the CBT and UC arm of the trial showed a diminished attentional bias for infant distress as compared to the comparison group of non-depressed pregnant women and previous non-depressed samples. The attentional bias indices of non-depressed women were 32 ms ($p$ = 0.060) higher than depressed women. |
| **Raz (2014)** | n.a. | STAI-T | Sustained attention; attentional bias toward emotional faces | Online Continuous Performance Test; Visual emotional oddball task | Age, ethnicity, educational level, number of children and level of anxiety. | Pregnant and non-pregnant women did not differ in their mean levels of anxiety [results of the association not provided]. |
| **Roos, A., et al. (2012)** | n.a. | STAI | Selective attention to fearful and angry faces | Emotional Stroop task | Parity, gravidity, age and education | No significant associations between selective attention to fearful faces and anxiety [no quantitative data provided]. |
| **Shin (2018)** | EPDS and BDI | n.a. | Prospective memory (PM); subjective cognitive decline; working memory; verbal learning/memory function. | fMRI paradigm for PM; CFQ; DST; Word List Recall and Recognition. | Age and duration of education | Decreased PM accuracy was correlated with a higher BDI score (greater depressive symptoms, ρ = −0.320, $p$ = 0.024); The BDI score did not significantly affect PM accuracy in both direct (ß = .035, $p$ = 094) or indirect ways (ß = .048, $p$ = .228). |
| **Skowron et al. (2014)** | EPDS | n.a. | Cognitive flexibility | The Cognitive Flexibility Scale | PDPI-R scores | No significant correlation between cognitive flexibility and postpartum depressive symptoms ($r$ = –.114, $p$ = .22). Cognitive flexibility (β = –.05, $t$ (44) = –.26, $p$ = .79) was not a significant individual predictor in the regression model. However, the interaction between cognitive flexibility and assertiveness significantly predicted depressive symptoms (β = –.34, $t$ (44) = –2.33, $p$ = .02). Cognitive flexibility was found to moderate the relationship between assertiveness and sub-clinical postpartum depressive symptoms. |
| **Sun et al. (2020)** | EPDS and PHQ-9 | STAI | Memory dysfunction | PRMQ | n.a. | ↑ levels of depressive and anxiety symptoms and ↑ levels of memory dysfunction in all groups. Levels of depression, anxiety symptoms and memory dysfunction [statistics not provided]. |

*We considered this instrument whenever anxiety/depression scores alone were extracted for the analysis and/or the instrument was combined with other specific measures of depressive/anxiety symptoms.
n.a.: not applicable; HAD: Hospital Anxiety and Depression scale; CIS-R: Clinical Interview Schedule; EPDS: Edinburgh Postnatal Depression Scale; STAI: State-Trait Anxiety Inventory; BDI: Beck Depression Inventory; PHQ-9: Patient Health Questionnaire; PM: Prospective memory; CFQ: Cognitive Failure Questionnaire; PRMQ: The Subjective Prospective and Retrospective Memory Scale

***Table 3*** *(continued)*

| Reference | Measures | | | | Controled variables | Results |
|---|---|---|---|---|---|---|
| | Measures to assess depression | Measures to assess anxiety | Measures of cognitive functioning | | | |
| | | | Cognitive domain | Measure | | |
| **Tang et al. (2019)** | EPDS | n.a. | Attentional processing of emotional information | Different paired pictures selected from the International Affective Picture System (Center for the Study of Emotion and Attention, 1999) | n.a. | Symptoms of depression were positively associated with the bias scores of initial-fixation direction to negative pictures ($r$ = 0.254, $p$ = 0.016), but not with the maintenance attention index of negative images. The three groups had an attentional bias to positive and negative pictures. Nevertheless, the MDS group paid significantly more attention to negative pictures ($p$ = 0.008), and the NDS group had significantly longer fixation duration to positive pictures ($p$ = 0.000), compared with neutral pictures. |
| **Wilson et al. (2011)** | DASS-21 | DASS-21 | Episodic memory - immediate and delayed recall, delayed recognition; attention | Logical Memory, Verbal Paired Associates, Faces, Family Pictures and Auditory Recognitions tasks of the WMS–III, RAVLT, Austin maze; TOVA | n.a. | Depression and anxiety did not show any significant associations with memory variables [no quantitative data provided]. |

n.a.: not applicable; EPDS: Edinburgh Postnatal Depression Scale; STAI: State-Trait Anxiety Inventory; DASS-21: Depression, Anxiety, and Stress Scale MADRS: Montgomery–Åsberg Depression Rating Scale; WMS-III: Wechsler memory scale–third edition; RAVLT: Rey auditory verbal learning test; TOVA: Test of variables of attention; MDS: major depression symptoms; NDS: non-depressive symptoms; MDS: major depression symptoms.

**Risk of bias in studies**

Assessment of risk of bias is presented in Tables 4 and 5. Most cross-sectional studies (N = 10) were of high-quality, with only three of them having a moderate quality (Almanza-Sepulveda et al., 2018; Cuttler et al., 2011; Fiterman & Raz, 2019) and one low quality (Nah et al., 2018). RCT studies revealed high and moderate quality (Dennis-Tiwary et al., 2017; Pearson et al., 2013, respectively). All case-control studies (Brussé et al., 2008; Kataja et al., 2017; Liakea et al., 2022) revealed moderate quality. Longitudinal studies revealed low (N = 13) and moderate (N = 11) quality and one revealed high quality (Hampson et al., 2015). Details on the risk of bias assessment are presented in Annex C.

***Table 4:*** *Risk of Bias Assessment for RCT and Cross-sectional Studies*

| **Reference** | Overall appraisal | | | Comments |
|---|---|---|---|---|
| | **Include** | **Exclude** | **Seek further info*** | |
| **Almanza-Sepulveda et al. (2018)** | | | x | Moderate quality study |
| **Cheng et al. (2013)** | x | | | High quality study |
| **Croll & Bryant (2000)** | x | | | High quality study |
| **Cuttler et al. (2011)** | | | x | Moderate quality study |
| **Dale-Hewitt et al. (2012)** | x | | | High quality study |
| **Dennis-Tiwary et al. (2017)** | x | | | High quality study |
| **Edvinsson et al. (2017)** | x | | | High quality study |
| **Fiterman & Raz (2019)** | | | x | Moderate quality study |
| **Mazor (2019)** | x | | | High quality study |
| **Messinis et al. (2010)** | x | | | High quality study |
| **Miranda et al. (2021)** | x | | | High quality study |
| **Nah et al. (2018)** | | x | | Low quality study |
| **Pearson et al. (2010)** | x | | | High quality study |
| **Pearson et al. (2013)** | | | x | Moderate quality study |
| **Raz (2014)** | x | | | High quality study |
| **Wilson et al. (2011)** | x | | | High quality study |

* Seek further info: nomenclature presented in both instruments. It did not imply further research in the context of the present review.

***Table 5:*** *Risk of Bias Assessment for Cohort and Case Control Studies*

| Reference | Total | Comments |
|---|---|---|
| **Atkinson et al. (2009)** | 2 stars | Low quality study |
| **Barda et al. (2021)** | 2 stars | Low quality study |
| **Brussé et al. (2008)** | 5 stars | Moderate quality study |
| **Buckwalter et al. (1999)** | 2 stars | Low quality study |
| **Callaghan et al. (2021)** | 2 stars | Low quality study |
| **Casey (2000)** | 5 stars | Moderate quality study |
| **Castro et al. (2021)** | 3 stars | Moderate quality study |
| **Choi et al. (2017)** | 3 stars | Moderate quality study |
| **Christensen et al. (2010)** | 2 stars | Low quality study |
| **Dudek & Haley (2020)** | 2 stars | Low quality study |
| **England-Mason et al. (2017)** | 1 star | Low quality study |
| **England-Mason et al. (2018)** | 1 star | Low quality study |
| **Farrar et al. (2014)** | 2 stars | Low quality study |
| **Hampson et al. (2015)** | 6 stars | High quality study |
| **Harris et al. (1996)** | 4 stars | Moderate quality study |
| **Hipwell et al. (2004)** | 4 stars | Moderate quality study |
| **Hoekzema et al. (2017)** | 3 stars | Moderate quality study |
| **Kataja et al. (2017)** | 5 stars | Moderate quality study |
| **Keenan et al., (1998)** | 5 stars | Moderate quality study |
| **Liakea et al. (2022)** | 6 stars | High quality study |
| **Logan et al. (2014)** | 3 stars | Moderate quality study |
| **O'Toole & Berntsen (2020)** | 3 stars | Moderate quality study |
| **Pearson et al. (2011)** | 2 stars | Low quality study |
| **Roos et al. (2012)** | 4 stars | Moderate quality study |
| **Shin (2018)** | 3 stars | Moderate quality study |
| **Skowron et al. (2014)** | 1 star | Low quality study |
| **Sun et al. (2020)** | 2 stars | Low quality study |
| **Tang et al. (2019)** | 2 stars | Low quality study |

### Qualitative synthesis

Cognitive and psychological assessments were conducted across included articles at different moments of the perinatal period (first trimester: n = 6; second trimester: n = 10; third trimester: n = 27; postpartum: n = 36). Some studies reported diagnoses of postpartum depression (Croll & Bryant, 2000; Messinis et al., 2010), peripartum depression (Edvinsson et al., 2017; Hampson et al., 2015) and comorbid anxiety disorder (Edvinsson et al., 2017). The remaining studies assessed symptomatology based on self-reports, with some of them reporting risk for depression (Cheng et al., 2013; Dale-Hewitt et al., 2012; Dudek & Haley, 2020; England-Mason et al., 2017; England-Mason et al., 2018; Hipwell et

al., 2004; Hoekzema et al., 2016; Kataja et al. 2017; Liakea et al., 2022; Logan et al., 2014; Miranda et al., 2021; Pearson et al., 2010; Pearson et al., 2013; Skowron et al., 2014; Sun et al., 2020; Tang et al., 2019) and/or anxiety disorders (Dennis-Tiwary et al., 2017; Dudek & Haley, 2020; Kataja et al., 2017; Pearson et al., 2010).

A few studies reported cases of hypothyroidism, hypertension (Barda et al., 2021), frequent headaches, backaches, breast infection, urinary problems, bowel problems, eating disorder/gastrointestinal upset, physical exhaustion, sleep disturbances (Cheng et al., 2013), eclampsia, premature deliveries, high-risk pregnancies with kidney complications or antiphospholipid syndrome (Hoekzema et al., 2017) and post-traumatic stress disorder symptoms (Dale-Hewitt et al., 2012) among pregnant participants.

Four studies did not find between-groups' differences (pregnant vs non-pregnant women on depression and/or anxiety scores) and thus inferred that the psychological functioning was not related to the cognitive deficits presented regarding working memory (Almanza-Sepulveda et al., 2018; Barda et al., 2021; Nah et al., 2018), verbal and learning memory (Barda et al., 2021; Nah et al., 2018), attention (Fiterman & Raz, 2019; Nah et al., 2018; Raz, 2014); Nah et al., 2018;), short and long-term memory (Nah et al., 2018) and subjective cognitive deficits (e.g., memory and perception) (Nah et al., 2018). Similarly, Brussé et al (2008) did not find significant differences between normotensive and preeclamptic groups on depression and anxiety scores, concluding that these would not be reasonable explanations to the memory disturbances reported.

Nine studies did not provide quantitative data (Atkinson et al., 2009; Buckwalter et al., 1999; Christensen et al., 2010; Dennis-Tiwary et al., 2017; Keenan et al., 1998; Pearson et al., 2011; Roos et al., 2012; Sun et al., 2020; Wilson et al., 2011).

After reviewing all included papers, outcomes were analyzed across different cognitive domains. Therefore, we qualitatively synthesized results about the association between depressive and anxiety symptoms and memory (working memory, recognition memory, autobiographical memory, prospective memory, verbal memory and subjective memory), attention and cognitive flexibility.

**Working memory**

Among seven studies that investigated the association between working memory and depressive/anxiety symptoms, two (Hampson et al., 2015; Kataja et al., 2017) found significant associations.

Hampson et al. (2015) found a significant correlation between depression severity and working memory errors in pregnancy ($r$ = .48; $p$ < 0.05), without evidence of change in postpartum. Hampson et al. (2015) found higher working memory performance during healthy gestations relative to a group

of healthy non-pregnant controls (*d* = 0.81; *p*=.013). Hoekzema et al. (2017), also found non-significant correlations between postpartum depression symptoms and working memory measures (*r* = -.077, *p* = .715, and *r* = .394, *p* = .057, for digit span task and Nback, respectively).

According to Kataja et al. (2017), visuospatial working memory errors correlated positively and significantly with depressive symptoms in the second and third trimesters of pregnancy (ranging between 0.147 and 0.161, *p* values between 0.009 – 0.013) and with pregnancy-related anxiety (*r* = 0.151, *p* = 0.012), especially concerns related to the well-being of the child ("worries about bearing a physically or mentally handicapped child"; *r* = 0.216, *p* = 0.001)]. The authors did not find a correlation between working memory performance and general anxiety symptoms.

Liakea et al. (2022) did not find a significant association between antepartum depression and working memory performance (assessed in the third trimester; *p* = 0.769), nor between total memory performance score and depression scores at six weeks postpartum. Christensen et al. (2010) studied cognitive deterioration associated with pregnancy and motherhood and found that depression and anxiety were not covariates for working memory.

Some authors described depression and pregnancy-related anxiety as positive predictors of working memory errors, when considered other variables. According to Hampsom et al. (2015), estradiol levels (β = −.44, *p* = .025) and depression scores (standardized β = .29, *p* = .110) together predicted the number of working memory errors. According to Kataja et al. (2017), pregnancy-related anxiety (β = 0.237, *p* = 0.001), depression (β = 0.193, *p* = 0.004), and maternal age (β = 0.135, *p* = 0.049) positively predicted the number of working memory errors.

According to Castro et al. (2021), depressive symptoms did not significantly predict working memory scores during the third trimester. Logan et al. (2014) did not find significant differences in working memory between participants with mild, moderate, or severe depression (BDI–II scores above 13) in the third trimester and the other pregnant women (*t* < 1.59, *p* > .13) or the never pregnant participants (control group) (*t* < 1.73, *p* > .10). Additionally, they did not find significant results of either depression or anxiety scores as moderators for working memory performance.

**Recognition memory**

Three studies assessed recognition memory (Callaghan et al., 2021; Farrar et al., 2014; Kataja et al., 2017). None of them found significant associations between depression and anxiety symptoms and recognition memory during the first (Farrar et al., 2014), second (Farrar et al., 2014; Kataja et al., 2017), and third trimester (Callaghan et al., 2021; Farrar et al., 2014; Kataja er al., 2017), and at three months postpartum (Farrar et al., 2014). Depression (Callaghan et al., 2021; Farrar et al., 2014) and anxiety symptoms (Farrar et al., 2014) were not significant predictors of performance on recognition memory tasks.

**Autobiographical memory**

Autobiographical memory assessment was conducted in three studies (Croll & Bryant, 2000; Hipwell et al., 2004; O'Toole & Berntsen, 2020).

Croll & Bryant (2000) found an association between postpartum depression and recall of specific memories. The authors reported a negative correlation between postpartum depression and recall of specific neutral ($r$ = -.43, $p$ < .05) and negative ($r$ = -.59, $p$ < .01) memories and a positive correlation between postpartum depression and latency to retrieve positive memories ($r$ = .55, $p$ < .01). Additionally, postpartum depression was also negatively associated with the recall of parent-related specific memories ($r$ = -.47, $p$ < .05).

According to Hipwell et al. (2004), although autobiographical memory assessed during third trimester pregnancy did not predict depressive symptomatology during the immediate postpartum period (seven – 10 days), the low specificity of autobiographical recall to positively valenced cues ($r$ = -0.29, $p$ < .05) predicted depressive symptoms more distally at two months postpartum.

O'Toole & Bernsten assessed "mental time traveling" through the generation of memories and future predictions by participants in response to neutral words. They found a negative association between recall or prediction of total number of birth-related events and psychological distress (depressive/anxiety symptoms). However, specificity of events (i.e., taking place within 24h) (r=.33, p=.011), particularly birth-related events ($r$ = 0.34, $p$ =.005) was positively associated with depressive and anxiety symptoms (O'Toole & Berntsen, 2020).

**Verbal memory**

Five studies investigated the association between verbal memory and depressive/anxiety symptoms and none of them found significant results. No relationship was found between verbal memory and depression in the second (Kataja et al., 2017) and third trimester (Buckwalter et al., 1999; Kataja et al., 2017; Logan et al., 2014) and in the postpartum (Buckwalter et al., 1999; Logan et al., 2014), nor between verbal memory and anxiety symptoms in the second (Kataja et al., 2017) and third trimesters (Logan et al., 2014) and in the postpartum (Logan et al., 2014). Messinis et al. (2010) found that, although postpartum depressed women presented lower performance on the initial verbal learning trial ($p$ = .011) and interference trial ($p$ = .010) than the healthy postpartum women, the performance of the two groups did not show a statistically significant difference. According to Christensen et al. (2010), depression and anxiety symptoms are not significant covariates for verbal memory.

**Prospective memory**

Two studies assessed prospective memory performance (Cuttler et al., 2011; Shin, 2018). Cuttler et al. (2011) did not find significant correlations between depression and prospective memory in pregnancy. Shin (2018) found a significant negative association between depressive symptoms and prospective memory accuracy during postpartum (ρ = −0.320, $p$ = 0.024). However, depressive symptoms did not significantly affect prospective memory in both direct (ß = .035, $p$ = 0.94) or indirect ways (ß = .048, $p$ = .228) in a mediation model (Shin, 2018).

**Other objective memory domains**

Other memory domains were assessed in studies without significant associations with psychological functioning, namely short- and long-term memory, semantic memory (Buckwalter et al., 1999), explicit (Hampson et al., 2015; Keenan et al., 1998) and episodic memory (Wilson et al., 2011).

**Subjective memory**

Among 10 studies assessing subjective cognitive functioning, six found significant associations between psychological functioning and subjective memory (Casey, 2000; Cheng et al., 2013; Cuttler et al., 2011; Mazor, 2019; Miranda et al., 2021; Sun et al., 2020), with one of them reporting direct effects of depression on memory ($B$ = -0.33, $p$ < 0.0001) during postpartum (Miranda et al., 2021). The remaining four studies did not report results on the association.

Three studies found significant positive correlations between subjective memory in pregnancy ($p$ < .001; Cuttler et al., 2011) and postpartum ($p$ < .01; Cheng et al., 2013) and depression and postpartum anxiety symptoms ($p$ < 0.05; Casey, 2000). However, Cuttler et al. (2011) did not find associations between depression symptoms and objective measures of prospective memory during pregnancy. Likewise, Mazor (2019) found that postpartum depression symptoms were independently and significantly associated with subjective (β = –13.71, $p$ < 0.001) but not with objective working memory (β = –3.48, $p$ = 0.15).

Sun et al., 2020 assessed subjective prospective and retrospective memory and depressive and anxiety symptoms and distributed them clockwise on a radar chart, considering four different subtypes of pregnant (second and third trimester) and postpartum participants. Participants presenting higher levels of depressive/anxiety symptoms also reported higher memory dysfunction when compared with the other groups (women presenting moderate, mild or no symptoms [control group]).

**Attention**

Nineteen studies investigated the association between attention and depressive/anxiety symptoms. Thirteen did not find significant associations between attention and depression in the second (Dennis-Tiwary et al., 2017; Kataja et al., 2017) and third trimesters (Buckwalter et al., 1999; Dudek & Haley, 2020; Edvinsson et al., 2017; Harris et al., 1996; Kataja et al., 2017; Logan et al., 2014) or in the postpartum (Atkinson et al., 2009; Buckwalter et al., 1999; Dale-Hewitt et al., 2012; England-Mason et al., 2017; England-Mason et al., 2018; Logan et al., 2014; Messinis et al., 2010; Pearson et al., 2011). Six studies did not find associations between measures of anxiety symptoms and attention in the second (Dennis-Tiwary et al., 2017; Kataja et al., 2017; Roos et al., 2012) and third trimesters (Dudek & Haley, 2020; Edvinsson et al., 2017; Kataja et al., 2017; Logan et al., 2014; Roos et al., 2012) and the postpartum (Edvinsson et al., 2017; Logan et al., 2014).

Seven studies reported significant associations between attention and depression in the first (Pearson et al., 2010; Pearson et al., 2013) and the third trimesters (Liakea et al., 2022; Tang et al., 2019) and the postpartum (Choi et al., 2017; Edvinsson et al., 2017; Harris et al., 1996; Liakea et al., 2022).

According to Pearson et al. (2010), depressive symptoms were not significantly associated with general attention bias but with differential attentional processing of infant emotion. Whereas nondepressed pregnant women (categorized according to pre-defined cut-off scores on symptoms' scales and diagnosis) showed an attentional bias toward distressed infant faces with reaction times slower than trials featuring happy infants ($t$ = 3.8, $p$ < 0.01) or neutral infant faces ($t$ = 2.8, $p$ < 0.01), women presenting depressive symptoms did not. Additionally, depressed women were quicker to disengage their attention from distressed infant faces than those without depressive symptoms ($p$ = 0.007). Similarly, Pearson et al. (2013) found that depressed women (categorized according pre-defined cut-off scores on symptoms scales) showed a diminished attentional bias for infant distress compared to non-depressed pregnant women ($p$ = 0.060; Pearson et al., 2013).

Tang et al. (2019) found that symptoms of depression were positively associated with the attentional bias scores of initial-fixation direction (i.e., early alertness) to negative pictures ($r$ = 0.254, $p$ = 0.016) but not with the maintenance attention index of negative images. Participants with major depressive symptoms paid significantly more attention to negative pictures (p = 0.008), and participants with no depressive symptoms had a significantly longer fixation duration to positive pictures ($p$ < .001) than neutral pictures.

According to Edvinsson et al. (2017), women with postpartum depression (categorized according to EPDS scores, psychiatric interview and ongoing use of antidepressants) displayed shorter reaction times (less emotional interference) to positive ($t$ = −2.21, $p$ = .028) and negative ($t$ = −2.37, $p$

= .022) stimuli than to neutral words in comparison with non-depressed women. In postpartum, depression severity was negatively correlated with emotional interference scores by positive (ρ = −.29, $p$ < .001 [considering Montgomery–Åsberg Depression Rating Scale scores]; ρ = −.25, $p$ < .01 [considering Edinburgh Postnatal Depression Scale scores]) and negative (ρ = −.20, $p$ < .05) stimuli (Edvinsson et al., 2017).

According to Harris et al. (1996), the degree of attention impairment was correlated with the severity of depression symptoms. Correlations during immediate postpartum (within 48H of delivery) were significant between Hospital Anxiety and Depression scale – Depression (HAD-D) and digit symbol ($r$ = -.38, $p$ < .02), Paced Auditory Serial Addition Test (PASAT) 4s ($r$ = -66, $p$ < .001) and PASAT 2s ($r$ = -.26. $p$ < .05). Correlations during the third trimester of pregnancy were not significant between HAD-D and digit symbol ($r$ = -.10), PASAT 4s ($r$ = -10) and PASAT2S ($r$ = -.06) and correlations at four weeks postpartum were significant between HAD-D and PASAT 4s ($r$ = -30, $p$ < .05), but not for PASAT2S ($r$ = -.13) and digit symbol ($r$ = -.20). The differences between pregnant and control groups in attention became non-significant when the effect of depression was controlled.

Choi et al. (2017) found that selective attention to masked (unconscious) fear stimuli negatively predicted postpartum depression scores through six months ($B$ = −.47, $p$ = .001), i.e., lower response latencies predicted higher levels of depression.

Liakea et al. (2022) found a better performance on Digit Span Task forward (DSF) in women with greater depressive symptoms at six weeks postpartum, when compared with women with fewer depression symptoms ($p$ = 0.047). DSF in pregnancy was a significant predictor of postpartum depression (PPD) symptoms (OR 1.15, 95% CI1.00, 1.33,p = 0.049) and remained a significant predictor when adjusted for confounders (OR 1.21, 95% CI 1.03, 1.42, p = 0.022), only for women without a pre-pregnancy history of depression (OR 1.32, 95% CI 1.04, 1.67, p = 0.024) and also those without antepartum depression symptoms (OR 1.20, 95% CI 1.01, 1.43,p = 0.040).

**Cognitive Flexibility**

Only one study assessed cognitive flexibility. Skowron et al. (2014) studied the association (correlation and regression models) between cognitive flexibility during the third trimester of pregnancy and depressive symptoms in postpartum and found no significant results ($p$ > .05 in both analyses;(Skowron et al., 2014).

**Quantitative synthesis – meta-analysis of the data extracted**

Meta-analysis of correlations between depression and cognitive functioning was expected to be performed with those subgroups of studies that offered a minimum of four data sets collected in comparable samples and using similar outcomes to enable a coherent combination of the data.

According to these conditions, only studies on attention in women presenting depressive symptoms during the postpartum period offered enough data (Dale-Hewitt et al., 2012; Edvinsson et al., 2017; England-Mason et al., 2017; Harris et al., 1996). England-Mason et al. (2018) data on the correlation between attention bias and depression were not considered for the meta-analysis because England-Mason et al. (2017) and England-Mason et al. (2018) used the same dataset.

Results based on random-effects model showed a non-statistically significant correlation between attention and depression ($r$ = -0.45; 95% CI = [-0.79 - 0.12]; $p$ = .114) (cf. Figure 1), with high heterogeneity of data ($Q$ = 182.66, $I^2$ = 96.17, $p$ < .001).

Because the heterogeneity across studies might be due to distinctive operationalizations of attention, we separated studies according to the nature of stimuli (emotional vs non-emotional). Only one study collected data on attention bias toward non-emotional stimuli (Harris et al.;1996). A secondary meta-analysis on the subgroup of studies that collected data on attention bias towards emotional stimuli (Dale-Hewitt et al., 2012; Edvinsson et al., 2017; England-Mason et al., 2017) was performed. The results showed a non-statistically significant correlation between attention bias towards emotional stimuli ($r$ = -0.56, 95% CI = [-0.90 - 0.22]; $p$ = .146) and depression scores with high heterogeneity of data ($Q$ = 178.04, $I^2$ = 97.75, $p$ < .001) (cf. Figure 2).

Meta-regression was performed in both the primary and the secondary analysis considering the sample size, type of study and controlling for the impact of confounding variables on variability: Dale-Hewitt et al. (2012) and England Mason et al. (2017) did not control for any confounding variable; Edvinsson et al. (2017) controlled for age and Harris et al. (1996) controlled for age and intellectual level. Sample size ($Q$ = 0.00, $p$ = 0.994; $Q$ = 0.07, $p$ = 0.80), type of study ($Q$ = 0.71, $p$ = 0.700; $Q$ = 0.27, $p$ = 0.601), and confounding variables ($Q$ = 1.37, $p$ = 0.504; $Q$ = 0.83, $p$ = 0.361) did not reveal a significant impact on the results in the primary and secondary analysis, respectively.

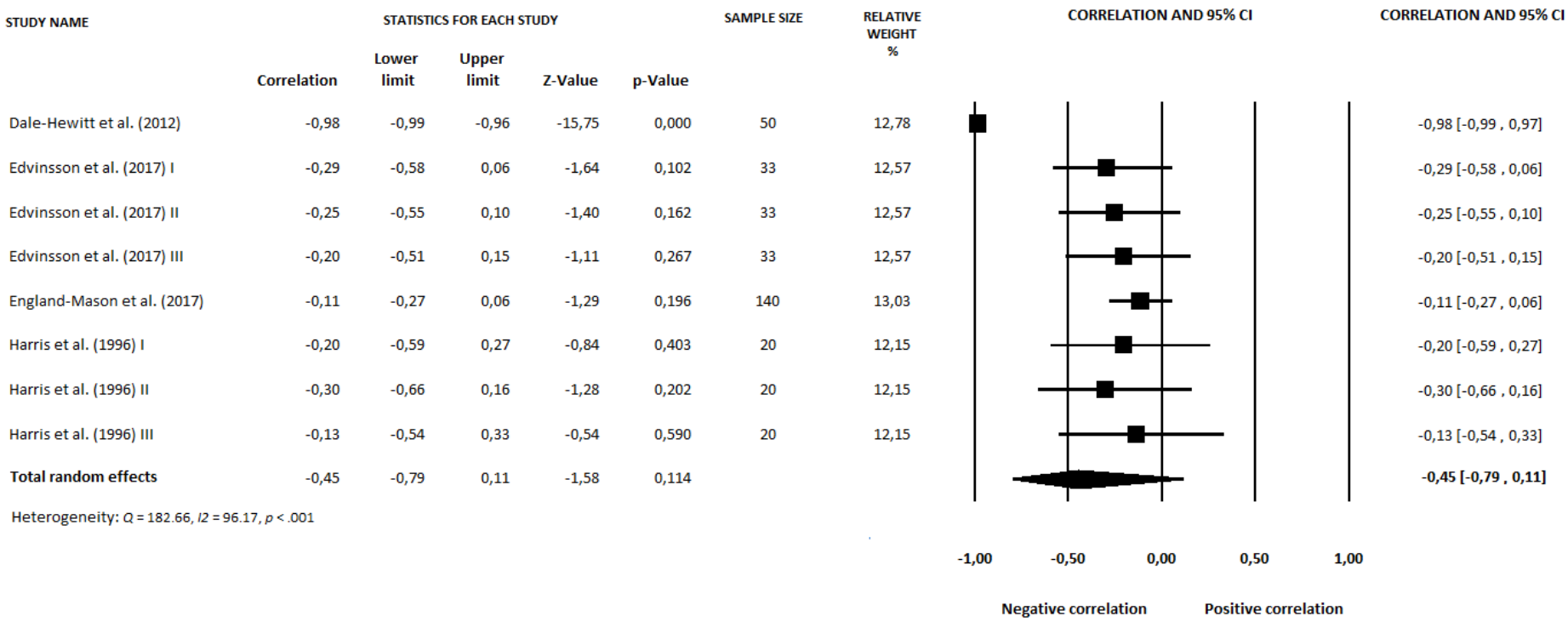


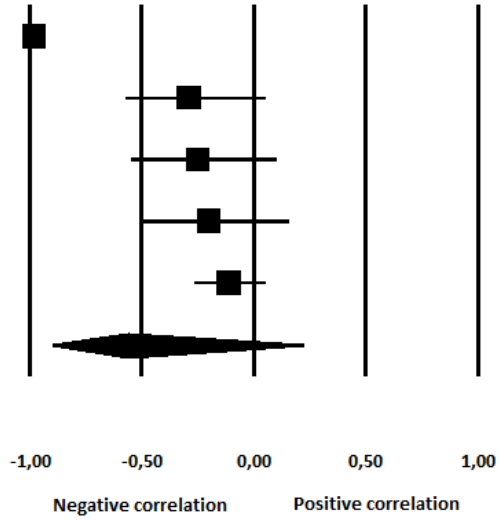

***Figure 1:*** *Meta-analysis of the Association between Attention and Depression during Postpartum Period*

Edvinsson et al. (2017) I: correlation between attention bias to positive stimuli and depressive symptoms assessed by Montgomery–Åsberg Depression Rating Scale (MADRS); Edvinsson et al. (2017) II: correlation between attention bias to positive stimuli and depressive symptoms assessed by EPDS; Edvinsson et al. (2017) III: correlation between attention bias to negative stimuli and depressive symptoms assessed by MADRS; Harris et al. (1996) I: correlation between attention assessed by digit symbol and depressive symptoms; Harris et al. (1996) II: correlation between attention assessed by digit PASAT 4s and depressive symptoms; Harris et al. (1996) III: correlation between attention assessed by digit PASAT 2s and depressive symptoms.

***Figure 2:*** *Meta-analysis of the Association between Attention Bias towards Emotional Stimuli and Depression Scores in the Postpartum Period*

| STUDY NAME | STATISTICS FOR EACH STUDY | | | | | SAMPLE SIZE | RELATIVE WEIGHT % | CORRELATION AND 95% CI |
|---|---|---|---|---|---|---|---|---|
| | Correlation | Lower limit | Upper limit | Z-Value | p-Value | | | |
| Dale-Hewitt et al. (2012) | -0,98 | -0,99 | -0,96 | -15,75 | 0,000 | 50 | 20,09 | -0,98 [-0,99 , 0,97] |
| Edvinsson et al. (2017) I | -0,29 | -0,58 | 0,06 | -1,64 | 0,102 | 33 | 19,84 | -0,29 [-0,58 , 0,06] |
| Edvinsson et al. (2017) II | -0,25 | -0,55 | 0,10 | -1,40 | 0,162 | 33 | 19,84 | -0,25 [-0,55 , 0,10] |
| Edvinsson et al. (2017) III | -0,20 | -0,51 | 0,15 | -1,11 | 0,267 | 33 | 19,84 | -0,20 [-0,51 , 0,15] |
| England-Mason et al. (2017) | -0,11 | -0,27 | 0,06 | -1,29 | 0,196 | 140 | 20,39 | -0,11 [-0,27 , 0,06] |
| **Total random effects** | -0,56 | -0,90 | 0,22 | -1,45 | 0,146 | | | **-0,56 [-0,90 , 0,22]** |

Heterogeneity: Q = 178.04, I2 = 97.75, p < .001




Edvinsson et al. (2017) I: correlation between attention bias to positive stimuli and depressive symptoms assessed by MADRS; Edvinsson et al. (2017) II: correlation between attention bias to positive stimuli and depressive symptoms assessed by EPDS; Edvinsson et al. (2017) III: correlation between attention bias to negative stimuli and depressive symptoms assessed by MADRS.

## Discussion

In the present review we aimed to understand the impact of symptoms of depression and/or anxiety on cognitive functioning in different cognitive domains (e.g., memory, attention, and cognitive flexibility) during pregnancy and the postpartum period (the first 12 months from delivery). Additionally, we aimed to see whether there is a difference in the strength of the associations between symptoms of depression and/or anxiety and cognitive functioning across distinctive perinatal periods.

Although our results did not allow for an homogeneous, undoubtful answer to our research questions, some paths can be drawn to reach a clearer understanding of the field.

Our study included 44 studies, offering an overall perspective of the associations between cognitive functioning and depressive/anxiety-related symptoms across eight cognitive domains (i.e., working memory, recognition memory, autobiographical memory, verbal memory, prospective memory, subjective memory, attention, and cognitive flexibility) and four subgroups (pregnancy/postpartum; with/without depressive and or anxiety symptoms). Therefore, we investigated memory outcomes in pregnant women who presented anxiety symptoms (N = 12); memory outcomes in pregnant women who presented depressive symptoms (N = 19); memory outcomes in women in the postpartum period who presented anxiety symptoms (N = 9); memory outcomes in women in the postpartum period who presented depressive symptoms (N = 20); attention outcomes in pregnant women who presented anxiety symptoms (N = 13); attention outcomes in pregnant women who presented depressive symptoms (N = 15); attention outcomes in women in the postpartum period who presented anxiety symptoms (N = 7); attention outcomes in women in the postpartum period who presented depressive symptoms (N = 14); cognitive flexibility outcomes in pregnant women who presented anxiety symptoms (N = 0); cognitive flexibility outcomes in pregnant women who presented depressive symptoms (N = 1); cognitive flexibility outcomes in women in the postpartum period who presented anxiety symptoms (N = 0); cognitive flexibility outcomes in women in the postpartum period who presented depressive symptoms (N = 1). Most studies did not report quantitative data on the correlation between our variables of interest, which explains the lack of data to perform meta-analysis.

In most studies, the investigation of the association between depressive and anxiety symptoms and cognitive functioning was not the primary goal of the research, but a secondary analysis (e.g., control for confounding psychological variables), highlighting the fact that this is an understudied field. Besides, we witness a variety of tools used to measure cognitive variables and heterogeneity in what concerns the analysis conducted (e.g., correlation, regression, comparisons between groups), jeopardizing a straightforward conclusion about the state of the literature on the topic. There was some variability among authors' assumptions considering the domains neuropsychological tools

assessed, for example, Digit Span Task (DST) from Wechsler Adult Intelligence Scale (WAIS). In other words, some authors considered the DST score as an index of working memory (Almanza-Sepulveda et al., 2018; Barda et al., 2021; Castro et al., 2021; Casey, 2000; Hoekzema et al., 2017; Shin, 2018), others as an index of attention (Buckwalter et al., 1999). A third group of authors considered DST as a measure of both memory and attention (Brussé et al., 2008; Logan et al., 2014). Likewise, Digit Span Task backwards (DSB) was considered a measure of working memory (Christensen et al., 2010; Cuttler et al., 2011; Liakea et al., 2022) and Digit Span Task forward (DSF) a measure of attention (Liakea et al., 2022).

We included some studies that reported high-risk pregnancies, pre-term birth, women presenting physical conditions (e.g., eclampsia) and other psychological symptoms besides peripartum depressive/anxiety ones (e.g., post-traumatic stress disorder symptoms), which apparently could seem conflicting, considering our exclusion criteria. However, either these cases were described in groups of participants not considered for the present review, or they existed in a small number, which would not influence the results.

Although research on the association between depressive/anxiety symptoms and working memory yielded inconsistent results, there appears to be an agreement regarding the absence of significant association between variables in postpartum. A negative relationship between these variables appears evident in pregnancy, particularly in the third trimester, under the possible influence of hormonal levels (estradiol) and maternal age. Literature has shown that estradiol levels, with an increase during pregnancy and a decrease around the time of labor (Duarte-Guterman et al., 2019), are positively associated with working memory performance (Hampson & Morley, 2013; Luine, 2014). Furthermore, depressive symptoms are often associated with disturbances in endocrine function, contributing to a decrease in estradiol levels (Hampson et al., 2015). Therefore, working memory should not be impaired in healthy pregnant women, who experience an increase in estradiol levels, but in a subset of pregnant women experiencing antepartum depression, together with decreased hormonal levels (Hampson et al., 2015).

Moreover, age, associated with an expected deterioration of cognitive functions (Luine et al., 2014), together with depression and pregnancy-related anxiety (but not general anxiety), has also been found to negatively predict working memory performance. Pregnancy-related anxiety, defined as a state of worry associated with pregnancy, that includes concerns related to the health of the child, changes in appearance, labor and parenting challenges/concerns (Blackmore et al., 2016), can negatively impact working memory accuracy (Gloe et al., 2021).

Studies reporting the assessment of recognition and verbal memory yielded more consistent results since both domains were non-associated with depressive/anxiety symptoms during the

perinatal period. Of note, Williams et al. (2015) whose study was excluded from our review due to a focus on the association between a history of depression, and not current depressive symptoms, and cognitive functioning, found that even a history of Major Depressive Disorder (MDD) in second-trimester pregnant women was not associated with recognition memory errors.

Regarding autobiographical memory, in the third trimester, depressive and anxiety symptoms were positively associated with the recall or prediction of specific birth-related events but with a lower recall of non-specific birth-related events (O'Toole & Bernsten, 2020). According to the authors, thinking about pregnancy-related events had a positive effect, whereas the recall or prediction of specific birth-related events (i.e., events that happened in the previous 24 hours or were predicted to happen in the following 24 hours) could induce depressive/anxiety symptoms. At nine months postpartum, Croll & Bryant (2000) found that higher depression was associated with lower recall of specific neutral, negative and parent-related memories. Finally, according to Hipwell et al. (2004), low specificity of autobiographical recall to positive cues (assessed in the third trimester) predicted depressive symptoms at two months postpartum but not at immediate postpartum (seven-10 days).

Still, these findings warrant further discussion due to the different tools used to assess autobiographical memory across studies. Although Croll & Bryant (2000) and Hipwell et al. (2004) used similar forms of the Autobiographical Memory Test (AMT), O'Toole & Bernsten (2020) used a different conceptualization because the study's primary goal was to assess "*mental time traveling*" through the generation not only of memories but also future predictions by the participants in response to neutral words (O'Toole & Berntsen, 2020).

Associations between depression and prospective memory seem to appear during the postpartum period (two and four months; Shin, 2018) but not during pregnancy (Cuttler et al., 2011).

Above mentioned results indicate the association between depressive and anxiety symptoms and objective cognitive functioning. By contrast, subjective cognitive performance refers to the subjective appraisal of participants' own cognitive abilities. We obtained consistent data regarding the association between depression/anxiety symptoms and specifically subjective memory impairment. In fact, studies reported a positive correlation between depressive symptoms and subjective memory impairment in the perinatal period. Anxiety symptoms were also positively correlated with subjective memory impairment at postpartum. Moreover, Cuttler et al. (2011) and Mazor (2019) did not find associations between depression symptoms and objective measures of prospective and working memory. Additionally, Mazor (2019) found that immediate postpartum depression symptoms were independently and significantly associated with subjective working memory. Nevertheless, we found it inaccurate to conclude this relationship, given the small number of papers included in this review, the lack of quantitative data on this topic and the potential bias concerning self-reports.

Attention was the most studied cognitive function with nineteen studies reporting the relationship between depressive/anxiety symptoms and attention. Although most studies used the Stroop Task to measure attention, the tool was presented using distinctive stimuli across studies (e.g., Emotional Stroop Task with negative, positive, neutral, attachment-related, obstetric-related, or labor-related words). This specific but diverse operationalization of attention is a barrier to reaching an overarching conclusion about the relationship between depressive/anxiety symptoms and attention.

Notably, non-significant results between depressive and anxiety symptoms and attention appear tendentially in the second and third trimesters and in the initial to intermediate months of postpartum (one – seven months). Significant associations between depression and attention were obtained in the first and third (however in smaller number) trimesters and initial weeks/months postpartum (first week and between 6 and 14 weeks). No significant results were obtained regarding the association between anxiety and attention at any perinatal period.

Pearson et al. (2010) and Pearson et al. (2013) found that depression was associated with a diminished attentional bias towards infant distress in the first trimester. In the third trimester and postpartum (six – 14 weeks), the authors found a positive association between depression symptoms and attentional bias (shorter reaction times) towards negative (Edvinsson et al., 2017; Tang et al., 2019) and positive (Edvinsson et al., 2017) stimuli.

Harris et al. (1996) and Liakea et al. (2022) used non-emotional measures of attention, and obtained conflicting results. At 48 hours postpartum, Harris et al. (1996) found a significant positive correlation between the severity of depression and the degree of attention impairment. Liakea et al. (2022) found a positive association between attention performance (assessed in the third trimester) and depression symptoms at six weeks postpartum. However, according to Liakea et al. (2022), attention (assessed in the third trimester) was a significant predictor of postpartum depression symptoms, only for women without a pre-pregnancy history of depression and for those without antepartum depression symptoms. According to Choi et al. (2017), selective attention to masked (unconscious) fear stimuli negatively predicted postpartum depression scores through six months.

The quantitative synthesis of results was possible for the association between attention and depressive symptoms in postpartum (ranging between four to 14 weeks and seven months postpartum). Pooled data showed a non-statistically significant correlation between depressive symptoms and attention in postpartum women, with high heterogeneity. Meta-regression showed that, in both the primary (regarding data on attention bias towards emotional and non-emotional stimuli) and the secondary (regarding data on attention bias towards solely emotional stimuli) analysis, sample size, type of study, and control for the impact of confounding variables were not

significant contributors to variability. However, both heterogeneity and the small number of studies included in the meta-analysis might be considered critical limitations to a reliable meta-analysis. Although two studies can be meaningfully pooled in a meta-analysis (Ryan, 2016), a minimum of 10 studies was recommended for subgroup analysis and meta-regression (Deeks et al. 2011).

Cognitive flexibility was not significantly associated with depressive symptoms (Skowron et al., 2014). However, this domain was only assessed in one study, highlighting the need for future research on this topic.

Our focus on psychological variables should not discard other variables that could explain pregnant women's cognitive performance, such as sleep quality. Since pregnancy is a period of significant demands, sleep can be compromised. A recent meta-analysis found that sleep deprivation significantly negatively affected cognitive functioning in neurocognitive domains such as sustained attention, long-term memory, and executive function, including working memory (Lowe et al., 2017). Miranda et al. (2021) found that greater postpartum depression symptoms were associated with greater severity of insomnia, which in turn was associated with lower cognitive abilities.

Additionally, we should consider every detail of women's adjustments to motherhood and other lines of reasoning should be debated, e.g., a social perspective of women's adaptations to this lifespan event. As Pownall and colleagues (2022) argued, women are "*socially allocated, rather than purely a product of biology*" (p. 4). The fact that subjective reports of cognitive changes and impairment appear more evident than the objective scores could be related to the possible implications of social stereotypes that contribute to women's social identity and may impact how they perceive their own performance.

The idea is not to find a unique explanation for the reported "baby brain" phenomenon but to address diverse possible explanations and their scientific evidence in order to achieve a growing understanding of the field. We find it unrealistic to think that a specific variable alone can explain this cognitive phenomenon, but maybe each variable could significantly impact the complex dynamics of changes that already exist (Pownall et al., 2022).

Some limitation can be identified throughout this review.

In the study selection phase, we obtained a moderate inter-rater agreement regarding the selection of reports in the full-text phase. A plausible explanation for this result should be the distinctive expertise across raters conducting a systematic review, which can represent possible bias in the systematic review process. Moreover, reporting bias assessment was not performed in the present review due to the limited time that researchers had to complete the study. This step demands a better understanding if the initially proposed analytical strategy and the outcomes of the included

studies were the reported ones. When this does not occur, authors could have possibly selected the reported data, contributing to possible bias due to missing results.

Another significant limitation of the present review is that meta-analysis and meta-regression were conducted with a limited number of studies with relatively low sample sizes, which may represent a statistical risk. Regarding the risk of bias assessment, most studies did not reach a high-quality appraisal, affecting the degree of certainty and confidence in their reported results.

Overall, the association between depression and anxiety symptoms and working memory or attention is highly inconsistent across studies. Subjective memory impairments seem to be associated with clinical symptomatology (i.e., higher depression or anxiety scores are associated with increased reports of subjective memory impairment), while no associations have been found for recognition and verbal memory. Moreover, there was greater evidence of the association between depressive/anxiety symptoms and cognitive functioning in the third trimester and postpartum. However, fewer investigations were conducted in the first and second trimesters, which could be a plausible explanation for the difference in results. Future research should consider higher sample sizes, and efforts should be made to reach a more homogeneous state of the field, e.g., through better consensus regarding the definition of cognitive domains assessed by specific measures. Future studies may address different variables contributing to the baby brain phenomenon.

**Registration and protocol**

The present review is registered in PROSPERO – International Prospective Register of Systematic Reviews, with the corresponding code CRD42022304212. Protocol is available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022304212.

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**Competing interests**

The authors declare no competing interests.

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**Annex A**

Search strategy by database

**PubMed**: (("memories"[All Fields] OR "memory"[MeSH Terms] OR "memory"[All Fields] OR "memory s"[All Fields] OR ("mental recall"[MeSH Terms] OR ("mental"[All Fields] AND "recall"[All Fields]) OR "mental recall"[All Fields] OR "recall"[All Fields] OR "recalling"[All Fields] OR "recallable"[All Fields] OR "recalled"[All Fields] OR "recallers"[All Fields] OR "recalls"[All Fields]) OR ("memory, short term"[MeSH Terms] OR ("memory"[All Fields] AND "short term"[All Fields]) OR "short-term memory"[All Fields] OR ("working"[All Fields] AND "memory"[All Fields]) OR "working memory"[All Fields]) OR ("attention"[MeSH Terms] OR "attention"[All Fields] OR "attentions"[All Fields] OR "attention s"[All Fields] OR "attentional"[All Fields] OR "attentive"[All Fields] OR "attentively"[All Fields] OR "attentiveness"[All Fields]) OR (("cognition"[MeSH Terms] OR "cognition"[All Fields] OR "cognitions"[All Fields] OR "cognitive"[All Fields] OR "cognitively"[All Fields] OR "cognitives"[All Fields]) AND ("flexibilities"[All Fields] OR "flexible"[All Fields] OR "flexibles"[All Fields] OR "pliability"[MeSH Terms] OR "pliability"[All Fields] OR "flexibility"[All Fields]))) AND ("maternally"[All Fields] OR "maternities"[All Fields] OR "maternity"[All Fields] OR "mothers"[MeSH Terms] OR "mothers"[All Fields] OR "maternal"[All Fields] OR ("mother s"[All Fields] OR "mothered"[All Fields] OR "mothers"[MeSH Terms] OR "mothers"[All Fields] OR "mother"[All Fields] OR "mothering"[All Fields]) OR ("motherhood"[All Fields] OR "motherhoods"[All Fields]) OR ("gravidity"[MeSH Terms] OR "gravidity"[All Fields] OR "pregnant"[All Fields] OR "pregnants"[All Fields]) OR ("pregnancy"[MeSH Terms] OR "pregnancy"[All Fields] OR "pregnancies"[All Fields] OR "pregnancy s"[All Fields]) OR ("perinatal"[All Fields] OR "perinatally"[All Fields] OR "perinatals"[All Fields]) OR ("peripartum period"[MeSH Terms] OR ("peripartum"[All Fields] AND "period"[All Fields]) OR "peripartum period"[All Fields] OR "peripartum"[All Fields]) OR ("antenatal"[All Fields] OR "antenatally"[All Fields]) OR "antepartum"[All Fields] OR ("postnatal"[All Fields] OR "postnatally"[All Fields]) OR ("postpartum period"[MeSH Terms] OR ("postpartum"[All Fields] AND "period"[All Fields]) OR "postpartum period"[All Fields] OR "postpartum"[All Fields])) AND ("depressed"[All Fields] OR "depression"[MeSH Terms] OR "depression"[All Fields] OR "depressions"[All Fields] OR "depression s"[All Fields] OR "depressive disorder"[MeSH Terms] OR ("depressive"[All Fields] AND "disorder"[All Fields]) OR "depressive disorder"[All Fields] OR "depressivity"[All Fields] OR "depressive"[All Fields] OR "depressively"[All Fields] OR "depressiveness"[All Fields] OR "depressives"[All Fields] OR ("depressed"[All Fields] OR "depression"[MeSH Terms] OR "depression"[All Fields] OR "depressions"[All Fields] OR "depression s"[All Fields] OR "depressive disorder"[MeSH Terms] OR ("depressive"[All Fields] AND "disorder"[All Fields]) OR "depressive disorder"[All Fields] OR "depressivity"[All Fields] OR "depressive"[All Fields] OR "depressively"[All Fields] OR "depressiveness"[All Fields] OR "depressives"[All Fields]) OR ("anxiety"[MeSH Terms] OR "anxiety"[All Fields] OR "anxieties"[All Fields] OR "anxiety s"[All Fields]) OR ("affect"[MeSH Terms] OR "affect"[All Fields] OR "mood"[All Fields]))) AND (humans[Filter])

**Web of Knowledge:** (memory OR recall OR (working memory) OR attention OR (cognitive flexibility)) (All Fields) and (maternal OR mother OR motherhood OR pregnant OR pregnancy OR

perinatal OR peripartum OR antenatal OR antepartum OR postnatal OR postpartum) (All Fields) and (depression OR depressive OR anxiety OR mood) (All Fields)

**PsycINFO:** (depression or depressive or anxiety or mood).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh word] AND (maternal or mother or motherhood or pregnant or pregnancy or perinatal or peripartum or antenatal or antepartum or postnatal or postpartum).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh word] AND (memory or recall or working memory or attention or cognitive flexibility).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh word] AND limit 4 to human.

**Annex B**

Tools for risk of bias assessment

**JBI Critical Appraisal Checklist for Analytical Cross-sectional studies**

1. Were the criteria for inclusion in the sample clearly defined?
2. Were the study subjects and the setting described in detail?
3. Was the exposure (depression/anxiety symptoms) measured in a valid and reliable way?
4. Were objective, standard criteria used for measurement of the condition pregnancy/postpartum)?
5. Were confounding factors identified?
6. Were strategies to deal with confounding factors stated?
7. Were the outcomes (cognitive functioning) measured in a valid and reliable way?
8. Was appropriate statistical analysis used?

**JBI Critical Appraisal Checklist for Randomized Controlled Trials**

1. Was true randomization used for assignment of participants to treatment groups?
2. Was allocation to treatment groups concealed?
3. Were treatment groups similar at the baseline?
4. Were participants blind to treatment assignment?
5. Were those delivering treatment blind to treatment assignment?
6. Were outcomes assessors blind to treatment assignment?
7. Were treatment groups treated identically other than the intervention of interest?
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?
9. Were participants analyzed in the groups to which they were randomized?
10. Were outcomes measured in the same way for treatment groups?
11. Were outcomes (cognitive functioning) measured in a reliable way?
12. Was appropriate statistical analysis used?
13. Was the trial design appropriate for the topic, and any deviations from the standard RCT design accounted for in the conduct and analysis?

**Newcastle-Ottawa Quality Assessment Scale Case Control Studies**

Selection

1) Is the case definition adequate?
   a) yes, with independent validation *

b) yes, e.g. record linkage or based on self-reports

c) no description

2) Representativeness of the cases

a) consecutive or obviously representative series of cases *

b) potential for selection biases or not stated

3) Selection of controls

a) community controls *

b) hospital controls

c) no description

4) Definition of Controls

a) no history of disease (endpoint) *

b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis

a) study controls for age and/or education*

b) study controls for any additional factor (e.g., parity, previous clinical history, ethnicity, IQ, socioeconomic status)*

Exposure (depression/anxiety symptoms)

1) Ascertainment of exposure

a) secure record (eg surgical records) *

b) structured interview where blind to case/control status *

c) interview not blinded to case/control status

d) written self report or medical record only

e) no description

2) Same method of ascertainment for cases and controls

a) yes *

b) no

3) Non-Response rate

a) same rate for both groups *

b) non respondents described

c) rate different and no designation

**Newcastle – Ottawa Quality Assessment Scale cohort studies**

Selection

1. Representativeness of the exposed cohort
   a) truly representative of the average pregnant/postpartum group in the community *
   b) somewhat representative of the average pregnant/postpartum group in the community *
   c) selected group of users eg nurses, volunteers
   d) no description of the derivation of the cohort
2. Selection of the non-exposed cohort
   a) drawn from the same community as the exposed cohort *
   b) drawn from a different source
   c) no description of the derivation of the non-exposed cohort
3. Ascertainment of exposure (depression/anxiety symptoms)
   a) secure record (eg surgical records) *
   b) structured interview *
   c) written self-report
   d) no description
4. Demonstration that outcome of interest (cognitive impairment) was not present at start of study (non-applicable)
   a) yes *
   b) no

Comparability

1. Comparability of cohorts on the basis of the design or analysis
   a) study controls for age and/or education*
   b) study controls for any additional factor (e.g., parity, previous clinical history, ethnicity, IQ, socioeconomic status)*

Outcome (cognitive functioning)

1. Assessment of outcome
   a) independent blind assessment *
   b) record linkage *
   c) self-report
   d) no description
2. Was follow-up long enough for outcomes to occur

a) yes (9-12 months postpartum) *

b) no

3. Adequacy of follow up of cohorts

a) complete follow up - all subjects accounted for *

b) subjects lost to follow up unlikely to introduce bias - small number lost - > 70 % follow up, or description provided of those lost) *

c) follow up rate < 70 % and no description of those lost

d) no statement

**Annex C** – Risk of bias assessment results

| JBI Critical Appraisal Checklist for Analytical Cross-sectional studies | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Authors, date** | **Study design** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | **Overall appraisal** | | | **Quality of the studies** |
| | | | | | | | | | | Include | Exclude | Seek further info | |
| **Almanza-Sepulveda et al. (2018)** | Cross-sectional | Yes | Yes | Yes | Yes | NA | NA | Yes | NA | | | x | Moderate |
| **Cheng et al.(2013)** | Merged data from two studies with a cross-sectional correlational design | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Croll & Bryant (2000)** | Cross-sectional | No | No | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Cuttler et al. (2011)** | Cross-sectional | No | No | Yes | Yes | No | NA | Yes | Yes | | | x | Moderate |
| **Dale-Hewitt et al. (2012)** | Cross-sectional | Yes | Yes | Yes | Yes | No | NA | Yes | Yes | x | | | High |
| **Edvinsson et al. (2017)** | Cross-sectional from a longitudinal cohort main study | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Fiterman & Raz (2019)** | Cross-sectional | Yes | Yes | Yes | Yes | NA | NA | Yes | NA | | | x | Moderate |
| **Mazor (2019)** | Cross-sectional | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Messinis et al. (2010)** | cross-sectional | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Miranda et al. (2021)** | Cross-sectional | Yes | Yes | Yes | Yes | No | NA | Yes | Yes | x | | | High |
| **Nah et al. (2018)** | Cross-sectional | No | No | Yes | Yes | NA | NA | Yes | NA | | x | | Low |
| **Pearson et al. (2010)** | Cross-sectional | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | x | | | High |
| **Raz, S. (2014)** | Cross-sectional | Yes | Yes | Yes | Yes | Yes | Yes | Yes | NA | x | | | High |
| **Wilson et al. (2011)** | Cross-sectional | Yes | Yes | Yes | Yes | No | NA | Yes | Yes | x | | | High |

**JBI Critical Appraisal Checklist for RCT**

| Authors, date | Study design | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Overall appraisal | | | Quality of the Studies |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Include | Exclude | Seek further info | |
| **Dennis-Tiwary et al. (2017)** | Pilot double-blind, randomized, placebo-controlled trial | Unclear | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | Yes | Yes | x | | | High |
| **Pearson et al. (2013)** | Pilot randomised control trial (RCT) | Yes | Unclear | Yes | No | No | No | No | Yes | Yes | Yes | Unclear | Yes | Yes | | | x | Moderate |

**Newcastle-Ottawa Quality Assessment Scale Case Control Studies**

| Authors, date | Study design | SELECTION | | | | COMPARABILITY | EXPOSURE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 1 | 1 | 2 | 3 | Quality of the studies |
| **Brussé et al. (2008)** | Case control | B | B | A* | B | A* B* | D | A* | A* | Moderate |
| **Kataja et al. (2017)** | Nested case-control Focus Cohort | B | B | A* | B | A* B* | D | A* | A* | Moderate |
| **Liakea et al. (2022)** | Nested case–control group within a longitudinal population-based cohort | B | B | A* | A* | A* B* | D | A* | A* | Moderate |

**Newcastle – Ottawa Quality Assessment Scale cohort studies**

| | | SELECTION | | | | COMPARABILITY | OUTCOME | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Authors, date** | **Study design** | 1 | 2 | 3 | 4 | 1 | 1 | 2 | 3 | **Quality of the studies** |
| **Atkinson et al. (2009)** | Longitudinal | D | NA | C | NA | NA | C | A* | B* | Low |
| **Barda et al. (2021)** | Prospective cohort | B* | A* | C | NA | NA | C | B | NA | Low |
| **Buckwalter et al. (1999)** | Longitudinal | A* | NA | C | NA | NA | C | B | B* | Low |
| **Callaghan et al. (2021)** | Longitudinal | B* | B | C | NA | A* B* | C | NA | NA | Low |
| **Casey (2000)** | Longitudinal | B* | A* | C | NA | A* B* | C | B | B* | Moderate |
| **Castro et al. (2021)** | Prospective cohort (from a longitudinal main study) | B* | NA | C | NA | A* B* | C | NA | NA | Moderate |
| **Choi et al. (2017)** | Prospective cohort (from a longitudinal main study) | A* | NA | C | NA | A* B* | C | B | NA | Moderate |
| **Christensen et al. (2010)** | Prospective cohort longitudinal | A* | NA | C | NA | NA | C | B | B* | Low |
| **Dudek & Haley (2020)** | Longitudinal | A* | NA | C | NA | NA | C | B | B* | Low |
| **England-Mason et al. (2017)** | Longitudinal | B* | NA | C | NA | NA | C | NA | NA | Low |
| **England-Mason et al. (2018)** | Prospective | B* | NA | C | NA | NA | C | NA | NA | Low |
| **Farrar et al. (2014)** | Longitudinal | B* | B | C | NA | NA | C | B | A* | Low |
| **Hampson et al. (2015)** | Repeated-measures | B* | A* | B* | NA | A* B* | C | A* | NA | High |

**Newcastle – Ottawa Quality Assessment Scale cohort studies**

| | | SELECTION | | | | COMPARABILITY | OUTCOME | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Authors, date** | **Study design** | 1 | 2 | 3 | 4 | 1 | 1 | 2 | 3 | **Quality of the studies** |
| **Harris et al. (1996)** | Longitudinal | B* | B | C | NA | A* B* | C | B | A* | Moderate |
| **Hipwell et al. (2004)** | Prospective cohort | A* | NA | C | NA | A* B* | C | B | B* | Moderate |
| **Hoekzema, et al. (2017)** | Prospective cohort | B* | A* | C | NA | NA | C | B | B* | Moderate |
| **Keenan et al., (1998)** | Longitudinal | A* | A* | C | NA | A* B* | C | B | B* | Moderate |
| **Logan et al. (2014)** | Longitudinal controlled | A* | A* | C | NA | NA | C | B | A* | Moderate |
| **O'Toole & Berntsen (2020)** | Longitudinal | A* | B | C | NA | A* B* | C | B | C | Moderate |
| **Pearson et al. (2011)** | Longitudinal | B* | NA | C | NA | NA | C | B | B* | Low |
| **Roos et al. (2012)** | Longitudinal | B* | A* | C | NA | A* B* | C | B | NA | Moderate |
| **Shin (2018)** | Prospective | A* | C | C | NA | A* B* | C | NA | NA | Moderate |
| **Skowron et al. (2014)** | Pro-spective cohort | A* | NA | C | NA | NA | C | B | C | Low |
| **Sun et al. (2020)** | Longitudinal | B* | A* | C | NA | NA | C | B | C | Low |
| **Tang et al. (2019)** | Cohort | B* | A* | C | NA | NA | C | NA | NA | Low |