Association of Maternal depression with diet: A systematic review

Rukhsana Khan1, Ahmed Waqas2,3, Arshia Bilal1, Zille Huma Mustehsan1, Juwayria Omar1, Atif Rahman3

Affiliations

1Department of Community Medicine, Fazaia Medical College, Air University, Islamabad, Pakistan

2,3Human Development Research Foundation, Islamabad, Pakistan

3 Institute of Psychology, Health & Society, University of Liverpool, United Kingdom

Abstract word count: 283 words

Manuscript word count: 4394 words (excluding references and tables)

Table: 2

Figure: 1

**Declarations:**

(1) **Conflict of Interest:** The authors declare that they have no conflict of interests. This manuscript was submitted for partial fulfillment of PhD in public health at the University of Liverpool, Liverpool, UK.

(2) **Ethical Approval:** Not applicable

(3) **Funding Sources:** None declared

**Corresponding author**

Dr. Rukhsana Khan

E: drrukhsanakhan@hotmail.com

A: Department of Community Medicine, Fazaia Medical College, Air University, Islamabad, Pakistan

M: +92-3445509238

**Emails of all authors:**

AW: ahmedwaqas1990@hotmail.com

AB: Arshia.bilal@mail.au.edu.pk

ZHM: zhmustehsan@gmail.com

JO: juwayria.omar@mail.au.edu.pk

AR: atif.rahman@liverpool.ac.uk

**Contribution statement**

RK made major contributions to the concept and design of the study, acquisition of data, analysis and interpretation of data and manuscript writing. AW contributed to the study design and manuscript writing. AB, ZHM & JO participated in screening of titles and abstracts and draft writing. AR supervised the project, guidelines and intellectual review of manuscript at every stage. All authors approved the final draft of the manuscript.

## Abstract

This reviewwas conducted to explore the bi-directional association of maternal depression with diet. This link is hypothesized because the mental health of pregnant women may adversely affect their nutritional intake; or inversely, that poor nutritional intake during pregnancy may cause mental health issues. Seven electronic databases were searched to retrieve relevant peer-reviewed articles published during 2000-2018. Primary research studies published in English that evaluated the relationship between maternal antenatal and postnatal depression with dietary intake were selected. We screened 1585 articles, of which 13 met the inclusion criteria. These included five cohort studies (including two birth cohorts) and eight cross-sectional studies representing a total of 12,742 participants altogether. Studies were divided into five groups depending on whether they analyzed all nutrients, micronutrients, dietary patterns, dietary behavior or intake of fish and vegetables.

The studies exploring the association of depression with dietary patterns found a protective association of “Health Conscious”, “Healthy” and “Brazilian” diet patterns with maternal depression. The group of studies which analyzed all nutrients, found an inverse relationship of the “Healthy Eating Index” with maternal depression. Deficiency of calcium, iron, and folate were also associated with maternal depression. Prenatal and early postpartum eating attitudes and BMI were found as predictors of depressive symptoms in the late post-partum period in a diet behavior study. A limitations of our review is the absence of meta-analysis which was not possible due to heterogeneity of the studies.

**Keywords**: nutrition; diet; maternal depression; prenatal, postnatal, review

##

## Introduction

Maternal depression is a global public health concern (Premji, 2014, Fisher et al., 2012, Shidhaye et al., 2013). Pregnancy represents a vulnerable phase for women as they undergo physical, physiological, and psychosocial changes, and may consume unhealthy or unbalanced nutrition (Clark et al., 2009, Fowles and Fowles, 2008, Barker and Thornburg, 2013, Osborne and Monk, 2013). During this period, pregnant women are at an increased risk of developing psychopathologies, especially depression. The mental well-being of a mother is defined by the WHO as “a state of well-being in which a mother realizes her abilities, can cope with the normal stresses of life, can work productively and fruitfully and is able to make a contribution to her community”(Engle, 2009).

In the past decade, the relationship between mental illness and diet has gained the attention of the researchers (Lai et al., 2013). For instance, a study conducted in Korea reported that the dietary intake of pregnant women were insufficient when assessed against o the Korean Recommended Nutrient Intake (R&I) guidelines (Won, 2011). These poor dietary levels influence the intake of micronutrients more than the macronutrients. For instance, Hurley et al. reported a high macronutrient intake but an insufficient micronutrient intake among pregnant women in Baltimore, USA (Hurley et al., 2005). Previous research has also indicated that several psychosocial and demographic variables influence the choice of intake of nutrients among pregnant women (Bodnar and Wisner, 2005). A positive association has also been found between unhealthy Western diets and the odds of depressive symptoms among pregnant women (Baskin et al., 2015, Lai et al., 2013).

Depression during pregnancy is not only responsible for economic costs, it also has adverse effects on the physical and mental wellbeing of both the mother and the fetus (Barker et al., 2013). The World Health Organization estimated that, by the year 2020, depressive disorders will become the leading cause of the global disease burden in women (World Health Organization, 2009). The high burden of maternal depression will affect both developed and developing countries (Nasreen et al., 2011, Hamirani et al., 2006, Rahman et al., 2008, Shah et al., 2011). It is important, therefore, to identify modifiable lifestyle risk factors which may contribute to maternal depression.

Previous reviews have focused on general dynamics and determinants of maternal depression (Baskin et al., 2015), with limited research on the association between maternal depression and nutrition in particular (Trujillo et al., 2018). This review seeks to fill this gap by exploring the bidirectional relationship between depression and dietary intake among pregnant women in the antenatal and post-partum period.

## Methods

### 2.1 Search Strategy

This systematic review was conducted according to the PRISMA guidelines (Supplementary File 1). We conducted an electronic literature search using the MeSH terms and free text key words in the following databases: PubMed, CINAHL, EMBASE, ERIC, PsycINFO, Cochrane Library and Google Scholar. The database searches were conducted in two phases. The first phase used the following search strategy: (“diet OR nutrition OR food OR “dietary intake” OR “food intake” OR “dietary supplement” OR “micronutrient”) AND (“perinatal depression” OR “antenatal depression” OR “prenatal depression” OR “postnatal depression” OR “postpartum depression” OR “maternal depression” OR “maternal mental health”).

The second step combined search related to aforementioned dietary terms with depression terms and maternity terms separately:

(“diet OR nutrition OR food OR “dietary intake” OR “food intake” OR “dietary supplement” OR “micronutrient”) OR (“pregnancy” OR “pregnant” OR mothers OR “maternal” OR “antenatal” OR “prenatal” OR “perinatal” OR “postnatal” OR “postpartum”) AND (depression OR depress OR “mood disorder” OR “depressive disorder” OR “mental health” OR “depression in pregnancy”).

Backward searches using references and bibliography lists from articles of interest were also part of the search strategy. Three independent reviewers (AB, ZHM and JO) searched the electronic databases in July 2018.

The results of searches conducted by the three independent reviewers were then assessed for any differences in the number of articles retrieved. Duplicates were removed based on the title, authors, year published and journals. For the remaining articles the titles and abstracts were screened to identify articles meeting the inclusion criteria (described below), followed by full text screening of potentially eligible articles to ensure the inclusion criteria was met. Any discrepancies were resolved by consulting with the senior authors (RK and AR).

The search strategy was independently conducted by three researchers to ensure inter reviewer reliability. The principal investigator (RK) supervised the search and screening process.

**2.2 Inclusion and Exclusion Criteria**

 Articles were eligible for inclusion in the review if:

1. They reported original research published during 2000 to 2018 in English, were analytical in design, and showed the association between maternal depression with dietary intake.
2. They assessed depression using a researcher or clinician-administered or self-report validated depression screening tool or clinical diagnosis by a specialist, administered to women in the antenatal or postnatal period, as per the International classification of Disease (ICD) or Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria
3. Evaluated specific diet patterns or intake of nutrients through food or supplements using validated food frequency, food recalls, eating habits and behaviour questionnaires administered to the women in the antenatal or postnatal period.

Studies which measured food insecurity, hormone levels, and chemical analysis of nutrients or used nutritional biomarkers were excluded. Also excluded were studies in which the participants were already diagnosed with depression or had comorbidities like diabetes, cardiac conditions etc. Moreover, letter to editors, abstracts and conference papers, and studies with non-analytical designs such as case reports and series, or those with incomplete data were also excluded.

### 2.3 Data Extraction & quality assessment

A data extraction tool was developed (Table 1). Information about authors, year of publication, study design, study setting, sample size, time of assessment (antenatal/post-natal), and tools used to measure depression and diet, and type of data analysis used were recorded. A descriptive summary of studies is presented in the current review. Meta-analysis could not be performed due to the low numbers of studies meeting the inclusion criteria for this review, and the highly variable dietary and depression measurements used in the studies.

Several studies were reviewed to develop the quality assessment checklist (Mirza and Jenkins, 2004, Sawyer et al., 2010, Fisher et al., 2012). However, the final checklist was adapted from Waqas et al., (2018), as it included assessing that informed consent of the participants had been obtained (Mirza and Jenkins, 2004, Sawyer et al., 2010, Fisher et al., 2012). This 12 item checklist helped in elucidating the quality of the studies included in this systematic review. Of the 12 item checklist, five related to the methodology and included information about clarity of aims and objectives, adequacy of sample size, representativeness of sample, study design, and reliability and validity of tool of measurement of depression; another five explained the analysis which encompassed data description, appropriate univariate and multivariate analysis, reporting on null finding, and generalizability issues; and the final 2 items were on response rate and informed consent.

Three assessors from the faculty scored all the included studies against the checklist. Cross-sectional study design and absence of any characteristic scored as “0”, while analytical study design and presence of a characteristic was scored “1” point. Based on these criteria, the maximum score was 12.

##

## Results

### 3.1 Study selection

A total of 1585 studies were retrieved from the databases searched. After the removal of duplicates, 148 studies were identified as suitable for title and abstract screening. After reading full texts, 13 studies were included in the present systematic review. These included three prospective cohort studies, two birth cohort studies, and eight cross-sectional studies, representing 12,742 participants overall (Figure 1).

These studies were then divided into five groups reporting similar outcomes:

a) The first group of studies considered dietary patterns. In this group one of each type; cohort, cross-sectional and birth cohort study were included.

b) The second group included three cross-sectional studies and one cohort study in which all major macronutrients and micronutrients were evaluated.

c) The third group included one birth cohort and one cross-sectional study in which specific intake of micronutrients like folate and calcium were evaluated.

d) The fourth group included two studies: one cohort and one cross-sectional study considering various eating behaviors.

e) The final group included two cross-sectional studies evaluating specific food items like oily fish and fats.

## 3.2 Quality Assessment

Of the 13 studies included in this systematic review, only one did not mention its aims and objectives clearly, and did not use a valid questionnaire to report depression, instead relying on participants reporting Post-partum Depression (PPD) (Bae et al., 2010). Except for two studies (Chatzi et al., 2011, Paskulin et al., 2017), all others used an adequate sample size to assess the outcomes of interest, with eight studies justifying the representativeness of their samples. Eight studies employed a cross-sectional design, whilst the others were prospective cohort or longitudinal birth cohort studies. None of the studies were experimental. All studies described the data adequately, but only five mentioned the participant response rate. Three studies did not mention obtaining participant informed consent prior to study initiation. Regarding analysis, all but one study applied appropriate univariate analysis, with multivariate analysis performed by eleven studies. Two studies did not report null findings of the research, and five did not discuss the generalizability of the research findings. Table 2 presents a detailed quality assessment of the studies included in the present review. A total of six studies fulfilled at least ten quality assessment criteria and were considered to have a lower risk of bias in their design.

**3.3 Prevalence of depression**

The prevalence of prenatal depression varied across the studies, from 7.2 – 21.6% (Paskulin et.al, 2017; Chong et.al 2014; Sontrop et.al, 2008), to much higher prevalence of 33% - 45% (Lukose et.al, 2014; Saeed et al., 2015; ud Din et.al, 2014). Prevalence reported in the postpartum period was not as high, ranging from 10.4% - 20.8% (Chong et al., 2014 ; Chatzi et al., 2011; Sontrop et.al., 2008).

**3.4 Assessment of depression**

There was significant heterogeneity in the usage of psychometric scales for the assessment of perinatal depression. In three cohortstudies, the Edinburgh Postnatal Depression Scale (EPDS) with a different cut off values ranging from 9 to 13 were used. Two cross-sectional and one cohort study used the Center for Epidemiologic Studies–Depression Scale (CES-D) with a cut-off score of 16. One cross-sectional study measured depression with Beck’s Depression Inventory (BDI) with 10 scores and another used Kessler Psychological Distress Scale (K-10) with >6 as cut off for depression. Primary Care Evaluation of Mental Disorders (PRIME-MD) was used to screen for mental disorders in a cross-sectional study. The Depression Anxiety and Stress Scale (DASS-42) was used in one cross-sectional study. Finally, the State-Trait Anxiety Inventory (STAI) was used to assess anxiety symptoms in a cohort study and a cross-sectional study.

**3.5 Measurement of diet outcomes**

Across the studies, the period of dietary recall was recorded at variable times. Only one study (Lukose et.al) reported pre-study dietary recall measurements for the last 3 months. Three studies captured a month recall for food frequency (Sontrop et al., 2008, Fowles et al., 2011, Barker and Thornburg, 2013). The rest of the studies captured either a one week or two week dietary recall period.

Timing for the assessment of dietary intake procedures also varied across the studies. The Food Agriculture Organization (FAO) guidelines recommended that dietary assessments should be conducted at multiple time points. In this context, separate day recalls are considered as a sensitive measure of diet intake, to avoid recall bias ( Food Agriculture Organization, 2018). Three of the included studies measured dietary intake at more than one time point (Saeed et al., 2016, Carter et al., 2000, Barker et al., 2013), and eight studies took measurements during the prenatal period only (from 14 to 36 weeks of pregnancy). Only one study measured the dietary outcomes exclusively in the postnatal period (Hogg-Kollars et al., 2011).

Out of 13 studies included in our review, eight used a food frequency questionnaire (FFQ) (Lukose et al., 2014, Hogg-Kollars et al., 2011, Hurley et al., 2005, Paskulin et al., 2017, Sontrop et al., 2008, ud Din et al., 2014, Chatzi et al., 2011, Barker et al., 2013). In 3 studies a 24 hour recall period has been used either alone or in addition to a FFQ (Fowles et al., 2012, Saeed et al., 2015, Bae et al., 2010). In this review, serum analysis was done in only one study (Chong et al., 2014), specifically for vitamin B12 and folate.

**3.6 Dietary Pattern**

Three studies, with varying study designs, considered the association between dietary patterns and prenatal depression. Chatzi et al., (2011) investigated the link between prenatal dietary patterns with a risk of postpartum depression (PPD) among Greek women. For this purpose, a FFQ was employed mid-pregnancy (14-18 weeks), while EPS evaluation was conducted at 8-10 weeks postpartum (cut-off=13) (Chatzi et al., 2011). Furthemore, Chatzi et al., (2011) applied principle component analysis (PCA) to reduce the dimensions of dietary patterns to ‘healthy’ and ‘Western’ dietary patterns, with the former associated with a decreased risk of postpartum depression (PPD), even after controlling for confounders.

Barker et al., (2013) conducted a longitudinal study in 6979 mother-offspring dyads which found that an unhealthy dietary pattern in women was related to higher incidence of prenatal depression. Prenatal depression was significantly associated with an unhealthy diet overall, and ultimately with reduced child cognitive function (Barker et al., 2013). No significant association between prenatal depression and postnatal dietary habits was found.

Paskulin et al., (2017) carried out a cross-sectional study to evaluate the association between dietary patterns and major depressive symptoms among pregnant women in southern Brazil. Using cluster analyses, dietary patterns were grouped into three dietary patterns: restricted, varied, and common-Brazilian (native). The “restricted dietary pattern” included food content such as cookies, French fries, and soft drinks; “varied pattern included grains, cereal, fruits, and vegetables while the “common-Brazilian pattern” composed of beans, boneless beef/chicken or eggs and coffee with sugar (Paskulin et al., 2017). Women who presented a “common-Brazilian dietary pattern” had a 62% higher prevalence of major depression when compared to a “varied pattern” of consumption, even after adjusting for potential confounders. The “restricted dietary pattern” showed no significant association with major depression symptoms when compared with “varied pattern” (Paskulin et al., 2017).

**3.7 All Nutrients**

Three cross-sectional and one cohort study used FFQ’s and 24-hour recall questionnaires to quantify essential nutrients from all food groups. The three cross-sectional studies assessed women for prenatal depression and dietary intake in healthcare settings in Korea, India, and Pakistan. A hospital-based, prospective cohort study was conducted on 94 middle-class antenatal attendees at the beginning of the second trimester in a tertiary care hospital in Pakistan (Bae et al., 2010). A total of 43% of women were found to have depression, with maternal dietary intake measured through 24 hour recall and a Food Frequency Checklist at baseline and again in the 36th week of gestation. Saeed et al., (2016) found that poor maternal dietary consumption measured at 36th weeks of gestation was higher in women with antenatal depression (R.R = 2.582; CI 1.60–5.23).

In a study conducted in Korea (Bae et al., 2010), the BDI was used to estimate depression levels in pregnant women, with a cut-off value of 10. Women reporting less severe depressive symptomatology showed higher consumption of most nutrients, however, there were no significant differences in terms of total energy intake and macronutrients (Lukose et al., 2014). Consumption of total calcium, plant calcium, plant iron, potassium, total folate, and dietary folate was found to be higher among women reporting less severe depressive symptoms (Lukose et al., 2014).

In another cross sectional study, Indian women in early pregnancy were screened for prenatal depression using the K-10, and habitual dietary intake for the preceding three months was assessed (Lukose et al., 2014). This found that the intake of energy-adjusted nutrients except for folic acid was slightly higher among healthy women. Significant associations between lower levels of depressive symptoms with anemia as compared to non -anemic (24 vs. 37 %, p = 0.021) and microcytic anemia (37 vs. 22 %, p = 0.018) were found (Barker and Thornburg, 2013). In a study conducted in a cohort of pregnant women in Greece, no significant associations between depressive symptoms and intake of macronutrients like protein, fat, carbohydrate, and trace elements such as phosphorus, vitamin B12, Folate, vitamin C and iron was found (Chatzi et al., 2011).

Another cross-sectional study conducted in antenatal clinics in Pakistan examined the association of psychological distress (using DASS) with dietary intake of food groups (using FFQ), energy, macronutrients, and micronutrients (Din et al., 2014). No significant differences in intake of total calories, amount of carbohydrates, fat or protein were found between depressed and non-depressed women. However, intake of calcium, iron and vitamin B3 was significantly higher in women without depressive symptoms, even after adjusting for confounders (Din et al., 2014).

**3.8 Eating behaviors & attitudes**

Eating habits and their association with perinatal depression was explored in a cross-sectional and longitudinal birth cohort study. Carter et al., (2000)investigated the association between body mass index (BMI; kg/m2), eating attitudes, and affective symptoms (using CES-D) during pregnancy. Measures included self-reported pre-pregnancy and 4-month postpartum BMI; as well as pregnancy, 4-month, and 14-month postpartum eating attitudes, and depressive and anxiety symptoms. Results showed evidence for a significant, albeit moderate, relationship between high BMI and symptoms of depression at 4 months and 14 months postpartum. Regression analysis revealed that 4 months’ post-partum eating attitudes and BMI were significant predictors of PPD at 14 months.

Hurley et al., (2005) reported a significant association between six indices of psychosocial wellbeing and dietary intake at 28 weeks of gestation in low-risk pregnancies. Psychiatric symptoms and social characteristics, including anxiety, depressed mood, anger, fatigue, social support, and stress were assessed between 24 and 32 weeks of gestation. A Health Habits and History Questionnaire (HHHQ) was used to estimate usual dietary intake. Maternal stress was initially found to significantly correlate with consumption of total energy, fat, proteins, iron, and zinc; but these relationships were rendered insignificant after adjusting for total energy intake (Hurley et al., 2005).

**3.9 Micro-Nutrients**

A cross-sectional and a cohort study assessed the association of micro-nutrients with depression. Fowles et al., (2012) recruited a small sample of 18 Texan women to assess the correlation between maternal depression and dietary intake. The Dietary Quality Index–Pregnancy (DQI-P) was used for nutritional assessment, with a score of >70 indicating good adherence to dietary recommendations. Depression was significantly correlated with calcium-rich food intake (spearman’s rho = 0.60, p = 0.018) (Fowles et al., 2012).

A prospective cohort of 709 Singaporean resident women evaluated the relationship between folate and vitamin B12 concentrations during pregnancy with probable prenatal and early postnatal depression (Chong et al., 2014). An assessment using EPDS at 26-week’s gestation and 3 months postpartum was conducted, and plasma levels of participant’s folate and vitamin B12 were estimated using blood tests. The plasma folate levels were significantly lower among women with prenatal depression than healthy (p=0.011) (Chong et al., 2014). The authors applied a logistic regression model adjusted for confounders which showed that the likelihood of antenatal (95% CI: 0.52, 0.94, p=0.016) and post-natal depression (95% CI: 0.58, 0.99, p= 0.040) was decreased by a factor of 0.69 and 0.75 respectively for each unit increase in folate level (Chong et al., 2014). No significant association of vitamin B12 was found with antenatal and postpartum depression.

**3.10 Fish and vegetarian diets**

The relationship between fish and vegetarian diet consumption was explored in two studies. Hogg-kollars et al., (2011) conducted a retrospective survey among 400 Austrian pregnant women from 2003 to 2008 (Hogg-Kollars et al., 2011). Recruited mothers were classified into those with or without PPD. A FFQ comprising 55 items was used to collect information about nutrients and anti-nutrients taken during pregnancy. Intake of oily fish (p= 0.03) and offal (p= 0.01) were significantly higher among women with depression. Women on a vegetarian diet (47.4%) were more depressed than those who consumed a non-vegetarian diet (19.4%) (Hogg-kollars et al., 2011).

A cross-sectional study conducted by Sontrop et.al, (2008) on 2394 pregnant women in Canada found that 18.8 % rates of probable depression, assessed using CES-D. Marine food was categorized into: canned food, dark meat fish, other fish, and shrimp/lobster/scallops. Consumption of eiocosapentaenoic acid and dodcosahexaenoic acid (EPA+DHA in mg/100 g of marine food was assessed for each of the categories, finding that 0.57 mg/100 g in canned tuna fish; 1.57 mg/100 g dark meat fish; 0.35 mg/100 g in other fish and 0.25 mg/100 g in shrimp/lobster or scallops (Sontroop et al., 2008). Multiple regression analysis initially showed a protective effect of >1/week fish consumption on depression (b = -0.8, CI: -1.5, -0.1, P<0.05) however, after controlling for confounders this association lost statistical significance (Sontrop et al., 2008).

## Discussion

**4.1 Summary**

This systematic review shows a significant association of perinatal depression with dietary intake. In general, the studies presented a low risk of bias. However, most of these were a cross-sectional design. Therefore, this evidence, albeit inconclusive in terms of temporality, suggests that there is a bidirectional association between depressive symptoms and unhealthy eating patterns and attitudes, and poor dietary intake.

Three studies showed a protective effect against depression symptoms during the pre and post-natal periods of healthy diets (Paskulin et al., 2017), health consciousness (Chong et al., 2014) and a varied diet (Hurley et al., 2005) which mostly consisted of cereals, non-meat proteins, dairy products, fish, green vegetables, and fruits. One study also reported a protective effect of micronutrient (folate level) with symptoms of prenatal depression (Jacka et al., 2013). Another study on diet behavior observed a protective association between Vitamin C and anxiety symptoms (Tucker et al., 2013). Hogg-collars and colleagues (YEAR) found a higher intake of oily fish, offal and vegetarian diets among women with depressive symptoms in the postpartum period. Three other studies included in this review (REFERENCES), found an association of diet behaviors such as eating disorders, attitude and health habits with symptoms of predominantly postnatal depression. Association of energy, macro and micronutrients from the diet of women with symptoms of perinatal depression was observed in three studies in which low intake of micronutrients like calcium, iron, and vitamin B3 was associated with depressive symptoms.

### 4.2 Strengths and limitations

This review has several strengths. It was based on broad inclusion criteria with studies applying heterogeneous psychometric instruments measuring depression and diet in women in both the pre- and post-natal periods. Previous systematic reviews have explored the association between dietary practices and depressive illness in the narrow context of single nutrients or micronutrient supplementations (RERFERENCE). However, it is important to study the effects of nutrients in a broader context, to account for their synergy and inhibitory effects (Wu et al., 2004). To address the diversity of studied outcomes, we categorized the studies according to factors such as dietary patterns, eating behaviors and specific nutrient intake. This allowed us to yield an in-depth understanding of the relationship between maternal depression and not only specific nutrients, but also with eating behaviors. The quality assessment checklist used in this study was found to be useful in several earlier studies (REFERENCES); however, it has not been statistically validated.

The main limitation of this study includes not searching local and indigenous databases, for instance, PakMedinet in Pakistan or CNKI in China. Articles published in languages other than English were not reviewed due to lack of resources. Both of these factors may have limited evidence in our review. We were not able to find any randomized controlled trials on the topic of interest in this systematic review. However, two studies, (Chatzi et al., 2011, Barker et al., 2013), were part of larger trials. This lack of randomized controlled trail design can limit the evidence regarding causality and temporality. Three (one Cohort and two cross-sectional) of the thirteen studies had a sample size of less than 200, and thus low statistical power.

### 4.3 Interpretation of evidence and recommendations for future research

Most of the studies assessing the intake of macro or micronutrients relied upon FFQs or 24-hour recall methods, which can introduce recall bias (Chong et al., 2014). These assessments are done at a single time point with no recording of baseline or control data. Given that dietary intake has been shown to exhibit trimester-specific trends (Fowles et al., 2011)conducting baseline measurement before pregnancy, and then subsequent measurements at regular intervals, should be ensured. The dietary intake during different trimesters and depressive symptoms both postpartum and antepartum should then be considered in multivariate analysis. This was only done in one study in this review (Chong et al., 2014). Ideally, dietary intake should be measured at baseline or prior to pregnancy and again at several follow-up time points to control the recall bias of a FFQ (Micali et al., 2011). The timing of the measurements for these outcomes was highly variable in all the studies reviewed.

History of depression prior to pregnancy is strongly associated with the development of perinatal depression. In a similar vein, antenatal depression is also a strong predictor post-partum depression; therefore, it is important to include measurements of depressive symptoms at pre-pregnancy, during pregnancy and postnatally. In this review, only one cohort study measured pre-pregnancy depression. Five studies including four cohorts (REFERENCES) and a cross-sectional study (Hurley et al., 2005) took repeated measurements in pregnancy and in the postpartum period (Carter et al., 2000, Barker and Thornburg, 2013, Chong et al., 2014, Bennett et al., 2004, Gibson et al., 2009).

The best method to diagnose depression is a clinical and diagnostic interview, which is time consuming and often not suitable for research settings (Gibson et al., 2009). Therefore, most of the research evidence is based on psychometric scales that assess depression or anxiety symptoms. The use of different tools to measure depressive symptoms in this review introduced significant methodological and clinical heterogeneity in the data. For future studies, it is important to consider screening tools with an established sensitivity and specificity in a particular population both prenatally and postnatally (Spies et al., 2009). In this systematic review, EPDS was the most extensively used instrument measuring perinatal depressive symptoms (Fowles et al., 2011, Sontrop et al., 2008), followed by CES-D (Lukose et al., 2014, Chong et al., 2014) for prenatal depression, and for both pre and post-natal depression in Carter et al. (YEAR). In a study, K-10 compared well with the (EPDS) in detecting depression (Lukose et al., 2014). Another instrument used was BDI (21 items), which was and based on the DSM-IV criteria for depression.

**4.4 Conclusion**

This systematic review has shown that depressive symptoms experiences by perinatal women are associated with poor dietary patterns, including the consumption of macronutrients and micronutrients. However, it also highlights that the evidence is based on poorly designed studies and is thus inconclusive. Therefore, it is recommended that cohort studies are conducted in countries where both problems are prevalent, as this may produce evidence relating to the association between depressive symptoms and dietary intake, whilst also addressing the reverse causality which is a feature of cross sectional-study designs.

References

Dietary Assessment: A resource guide to method selection and application in low resource settings. 2018. *FAO: Rome, Italy*.

Bae, H. S., kim, S. Y., Ahn, H. S. & Cho, Y. K. 2010. Comparison of nutrient intake, life style variables, and pregnancy outcomes by the depression degree of pregnant women. *Nutrition Research And Practice,* 4**,** 323-331.

Barker, D. J. & Thornburg, K. L. 2013. The obstetric origins of health for a lifetime. *Clinical obstetrics and gynecology,* 56**,** 511-519.

Barker, E. D., Kirkham, N., Ng, J. & Jensen, S. K. 2013. Prenatal maternal depression symptoms and nutrition, and child cognitive function. *The British Journal of Psychiatry,* 203**,** 417-421.

Baskin, R., Hill, B., Jacka, F. N., O'neil, A. & Skouteris, H. 2015. The association between diet quality and mental health during the perinatal period. A systematic review. *Appetite,* 91**,** 41-47.

Bennett, H. A., Einarson, A., Taddio, A., Koren, G. & Einarson, T. R. 2004. Prevalence of depression during pregnancy: systematic review. *Obstetrics & Gynecology,* 103**,** 698-709.

Bodnar, L. M. & Wisner, K. L. 2005. Nutrition and depression: implications for improving mental health among childbearing-aged women. *Biological psychiatry,* 58**,** 679-685.

Carter, A. S., Baker, C. W. & Brownell, K. D. 2000. Body mass index, eating attitudes, and symptoms of depression and anxiety in pregnancy and the postpartum period. *Psychosomatic Medicine,* 62**,** 264-270.

Chatzi, L., Melaki, V., Sarri, K., Apostolaki, I., Roumeliotaki, T., Georgiou, V., Vassilaki, M., Koutis, A., Bitsios, P. & Kogevinas, M. 2011. Dietary patterns during pregnancy and the risk of postpartum depression: the mother–child ‘Rhea’cohort in Crete, Greece. *Public Health Nutrition,* 14**,** 1663-1670.

Chong, M. F., Wong, J. X., Colega, M., Chen, L.-W., Van Dam, R. M., Tan, C. S., Lim, A. L., Cai, S., Broekman, B. F. & Lee, Y. S. 2014. Relationships of maternal folate and vitamin B12 status during pregnancy with perinatal depression: The GUSTO study. *Journal Of Psychiatric Research,* 55**,** 110-116.

Clark, A., Skouteris, H., Wertheim, E. H., Paxton, S. J. & Milgrom, J. 2009. The relationship between depression and body dissatisfaction across pregnancy and the postpartum: A prospective study. *Journal of Health Psychology,* 14**,** 27-35.

Engle, P. L. 2009. Maternal mental health: program and policy implications. *The American Journal Of Clinical Nutrition,* 89**,** 963S-966S.

Fisher, J., Mello, M. C. D., Patel, V., Rahman, A., Tran, T., Holton, S. & Holmes, W. 2012. Prevalence and determinants of common perinatal mental disorders in women in low-and lower-middle-income countries: a systematic review. *Bulletin of the World Health Organization,* 90**,** 139-149.

Fowles, E. R. & Fowles, S. L. 2008. Healthy eating during pregnancy: determinants and supportive strategies. *Journal of Community Health Nursing,* 25**,** 138-152.

Fowles, E. R., Murphey, C. & Ruiz, R. J. 2011. Exploring relationships among psychosocial status, dietary quality, and measures of placental development during the first trimester in low-income women. *Biological Research For Nursing,* 13**,** 70-79.

Fowles, E. R., Stang, J., Bryant, M. & Kim, S. 2012. Stress, depression, social support, and eating habits reduce diet quality in the first trimester in low-income women: a pilot study. *Journal of the Academy of Nutrition and Dietetics,* 112**,** 1619-1625.

Gibson, J., Mckenzie‐Mcharg, K., Shakespeare, J., Price, J. & Gray, R. 2009. A systematic review of studies validating the Edinburgh Postnatal Depression Scale in antepartum and postpartum women. *Acta Psychiatrica Scandinavica,* 119**,** 350-364.

Hamirani, M. M., Sultana, A., Ibrahim, Z., Iqbal, H. & Sultana, S. 2006. Frequency of prenatal depression in second and third trimesters of pregnancy in Karachi: a hospital based study. *Journal of the Liaquat University of Medical and Health Sciences,* 5**,** 106-109.

Hogg-Kollars, S., Mortimore, D. & Snow, S. 2011. Nutrition health issues in self-reported postpartum depression. *Gastroenterology And Hepatology From Bed To Bench,* 4**,** 120.

Hurley, K. M., Caulfield, L. E., Sacco, L. M., Costigan, K. A. & Dipietro, J. A. 2005. Psychosocial influences in dietary patterns during pregnancy. *Journal of the American Dietetic Association,* 105**,** 963-966.

Jacka, F. N., Pasco, J. A., Williams, L. J., Meyer, B. J., Digger, R. & Berk, M. 2013. Dietary intake of fish and PUFA, and clinical depressive and anxiety disorders in women. *British Journal of Nutrition,* 109**,** 2059-2066.

Lai, J. S., Hiles, S., Bisquera, A., Hure, A. J., Mcevoy, M. & Attia, J. 2013. A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *The American Journal of Clinical Nutrition,* 99**,** 181-197.

Lukose, A., Ramthal, A., Thomas, T., Bosch, R., Kurpad, A. V., Duggan, C. & Srinivasan, K. 2014. Nutritional factors associated with antenatal depressive symptoms in the early stage of pregnancy among urban South Indian women. *Maternal and Child Health Journal,* 18**,** 161-170.

Micali, N., Simonoff, E. & Treasure, J. 2011. Pregnancy and post-partum depression and anxiety in a longitudinal general population cohort: The effect of eating disorders and past depression. *Journal of Affective Disorders,* 131**,** 150-157.

Mirza, I. & Jenkins, R. 2004. Risk factors, prevalence, and treatment of anxiety and depressive disorders in Pakistan: systematic review. *BMJ,* 328**,** 794.

Nasreen, H. E., Kabir, Z. N., Forsell, Y. & Edhborg, M. 2011. Prevalence and associated factors of depressive and anxiety symptoms during pregnancy: a population based study in rural Bangladesh. *BMC women's health,* 11**,** 22.

World Health Organization. 2009. *Mental health aspects of women's reproductive health: a global review of the literature*, World Health Organization.

Osborne, L. M. & Monk, C. 2013. Perinatal depression—the fourth inflammatory morbidity of pregnancy?: theory and literature review. *Psychoneuroendocrinology,* 38**,** 1929-1952.

Paskulin, J. T., Drehmer, M., Olinto, M. T., Hoffmann, J. F., Pinheiro, A. P., Schmidt, M. I. & Nunes, M. A. 2017. Association between dietary patterns and mental disorders in pregnant women in Southern Brazil. *Revista Brasileira de Psiquiatria,* 39**,** 208-215.

Premji, S. 2014. Perinatal distress in women in low-and middle-income countries: allostatic load as a framework to examine the effect of perinatal distress on preterm birth and infant health. *Maternal and Child Health Journal,* 18**,** 2393-2407.

Rahman, A., Malik, A., Sikander, S., Roberts, C. & Creed, F. 2008. Cognitive behaviour therapy-based intervention by community health workers for mothers with depression and their infants in rural Pakistan: a cluster-randomised controlled trial. *The Lancet,* 372**,** 902-909.

Saeed, A., Raana, T., Saeed, A. M. & Humayun, A. 2015. Effect of antenatal depression on maternal dietary intake and neonatal outcome: a prospective cohort. *Nutrition Journal,* 15**,** 64.

Saeed, A., Raana, T., Saeed, A. M. & Humayun, A. 2016. Effect of antenatal depression on maternal dietary intake and neonatal outcome: a prospective cohort. *Nutrition Journal,* 15**,** 64.

Sawyer, A., Ayers, S. & Smith, H. 2010. Pre-and postnatal psychological wellbeing in Africa: a systematic review. *Journal of Affective Disorders,* 123**,** 17-29.

Shah, S. M. A., Bowen, A., Afridi, I., Nowshad, G. & Muhajarine, N. 2011. Prevalence of antenatal depression: comparison between Pakistani and Canadian women. *JPMA-Journal of the Pakistan Medical Association,* 61**,** 242.

Shidhaye, R., Mendenhall, E., Sumathipala, K., Sumathipala, A. & Patel, V. 2013. Association of somatoform disorders with anxiety and depression in women in low and middle income countries: a systematic review. *International Review of Psychiatry,* 25**,** 65-76.

Sontrop, J., Avison, W. R., Evers, S. E., Speechley, K. N. & Campbell, M. K. 2008. Depressive symptoms during pregnancy in relation to fish consumption and intake of n‐3 polyunsaturated fatty acids. *Paediatric and Perinatal Epidemiology,* 22**,** 389-399.

Spies, G., Stein, D., Roos, A., Faure, S., Mostert, J., Seedat, S. & Vythilingum, B. 2009. Validity of the Kessler 10 (K-10) in detecting DSM-IV defined mood and anxiety disorders among pregnant women. *Archives of Women's Mental Health,* 12**,** 69-74.

Trujillo, J., Vieira, M. C., Lepsch, J., Rebelo, F., Poston, L., Pasupathy, D. & Kac, G. 2018. A systematic review of the associations between maternal nutritional biomarkers and depression and/or anxiety during pregnancy and postpartum. *Journal of Affective Disorders,* 232**,** 185-203.

Tucker, K. L., Smith, C. E., Lai, C.-Q. & Ordovas, J. M. 2013. Quantifying diet for nutrigenomic studies. *Annual Review of Nutrition,* 33**,** 349-371.

Ud Din, Z., Ambreen, S., Iqbal, Z., Iqbal, M., Ahmad, S., Hussain, M. & Emmett, P. 2014. Inadequate Dietary Intake in Women with Antenatal Psychological Distress: A Population Based Study in Pakistan. *Journal of Food and Nutrition Research,* 2**,** 1021-1028.

Waqas, A., Elhady, M., Dila, K. S., Kaboub, F., Nhien, C., Al-Husseini, M., Kamel, M., Elshafay, A., Nhi, H. & Hirayama, K. 2018. Association between maternal depression and risk of infant diarrhea: a systematic review and meta-analysis. *Public health,* 159**,** 78-88.

Won, K. H. 2011. Associations of Dietary Intake Levels with Ante-natal Depression in Pregnant Women. *Korean Journal of Women Health Nursing,* 17.

Wu, G., Bazer, F. W., Cudd, T. A., Meininger, C. J. & Spencer, T. E. 2004. Maternal nutrition and fetal development. *The Journal of Nutrition,* 134**,** 2169-2172.