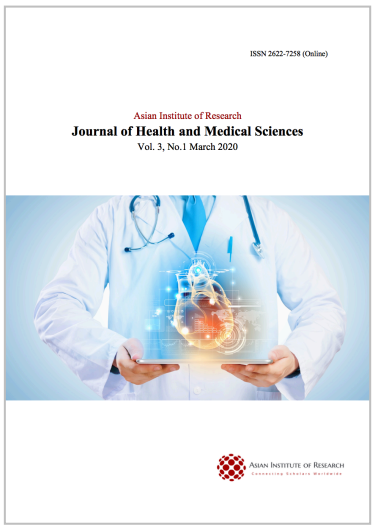

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Considering Xenobiotics as Risk Factors for Postpartum Depression: A Qualitative Systematic Review

Hailey A Mitchell[1], Sarah Edali[2], Anne TM Konkle[2]

[1] Interdisciplinary School of Health Sciences, University of Ottawa, Ottawa, Canada
[2] School of Psychology, University of Ottawa, Ottawa, Canada
[3] University of Ottawa Brain and Mind Research Institute, Ottawa, Canada

Correspondence: Anne TM Konkle, Interdisciplinary School of Health Sciences, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada. Tel: 1-613-562-5800 ext 3457 -. E-mail: Anne.Konkle@uOttawa.ca

Abstract
Postpartum depression is a serious mental health condition with onset of symptoms appearing anytime within the first four months after delivery (e.g. irritability, severe sadness, profound feelings of hopelessness, etc.). Environmental toxicants are synthetic (i.e. manufactured) or naturally found chemicals that are not produced by organisms as a result of cellular metabolism (e.g. tobacco smoke, pesticides, etc.). There is limited consideration for how exposure to environmental toxicants/xenobiotics can create adverse psychological health effects, specifically postpartum depression. The purpose of this systematic review was to determine if the literature supports a link between exposure to environmental toxicants/xenobiotics during the prenatal/perinatal period and postpartum depression and if so, to identify whether there are specific classes of xenobiotics that provide a higher risk for postpartum depression. Several databases were used to search the online literature, with the following inclusion criteria: articles published in English, publication years between 1995-2018, and with women of reproductive age (15-49 years old). The article selection process comprised of screening each article by title/abstract, followed by screening those articles based on full-text. Six categories of xenobiotics were identified among the thirty included articles. Active/passive smoke exposure was largely found to increase the risk of developing postpartum depression; dietary supplements provided mixed results; antidepressants demonstrated preventative effects; particulate air pollution was found to be associated with postpartum depression; oral contraceptives (DMPA) exhibited an increase in postpartum depressive symptoms; and organochlorine pesticides had no associative risk. Quality assessments were performed for all of the included articles, with the majority being assessed as satisfactory. This systematic review presents as a foundation for encouraging future research to investigate the link between environment and mental health, in order to attain a greater perspective.

Keywords: Postpartum Depression, Environment, Toxicants, Xenobiotics, Prenatal, Perinatal, Exposure, Maternal Mental Health

1. Introduction

1.1 Postpartum Depression

Depression is among the most disabling disorders for women in their childbearing years (O'Hara, 2009). Childbirth represents a time of great vulnerability for women to become mentally unwell, with postpartum depression representing the most frequent form of maternal morbidity after delivery (Stocky & Lynch, 2000). Postpartum depression is a serious mood disorder affecting 10-13% of women worldwide with symptoms such as depressed mood, loss of interest and enjoyment, and reduced energy leading to diminished activity (World Health Organization, 2015). Postpartum [nonpsychotic] depression occurs in approximately 10-20% of women within 6 months of delivery (Miller, 2002). Postpartum depression is characterized by low mood and sadness accompanied by anhedonia, impaired concentration, disrupted sleep and appetite, psychomotor disturbance, feelings of worthlessness or guilt, social withdrawal, and recurrent suicidal ideation (Meltzer-Brody et al., 2018). There has been some debate over the phenomenology of postpartum depression as compared to depression not relating to childbearing (Seyfried & Marcus, 2003). Major depressive disorder with peripartum onset is defined in the DSM-V as the most recent major depressive episode occurring during pregnancy as well as within the four weeks following delivery (Segre & Davis, 2013; American Psychiatric Association, 2013).

1.2 Risk Factors

The risk factors associated with developing postpartum depression have been extensively reported and identified in the literature and these factors can be characterized as biological or psychosocial. Biological factors which have consistently been found to be associated with an increased risk of postpartum depression include: family history of depression, a past history of depression or premenstrual dysphoric disorder, and experiencing depressed mood or anxiety during pregnancy (Robertson et al., 2004). Psychosocial factors which have been consistently found to predict postpartum depression include: experiencing stressful life events, domestic violence, and lack of perceived social support (Miller & LaRusso, 2011). Several other factors, including low socioeconomic status, low self-esteem (particularly in relation to parenting ability), unplanned or unwanted pregnancy, negative birth experience or obstetric complications, as well as difficult infant temperament, have all been less consistently demonstrated to be risk factors for developing postpartum depression (Miller & LaRusso, 2011).

In the majority of cases, postpartum depression is self-limiting and could resolve within months of onset; however, for many women, childbirth can be the stressor that triggers the start of recurrent or chronic episodes of the depressive disorder (Roberston et al., 2004). The current evidence shows that untreated maternal depression can have serious and long-lasting effects: they range from a general negative impact on the child, the partner, and other family members to the danger of an increased risk of recurrence, suicidality of the mother, threat to the bonding between mother and child, as well as physical, cognitive, emotional, and social developmental disorders in the children (Schipper-Kochems et al., 2019). Although all women are susceptible to postpartum depression, it is possible for physicians and healthcare professionals to identify women at higher risk for closer follow-up and intervention when necessary (Roberston et al., 2004).

1.3 Xenobiotics

Environmental toxicants are synthetic (i.e. manufactured) or naturally found chemicals that are not produced by organisms as a result of cellular metabolism (e.g. arsenic) (Belson, Schier, & Patel, 2005). They can be chemical, biological or physical in nature and can be encountered in a variety of indoor and outdoor locations, via different routes of exposure. The following are examples of toxicants to which many are exposed: carbon monoxide, tobacco smoke, molds/biologic pollutants, lead/heavy metals, pesticides/disinfectants, methylmercury, plasticizers (BPA and phthalates), solvents, and asbestos (Falck et al., 2015). Routes of exposure can include inhalation, such as dust or fumes; ingestion, such as, of pesticide residues on fruits and vegetables; and dermal absorption, such as, of ultraviolet-B radiation from the sun or direct skin contact with corrosive household cleansers (Pope, Snyder, & Mood, 1995).

In addition to these environmental toxicants, there is the consideration of the 'environment' to be defined as 'any external exposure to substances.' This continued definition of 'environment' for this systematic review allows for the inclusion of articles which discuss other types of substances women may be exposed to in their perinatal environment such as antidepressants, dietary supplements, and oral contraceptives. For this reason, we employ the terminology of xenobiotics.

The focus of this research was expanded to include prenatal and/or perinatal exposure to those additional substances as potential risk factors for the development of postpartum depression. Antidepressants (ex: sertraline and nortriptyline) are a type of prescribed medication primarily used to treat clinical depression. A significant number of pregnant women use antidepressants with estimates from 4-10% in different populations and the majority of these women are being treated with selective serotonin reuptake inhibitors (SSRIs), however the use of newer antidepressants is increasing (Pedersen, 2017). The relative safety of such medication, for example, selective- serotonin reuptake inhibitors (SSRIs), has led to their widespread use to treat depressive disorders in women of childbearing age, despite knowledge regarding the risks of prenatal exposure to SSRI medication remains far from complete (Casper et al., 2011). The majority of these health risks mentioned in the literature have been largely centered on resulting neonatal developmental outcomes, while minimal research mentions potential adverse maternal health outcomes with prenatal and perinatal exposure to this type of medication (Dubovicky, Belovicova, Csatlosova, & Bogi, 2017).

Women may also take dietary supplements (for example, omega-3 fatty acids) before/during their pregnancy, in order to meet their extra nutritional needs. As defined by the U.S. Congress in the Dietary Supplement Health and Education Act (DSHEA), a dietary supplement is a product that: 1) is intended to supplement the diet, 2) contains one or more dietary ingredients (including vitamins, minerals, herbs, or other botanicals, amino acids, and other substances) or their constituents, 3) is intended be taken by mouth as a pill, capsule, tablet, or liquid, and 4) is labeled on the front panel as being a dietary supplement (Schweitzer, 2006). The interest in including these supplements is based on the notion that certain nutritional deficiencies such as low levels of DHA (docosahexaenoic acid, an omega-3 fatty acid) found in seafood, calcium, B vitamins, vitamin D, and iron have been investigated in relation to postpartum depression but so far this research has been inconclusive (Miller, 2002). Although, research studies have presented conclusive evidence that women have been found to be depleted in omega-3 polyunsaturated fatty acids during gestation and breastfeeding as there is preferential diversion of omega-3 fats to the baby (Huang, et al., 2013). An assumption can be concurred from this finding, in that pregnant women would be encouraged and feel more inclined to consume dietary supplements, such as omega-3 fatty acids, in order to compensate for this nutritional depletion. Given that these supplements could be beneficial in improving nutritional health during the perinatal period, there should also be consideration for the further exploration as to whether these supplements could in turn affect maternal mental health.

Hormonal birth control includes estrogen-progesterone combined hormonal contraception, which can provide effective protection against pregnancy with many non-contraceptive health benefits and can safely be used by most women (Lauring et al., 2016). Oral contraceptives regulate the changes in hormone levels during a woman's cycle by using different forms of synthetic hormones that mimic the estrogen and progesterone that is naturally produced in a woman's body ("Hormonal Contraception", 2018). There are many different types of estrogens and progestins, and different types of pills contain different combinations, though their mode of action is similar (Jin, 2014). Postpartum contraception is used to prevent unintended and closely spaced pregnancies in the first twelve months after giving birth (Singhal et al., 2014). Some types of contraception can be used immediately after delivery; however, it is recommended to use progestin only methods, which research shows has no effect on breast milk volume, or on infant-growth (Singhal et al., 2014).

1.4 Current Study

The link between adverse health effects and exposure to environmental hazards has been well documented in the literature. However, there is limited consideration for how exposure to environmental toxicants can create adverse psychological health effects; most research has focused on the link between xenobiotics and neurodevelopmental disorders. Taken together, these notions serve as the underlying rationale for this systematic

review, that is, in the determination of what has been reported in the literature in terms of xenobiotic exposure and maternal mental health, with a focus on postpartum depression. The objectives of this work are to: 1. Determine if the literature supports a link between exposure to xenobiotics and postpartum depression, and 2. Assess whether there are specific classes of xenobiotics that provide a higher risk for postpartum depression.

2. Method

2.1 Eligibility Criteria

For inclusion as part of this review, the following were fulfilled:

1. Studies: journal articles (peer-reviewed), reviews (literature, intervention, and systematic), prospective studies, longitudinal studies, follow-up studies, cross-sectional (prevalence) studies, research in progress studies, and conference proceedings/abstracts.
2. Participants: women of reproductive age (15-49 years old - as defined by the World Health Organization (2006)), single or married, first-time pregnancy or otherwise, vaginal or Caesarean birth, though in some studies this was not specified, and among either low-, middle-, or high-socioeconomic status.
3. Interventions (xenobiotic exposure): carbon monoxide, tobacco smoke, molds/biologic pollutants, lead/heavy metals, pesticides/disinfectants, methylmercury, plasticizers (BPA and phthalates), solvents, and asbestos as well as antidepressants (sertraline and nortriptyline), dietary supplements (vitamin A, vitamin B, vitamin C, vitamin D, omega-3 fatty acids, B_{12}), calcium, zinc, magnesium, selenium, iron, and folate) and oral contraceptives.
4. Outcome: all types of methods for the potential diagnosis of such symptoms were considered: Edinburgh Postnatal Depression Scale (EPDS), Beck's Depression Inventory II (BDI-II), and the Hamilton Rating Scale for Depression (HAM-D).

Studies were excluded if they included men as primary participants, or studied paternal mental health as the outcome.

2.2 Search Strategy

A systematic search was conducted for articles published in English between 1995-2018 searched using the electronic databases MEDLINE(Ovid), PsycINFO, EMBASE(Ovid), CINAHL(Ebsco),and Toxline. A set of search terms were created by key words, truncations, Subject Headings and Boolean operators, when appropriate; these were searched in Title, Abstract and Keywords, an example for our Medline (Ovid) search is shown in Table 1.

2.3 Data Extraction

The search results for each of the databases were imported into the Covidence software (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org) (via uploaded RIS file formats). This software allowed for the removal of any duplicates across the five databases. The screening of articles for the eligibility criteria was completed by first screening title/abstract (by HM and SE) and then by full- text screening (by HM and SE). The data were then tabulated to show the author and year of publication, the population under study, the aim of the study, the study design, the interventions, and the primary outcomes. The extraction was completed by HM and SE with ATMK serving to resolve any opposing views.

2.4 Assessment of Quality

Quality assessment entailed evaluating whether the studies have been designed, conducted, and reported in such a way that they can be considered reliable (i.e. having rigour) and whether or not they provide meaningful

answers to the research question (i.e. have relevance) (Boland, Cherry, & Dickson, 2017). As suggested by Boland and colleagues (2017), a design-specific quality assessment was used for each of the different study types. A Risk of Bias tool was used to assess the quality of randomized controlled trials (Higgins & Green, 2011). The Critical Appraisal Skills Programme (CASP) contains quality assessment checklists for both cohort studies and literature reviews ("Home - CASP", 2018). Lastly, the Downs and Black (1998) 27-item checklist was used to assess the quality of the cross-sectional studies.

2.5 Data Analysis

Given our interest in looking at different types of studies, and the varied outcomes associated with each of these, we opted to conduct a narrative synthesis. This approach allowed us to include as many studies as possible as well as provide an analysis that was comprehensive.

3. Results

A total of 835 studies were imported from screening. A total of 270 duplicates were removed. From there, 565 studies were screened based on the title and abstract as well as the predetermined inclusion criteria. Of these, 500 studies were deemed irrelevant and were therefore excluded from the review. Therefore, 65 studies were screened based on the full-text, while 35 were excluded as these studies did not have full-text available (n=9), resulted in different study outcomes (other mental health conditions such as anxiety and suicidality) (n=9), comprised of the wrong interventions (e.g. non-environmental toxicants) (n=8), were unrelated to the research question (n=4), incorrect study design (n=2), duplicate (n=1), not published in English (n=1), and contained the wrong study population (e.g. men, children) (n=1). A final number of 30 studies were eligible to be included as part of the systematic review. See the Prisma flowchart (Figure 1) for additional details.

3.1 Description of Studies

The 30 articles included in this review comprised 11 literature reviews (including systematic and intervention) (37%), 10 cohort studies (33%), 5 cross-sectional studies (17%), and 4 randomized controlled trials (13%). Table 2 showcases the summary of the number of articles in each category. The inclusion of secondary data contributes to the overall investigation of this topic by exploring the comprehensive findings from prior literature reviews in order to obtain a greater sense of the extent to which these environmental toxicants have been previously reported in the literature in relation to postpartum depression. However, it is important to note that this ultimately lessens the rigor of this systematic review, as it affects the validity and reliability of the systematic review by including both primary and secondary data in the analysis and by impacting the exact replicability of the findings which were generated from the methodological process.

There were six categories of environmental toxicants which were studied among the 30 included articles in this systematic review. The categories and the associated number of articles (n) for each are:

1. Cigarette smoke exposure (n=14)
- Active smoking and second-hand smoke

2. Dietary supplements (n=8)
- Micronutrients, vitamins, omega-3 fatty acids

3. Antidepressants (n=5)
- Sertraline and nortriptyline

4. Air pollution (n=1)
- Particulate air pollution

5. Oral contraceptives (n=1)
- Depot medroxyprogesterone acetate (DMPA)

6. Pesticides (n=1)
- Organochlorine pesticides

3.2 Quality Assessment

The quality of the literature reviews (including systematic and intervention) (n=11) and cohort studies (n=10) was assessed using the CASP (The Critical Appraisal Skills Programme) checklist. The core CASP checklists (randomized controlled trial and systematic review) were based on JAMA 'Users' guides to the medical literature adapted from Guyatt, Sackett, and Cook (1994), and piloted with health care practitioners ("CASP – Systematic Review", 2018). Three literature reviews were assessed as being of satisfactory quality, another three of good quality while five were found to be of poor quality. Four cohort studies were deemed of satisfactory quality, three were adequate while two were deemed to be of poor quality. Please consult Table 2 for additional information regarding each study.

The quality of the cross-sectional studies (n=5) was assessed using the Downs and Black checklist, as suggested by Boland and colleagues (2017). Three of these studies were deemed of good quality, whereas one was deemed adequate and another of poor quality.

The quality of the randomized controlled trials (n=4) was assessed using the Cochrane Risk of Bias Tool. The Fard et al. (2017) study was judged as 'low risk' of bias, therefore of good quality. The Hantsoo et al. (2014) study had an overall judgment of 'low risk' of bias with two domains judged as 'high risk', therefore of adequate quality. The Singata-Madiliki et al. (2016) study was judged as 'low risk' of bias, therefore of good quality. Lastly, the Sunder et al. (2004) study had an overall judgment of 'high risk' of bias, therefore of poor quality.

3.3 Analysis of Results

Based on the findings from the included studies, prenatal/perinatal exposure to active/passive smoke was largely found to increase the risk of developing postpartum depression and depressive symptoms in the postpartum period. Prenatal active smoking was found to be associated with an increased risk for postpartum depression, particularly those who smoked prior to pregnancy and continued to smoke during pregnancy into the postpartum period, compared to those women who quit during pregnancy and those who were non-smokers (Chen et al., 2018; Dagher & Shenassa, 2012; Frandsen, Thow, & Ferguson, 2017; Munafò, Heron, & Araya, 2008; Salimi et al., 2015; Vivilaki et al., 2016). The study by Underwood et al. (2017) did not find an association between prenatal active smoking and postpartum depression. Perhaps the reason this study did not find an association between prenatal active smoking and postpartum depression could be because these investigators also measured perceived stress and alcohol consumption along with smoking status. The perceived stress experienced by the participants was significantly associated with the development of postpartum depressive symptoms and surpassed the presence of an association between prenatal active smoking and postpartum depression. The other studies which investigated active smoking exposure did not include any other factors in their outcome measurement and only focused on prenatal smoking. This in turn, could explain the difference in findings between these studies.

The studies which investigated dietary supplements found mixed results overall, however, omega-3 fatty acid intake was found to be the most beneficial in reducing depressive symptoms in the postpartum period. These studies which focused on omega-3 fatty acids were able to demonstrate a reduced risk of depression in the postpartum period with prenatal and/or perinatal consumption (Coletta, Bell, & Roman, 2010; Glenville, 2006; Leung & Kaplan, 2009) and identifying a decrease in EPDS scores by 52% (Freeman, 2006). However, there were other studies with opposite results pertaining to omega-3 fatty acids, in that omega-3 fatty acid intake and postpartum depression incidence findings are contradictory and with varying results (Derbyshire & Costarelli, 2008; Ellsworth-Bowers & Corwin, 2012). These variations could be reflected on their literature review study

design. As noted by Derbyshire and Costarelli (2008), the lack of associations may be a result of low supplement dosages, under-reporting of fatty acid intake, short-term follow-up and unsuitable ratios of EPA:DHA among the included studies. Furthermore, these investigators are primarily reporting preliminary findings in their reviews; additional larger studies and randomized controlled trials are recommended in order to further investigate this association.

The studies which investigated antidepressants found that sertraline was more likely to exhibit preventative effects in developing postpartum depression and reduce the extent of depressive symptoms in the postpartum period. These studies found that sertraline was more effective in reducing the risk of developing postpartum depression and experiencing postpartum depressive symptoms compared to nortriptyline (Howard et al., 2005; Molyneaux et al., 2018; Pariser, Nasrallah, & Gardner, 1997). Other studies compared sertraline with a placebo in treating postpartum depression. Hantsoo et al. (2014) found that sertraline produced a significantly greater response rate (59%) than placebo (26%) and more than a two-fold increased remission rate. Sunder et al. (2004) compared sertraline to a placebo and postpartum depression and they found no significant difference between the two in preventing postpartum depression. Both studies Hantsoo et al. (2014) and Sunder et al. (2004) were randomized controlled trials and they each had relatively small number of participants (38 and 11 women respectively). Considering the small number of participants for these two studies, this presents as a possible limitation in that there were not equal distributions between the intervention groups and could have therefore had an influence on the overall results.

The one study that investigated air pollution found that increased particulate air pollution exposure was associated with an increased risk in depressive symptoms in the postpartum period. Sheffield et al. (2018) aimed to determine a link between air pollution exposure with psychological functioning among postpartum women. The participants included an ethnically diverse, lower income urban cohort of pregnant women. The results demonstrated an association between prenatal ambient $PM_{2.5}$ exposure levels and postpartum total EPDS and the investigators observed a statistically significant sensitive window of $PM_{2.5}$ exposure for elevated anhedonia subscale scores during mid-pregnancy, especially gestational weeks 13 to 20 (Sheffield et al., 2018). In stratified analyses, effects were most evident among African-American women. For this group of women, increased exposure to $PM_{2.5}$ was significantly associated with higher total postpartum EPDS scores as well as higher scores on the depressive and anhedonia symptom subscales, with minor variability in the identified window of vulnerability in pregnancy across these outcome measures (Sheffield et al., 2018).

The one study that investigated oral contraceptive use in the perinatal period found an association with an increased risk of depressive symptoms in the postpartum period. Singata-Madiliki, Hofmeyr, and Lawrie (2016) aimed to determine whether DMPA (the most commonly used postnatal contraception option in South Africa) increases the risk of postpartum depression compared with the intrauterine device (IUD) when administered after delivery (within 48 hours of childbirth). The finding from this study indicated that one-month depression scores were significantly higher with DMPA use compared with IUD use according to EPDS data; 3-month depression scores were higher with DMPA according to the BDI-II data. Although the results are highly suggestive of a higher risk of postpartum depression with DMPA, the trial findings cannot be regarded as conclusive (Singata-Madiliki et al., 2016).

Lastly, the one study that investigated pesticide exposure found no associative risk in developing postpartum depression. Yalçin et al. (2015) aimed to determine the levels of organochlorine pesticides (OCPs) in breast milk and to evaluate the relation between OCPs and maternal psychopathologies. The authors state that breast milk is a unique biological matrix for investigating certain environmental contaminants because it can provide exposure information about the mother and her breastfed infant (Thundiyil, Solomon, & Miller, 2007). The results of this study identified and analyzed 12 OCPs among the 75 samples and found that no relation was detected between EPDS and OCPs (Yalçin et al., 2015).

The participants among the included studies were female and of an average age between 28-35 years old. This age range is on the lower end of the range sought from our review; the potential for exposure to certain toxicants

lessens for women of younger age. Furthermore, the participants were of various ethnicities: Caucasian, African-American, Hispanic, Asian, Native American, or unlisted.

Please refer to Table 2 for the complete data extractions. The production of this table by means of a narrative synthesis enables the examination of the similarities and differences between the included studies and warrants descriptive conclusions based on the present summary of the current knowledge surrounding this research topic.

4. Discussion

4.1 Main Findings

The main findings of this systematic review suggest that those exposed to active/passive smoke (cigarette/tobacco) during the prenatal/perinatal period had the greatest risk of developing postpartum depression and depressive symptoms in the postpartum period, compared to the other categories of toxicants. The literature does support a link between certain environmental toxicants and postpartum depression (Chen et al., 2018; Dagher & Shenassa, 2012; Frandsen et al., 2017; Munafò et al., 2008; Salimi et al., 2015; Sheffield et al., 2018; Singata-Madiliki et al., 2016; Vivilaki et al., 2016), although there were studies with inconclusive results and/or that found no association. These observations will be further explained throughout the following sections and the results for each category of toxicant will be interpreted.

The studies that focused on cigarette/tobacco smoke exposure studies reported that exposure to this toxicant during the prenatal and/or perinatal period was primarily found to increase the risk of developing postpartum depression and depressive symptoms in the postpartum period. It is already well known that active smoking can have harmful effects on one's health by increasing the risk of lung cancer and respiratory conditions (Hawari et al., 2019; Laniado- Laborín, 2009; Papadopoulos et al., 2011; Sousa et al., 2019), however, the studies in this review demonstrated that not only does tobacco exposure affect physical health but can most notably affect mental health. The prenatal and perinatal periods are sensitive times for women as they are undergoing physiological changes (Soma-Pillay et al., 2016; Talbot & Maclennan, 2016) and experiencing drastic lifestyle changes (relating to sleep, diet, exercise, etc.) (Barakat et al., 2015; Chien & Ko, 2004; Danielewicz et al., 2017; Hall et al., 2009), and with the introduction of harmful toxic chemicals to their bodies, this has been shown to ultimately affect their mental health well into the postpartum period, resulting in the experience of major depressive symptoms. The importance of recognizing the harmful effects of tobacco exposure during the prenatal and perinatal periods will further advance research in the investigation of this association and will hopefully create awareness of relating tobacco exposure to mental health.

Given the major presence of cigarette/tobacco smoke studies, we acknowledge the limited amount of evidence regarding the other toxicants identified in this review and their relationship with postpartum depression; investigation of the relationship between mental health and air pollution or pesticide exposure is particularly lacking. More often than not, people are unaware and inattentive to what they are regularly exposed to in their environment, especially regarding those toxicants for which it is difficult to measure their underlying effects on physical health (i.e. difficult to determine the amount of levels of these toxicants as they can be airborne). However, in a study included in this review, investigators did find the means to measure exposure levels and thus, were able to associate them with postpartum depression among their participants. From these experimental tools, we see a potential for measuring other pollutants present in the maternal environment in order to target their relationship with other mental health disorders in the same way. Aside from cigarette/tobacco smoke, more research is necessary in the investigation of other categories of toxicants and their effects on maternal health, in order to gather a greater understanding of the most advantageous techniques in addressing this association.

4.2 Limitations

This review was able to consider a variety of environmental toxicants as part of the search criteria in the investigation of risk factors for the development of postpartum depression and did not exclusively focus on more conventional toxicants (i.e. pesticides, cigarette smoke). This review also included worldwide studies as part of

the article selection process and was therefore not limited to North American studies. However, there were some important limitation to consider. First, this review did not consider non-English articles pertaining to our topic of study. Second, it was limited to the five online databases used in searching the literature for relevant articles and although this can be seen as a sufficiently diverse group of databases, there are many more databases available to use but that were not considered. Third, this review primarily included non-randomized studies (87%) while there were only a few randomized controlled trials (13%), which therefore established heterogeneity among the included studies. Relatedly, a meta-analysis was not performed for this systematic review and therefore the results from the four randomized-controlled trials were not combined to give an overall measure of the effect of the one toxicant compared to another - the small sample size would not have allowed a very good comparison. Fourth, in terms of the quality assessment of the non-randomized studies, only one reviewer assessed the quality of those studies and completed the required checklists. And fifth, although the Downs and Black (1997) quality assessment checklist was deemed suitable to use to assess the quality of the cross-sectional studies, this tool is somewhat outdated, and the use of a more recent assessment tool could have been more appropriate based on the prevalence of the fairly recent studies included in the review.

5. Conclusion

The findings from this review demonstrate the current knowledge and understanding surrounding the topic of environmental toxicants/xenobiotics as risk factors for postpartum depression. Based on the results from the included studies, the literature does support a link between certain categories of environmental toxicants and the development of postpartum depression – majority involving cigarette/tobacco smoke exposure and some evidence regarding particulate air matter exposure – although, there are other studies in this review which found inconclusive and/or differing results. Given these variations, this systematic review could present as a foundation for encouraging future research to investigate this matter, in order to attain a greater perspective when conducting further studies. Additionally, many countries seem to have policies and regulations set in place that take into account the environment and its effect on human health, and even though there are also informative services and resources regarding mental health, there is still an absence of recognition regarding the relationship between the environment and mental health specifically - much work is needed to help change this.

We are constantly exposed to a variety of environmental toxicants and other xenobiotics with a great potential to profoundly impact our health, often without awareness of the extent of this exposure. A better understanding of the potential risk certain xenobiotics may have on the onset and progression of mood disorders such as postpartum depression could influence its diagnosis and treatment with crucial consequences for the mother, child, and her family.

6. Acknowledgements

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7. Disclosure Statement

The authors have no potential conflict of interest to report.

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