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Emerging Risk Factors for Postpartum Depression: Serotonin Transporter Genotype and Omega-3 Fatty Acid Status

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Abstract

Objective—Depression is a leading cause of disability and hospitalization. Women are at the highest risk of depression during their childbearing years, and the birth of a child may precipitate a depressive episode in vulnerable women. Postpartum depression (PPD) is associated with diminished maternal somatic health as well as health and developmental problems in their offspring. This review focuses on 2 PPD risk factors of emerging interest: serotonin transporter (5-HTT) genotype and omega-3 polyunsaturated fatty acid (n-3 PUFA) status.

Method—The MEDLINE, PubMed, and Web of Science databases were searched using the key words postpartum depression, nutrition, omega-3 fatty acids, and serotonin transporter gene. Studies were also located by reviewing the reference lists of selected articles.

Results—Seventy-five articles were identified as relevant to this review. Three carefully conducted studies reported associations between the 5-HTT genotype and PPD. As well, there is accumulating evidence that n-3 PUFA intake is associated with risk of PPD. Preliminary evidence suggests that there could be an interaction between these 2 emerging risk factors. However, further studies are required to confirm such an interaction and to elucidate the underlying mechanisms.

Conclusions—Evidence to date supports a research agenda clarifying the associations between n-3 PUFAs, the 5-HTT genotype, and PPD. This is of particular interest owing to the high prevalence of poor n-3 PUFA intake among women of childbearing age and the consequent potential for alternative preventive measures and treatments for PPD.

Keywords

serotonin transporter gene; omega-3 fatty acids; postpartum depression; nutrition

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Major depressive disorder is the most common mental disorder in Canada,[1] with a lifetime incidence of 7.9% to 8.6%, a 1-year prevalence of 4% to 5%, and a 6% point prevalence of symptoms consistent with depression.[2] The rate of outpatient treatment for depression increased more than 3-fold in the United States between 1987 and 1997.[3] Among women of childbearing age, depression is the second-leading cause of disability worldwide.[4] Taken together, depression and other affective disorders constitute the leading cause of nonobstetric hospitalization among women of childbearing age in the United States.[5] In Canada, the incidence and rate of hospitalization for MDD is about 50% higher for women than for men.[2,6] Finally, it is during the first postpartum year that women are at the highest risk of depression, with 45% to 65% of ever-depressed women having their first episode.[7]

Postpartum Depression

PPD is defined as a nonpsychotic depressive illness of mild-to-moderate severity occurring in a mother during the first postnatal year. Though clinically heterogeneous, PPD is distinct from the less severe postpartum blues or baby blues (a mild depressive reaction within the first few days following birth, occurring in 15% to 84% of mothers depending on timing, number of assessments, and criteria used to establish a case)[8] and the much less frequent, though more serious, postpartum psychosis (a psychiatric emergency occurring in fewer than 1 of 500 mothers, with rapid onset within the first 4 weeks after delivery, generally associated with bipolar disorder and requiring hospitalization).[9] The prevalence of PPD is generally reported as between 10% and 15%.[7,10]

Consequences of PPD

PPD is associated with reduced maternal functional status,[11] chronic disease[12] and diminished physical health-related quality of life.[13] PPD has also been linked with numerous somatic and psychiatric problems in the children of depressed mothers.[14,15] Research suggests that mothers suffering from PPD tend to be more disengaged, hostile, critical, and less sensitive and responsive toward their children.[16–18] These patterns can lead children to develop an insecure attachment relationship with their mother, resulting in disruptions in sleep patterns, delays in language and cognitive development, poor affect regulation, and other emotional and behavioural problems.[19] For example, 10-year-old children exposed to maternal PPD symptoms since birth have larger left and right amygdala and a heightened cortisol response to stress,[20] and other long-term associations have also been observed between maternal PPD and cognitive outcomes including IQ in adolescents.[21]

Clinical Implications

- Nutritional and genetic exposures are emerging as risk factors of interest in the etiology of PPD.
- If confirmed in future studies, these exposures hold potential as part of a screening strategy to identify women at risk of PPD, and to define target populations for evaluating prevention strategies.

- Intakes of n-3 PUFA in pregnant women are well below recommendations and are amenable to improvement.

Limitations

- The number of studies on these risk factors is too small to be able to draw firm conclusions.
- More evidence is required concerning the specific biological mechanisms underlying PPD, and the pathways through which these risk factors could potentially interact.

PPD, Compared With Other Depression

While the diagnostic criteria for PPD are otherwise identical to those for depression occurring at other times, certain biologic markers distinguish PPD from other types of depression. It is likely that hormonal changes associated with parturition contribute to mood alterations in vulnerable women.[22] Studies have shown decreased susceptibility to depression in women during times of reproductive hormone stability, suggesting that PPD may stem, in part, from marked hormonal variations associated with childbirth.[23] Over the course of pregnancy, cortisol levels double,[24] while progesterone and estradiol levels increase 10 and 50 times, respectively; these hormones then abruptly return to normal levels within the first 2 weeks of the postpartum period.[25] Experimental evidence suggests that women who develop PPD may be particularly sensitive to these hormonal fluctuations.[26–28] Further, decreased levels of monoamines, including 5-HT, norepinephrine, and dopamine, are implicated in the pathogenesis of depression,[29] and data from animal models suggest that estrogen and other steroid hormones mediate the transcription of genes regulating synthesis and metabolism of neurotransmitters and their receptors,[30,31] supporting the hypothesis that hormonal fluctuations affect the risk of PPD, in part, through their effects on the central nervous system. Finally, the prenatal and postpartum periods involve exceptional social stressors and demands on women that have been found to increase both the risk and the consequences of depression.[32,33]

Treatment of PPD

The care and treatment of women with PPD varies widely between countries, owing, in part, to inadequate guidelines and disparities in accessible treatment options.[34] Nonetheless, there is evidence supporting pharmacologic and other biological interventions (for example, hormonal interventions or bright light therapy) for the treatment of moderate-to-severe depression in postpartum women.[35,36] While few placebo-controlled trials of ADs have been conducted in women with PPD, 2 trials have yielded positive body of research results,[37,38] and ADs appear to be as effective for PPD as for MDD occurring at other times in the life cycle.[36] However, concerns have been raised regarding the robustness of evidence on which these conclusions are based,[35] and few studies have compared different classes of medications for the treatment of PPD.[39] In addition, evidence suggests that adherence to ADs during the postpartum period may be poor.[34] Psychotherapeutic and other nonpharmacologic interventions, including relaxation and massage therapy, infant sleep

interventions, and maternal exercise, have also shown promise in the treatment of PPD. However, the evidence base concerning their effectiveness is still limited.[40,41]

Risk Factors for PPD

Given the limited knowledge regarding efficient and safe treatment of PPD, one avenue for reducing PPD and need for treatment would be through preventive approaches targeting risk factors. A constellation of risk factors for PPD has been identified that includes social, demographic, obstetric, biological, hormonal, psychiatric, and genetic features, as well as characteristics of the newborn child. Among the key social factors predicting PPD are a strained marital relationship, low social support, and stressful life events.[7,14] Low SES[42,43] and personal or family history of depression or mood disorders[14] have also been identified as significant risk factors for PPD. PPD has been linked with severe obstetrical complications during pregnancy[44,45] and at delivery[46]; with adverse birth outcomes (low birth weight and preterm birth)[47]; and with adverse neonatal outcomes, such as infant irritability and poor motor function.[48]

It has also been proposed that the environmental risk for depression may be moderated by genetic factors. It is estimated that about 40% to 50% of the risk for depression is genetic,[49] with family studies showing a 3- to 4-fold increased risk of depression for family members with depression, depending on the degree of relation.[50] However, the specific mechanisms of genetic causality are not well understood,[25] and the relative contribution of various combinations of genetic and environmental factors to PPD is as yet undetermined.

Beyond social influences, one key environmental factor may be nutrition. There is indeed evidence that diet quality, dietary intake, and overall nutritional status can affect the risk of PPD.[51] Pregnancy is a period during which nutritional requirements and vulnerability to poor nutritional status are heightened. In fact, requirements for many nutrients in women reach a lifetime peak during pregnancy or lactation. Improved nutritional status during these periods may positively impact on maternal mental health, both directly and by augmenting the effectiveness of ADs.[51]

Therefore, our review will focus on 2 risk factors of emerging interest, 5-HTT genotype and n-3 PUFA status. The 5-HTT gene was selected because it has become the most investigated genetic variant in psychiatry, psychology, and neuroscience.[52] Further, a significant body of research has explored the association between n-3 PUFAs and PPD.[53–56] Because n-3 PUFAs are hypothesized to reduce the risk of depression, in part through the regulation of gene expression,[53] studies testing the interaction between n-3 PUFAs and genetic exposures in the prediction of PPD would be warranted. This is particularly important as nutrition is a potentially modifiable environmental risk factor[51,57] that could interact with a genetic predisposition to PDD.

Literature Search

We searched the MEDLINE (1950 to 2011), PubMed (1966 to 2011), and Web of Science (1965 to 2011) databases for articles in English or French using the key words postpartum depression, nutrition, omega-3 fatty acids, and serotonin transporter gene. We included

narrative and systematic reviews, original research reports of observational or experimental studies, and editorials. Studies were also located by reviewing the reference lists of selected articles. Our search generated 257 articles. Abstracts from research reports and systematic reviews were assessed for exposure and outcome measures. To be included, studies needed to have PPD or depressive symptoms as an outcome. At least one of the following exposures was also required: 5-HTT genotype, n-3 PUFA dietary intake, supplementation, or biomarker measurement, and fish consumption. Review articles and editorials addressing these exposures, as well as other genetic and nutritional risk factors for PPD, were included. This left 75 articles forming the core of our narrative review.

The 5-HTT Gene and PPD

Following reports of associations between the short allele of the 5-HTTLPR and anxiety-related personality traits,[58] studies have addressed the influence of the 5-HTT gene on depression, both alone[59] and in interaction with environmental risk factors.[60] The 5-HTT gene modulates the reuptake of 5-HT at brain synapses, a principal neurobiological feature of depression and the target of selective serotonin reuptake inhibitor ADs.[60]

Nevertheless, the precise relation between 5-HTT and the risk of depression is somewhat controversial, with a recent meta-analysis concluding no overall effect.[61] However, this finding has been critiqued on several grounds, including heterogeneity in measurement of outcome and environmental exposure, exclusion of studies with high-quality designs,[62] inadequate measurement of relevant environmental exposures,[62,63] and use of inappropriate interaction models.[64,65] Another meta-analysis concluding that positive results for interactions between 5-HTTLPR and stressful life events in the prediction of depression were compatible with chance findings[66] has also been critiqued on some of these same grounds.[67] A third meta-analysis with broader inclusion criteria[68] concluded that 5-HTTLPR moderates the relation between stress and depression. In addition, significant associations between 5-HTTLPR genotype and depression were found in 2 other meta-analyses that did not take into account stress as a covariable.[69,70] Accordingly, there are reasons to suspect that the 5-HTT gene is related to depression in some subpopulations, including women in the postpartum period.

Biologic evidence suggests a role of the 5-HT system in PPD that may differ from that in other forms of depression.[71] Synthesis of cerebral 5-HT decreases during pregnancy owing to placental catabolism of tryptophan, the precursor to 5-HT.[72] PPD symptoms are positively correlated with postnatal tryptophan catabolism[73] and inversely correlated with maternal plasma tryptophan concentrations.[71] This suggests that the 5-HT system may be of particular importance in the pathophysiology of depression in postpartum women.

Epidemiologic evidence suggests that 5-HTT gene expression patterns may have differential effects for men and women, particularly in the context of psychosocial stress. One study[74] on 5-HTT, family environmental risk, and depression showed effects for women but not men. Two additional studies[75,76] showed increased depressive symptoms in females carrying the short allele but a protective effect of the short allele in males.

The 5-HTT genotype was linked to PPD in 3 other studies. A study[77] looking at depressive symptoms at 3 time points after delivery found a significant positive association between depressive symptoms and 5-HTT expression level at 8 weeks into the postpartum period. Another study[78] of women with a prior history of depression found that short allele carrier status (either 1 or 2 copies of the short allele) of the 5-HTT gene predicted depression at 1- to 8-weeks during the postpartum period (OR 5.13; 95% CI 1.16 to 22.7, $P = 0.02$). Finally, a recent study[79] showed the 5-HTT short allele to be associated with increased risk of PPD in low-SES women but with decreased risk in high-SES women. Taken together, these heterogeneous results suggest that null findings from other studies, [80,81] particularly meta-analyses,[61,66] may mask interactions between 5-HTT genotype and environmental risk factors.

n-3 PUFA and PPD

Found in fish as well as some seeds and nuts,[82] n-3 PUFAs are essential unsaturated fatty acids, and they merit attention and further study for several reasons. First, n-3 PUFAs directly affect brain activities, including receptor function, neurotransmitter uptake, and signal transmission,[51] and evidence suggests a beneficial role of n-3 PUFAs in the treatment of patients with diagnosed depression.[83,84] Second, dietary intake of n-3 PUFAs is particularly poor, and the ratio of n-6 to n-3 PUFA intake has risen dramatically over the last century.[85] This ratio is a commonly used marker of dietary fatty acid composition and is positively related to risk for various diseases.[86] Finally, as n-3 PUFA stores are transferred from the mother to the developing fetus during gestation and later to the infant by lactating mothers, maternal n-3 PUFA levels decrease during pregnancy and remain lowered at least 6 weeks into the postpartum period.[87]

Research on n-3 PUFAs and PPD has been informed by an interest in the interrelations between fatty acids, depression, and cardiovascular disease.[88,89] Patients with depression show increased cardiovascular mortality, and depression is a frequent comorbidity in patients with coronary artery disease and is associated with worse outcomes in these patients.[89–91] Depression and cardiovascular disease may exacerbate each other directly, but it is also hypothesized that these 2 seemingly disparate health problems share common causes.[92] n-3 PUFAs are understood to modulate both serotonergic neurotransmission and thrombotic and inflammatory mechanisms associated with coronary disease,[90,93] and it is likely that inflammatory markers comprise part of the physiological mechanism of depression as well.[94–97]

Evidence linking n-3 PUFAs and depression spans multiple study designs and populations.[85,98,99] Associations have been found in case–control, cross-sectional, and cohort studies; with exposures including blood lipid samples, adipose tissue samples (reflecting long-term or habitual intake), fish consumption, overall dietary fatty acid intake,[100] and postmortem brain cortex analyses;[101] and with outcomes including clinical depression, depressive symptoms,[99] depression during pregnancy, and PPD.[102] Serum levels of DHA, one of the principal n-3 PUFAs associated with depression, have been observed to decline during pregnancy and after delivery, leaving postpartum women vulnerable to DHA deficiency.[55,103] Dietary intake and serum levels of n-3 PUFAs have been inversely associated with

PPD[53,55] and with depression in other populations.[99,104] Ecologic and cross-sectional studies[85] have found inverse associations between consumption of fish (a primary dietary source of n-3 PUFAs) and major depression and PPD.

Evaluating research on n-3 PUFAs and PPD must be done with caution. This research is conducted against a background of robust links between psychosocial exposures and affective disorders and strong demonstrated associations between depression, before or during pregnancy, and PPD. An emerging body of research also shows links between depression and other nutrients whose intake is likely to exhibit some collinearity with n-3 PUFAs. Nevertheless, randomized controlled trials have shown n-3 PUFAs to be effective as AD treatment,[84,105] suggesting a causal role for this nutrient class in the etiology of depression. This claim is supported by evidence linking n-3 PUFAs with efficient neurotransmission[106] and with inflammatory mechanisms connected to depression. Several clinical trials of n-3 PUFA supplementation for patients with MDD have shown large effect sizes.[107] However, meta-analyses suggest it is more realistic to expect moderate effect sizes from supplementation.[83,84] Observational studies of n-3 PUFAs and depression have also shown moderate effect sizes. For example, in a study[91] of patients with recent acute coronary syndromes (representing a high-risk group), the per cent of phospholipid fatty acids represented by n-3 PUFAs was about 12% lower in people with depression, and the percentage of DHA about 14% lower, compared with nondepressed people.

Finally, it needs to be considered that plasma levels of fatty acids are an imperfect measure of dietary intake and also an imperfect predictor of fatty acid levels in brain tissue. Serum fatty acid levels have been shown to be sensitive to recent changes in dietary fatty acid intake in adults.[108–110] This pattern has specifically been observed in pregnant women, with n-3 PUFA supplementation associated with elevated plasma and postpartum breast milk DHA levels.[111] Findings from animal studies[85,112] suggest a robust relation between serum and brain fatty acid levels, and dietary deficiency in n-3 PUFAs has been associated with observed changes in brain composition and neural functioning in animal models.[85] Significantly, n-3 PUFA deficiency has been associated with altered metabolism of dopamine and 5-HT,[109] 2 of the key neurotransmitters underlying the neural physiology of depression. However, animal models show the mechanisms through which fatty acids. are absorbed, converted, synthesized, and processed in the brain are complex and change over the life course.[109,113–118] Dietary fatty acid intake affects brain fatty acid levels most readily during early development,[119–121] and it is unclear how quickly brain fatty acid levels change in relation to dietary intake in mature animals. Nevertheless, significant changes in brain fatty acid levels were observed in adult female rats within a time span of one reproductive cycle following diet modification.[122]

n-3 PUFA Status and Modification of Intake

Evidence from numerous fronts suggests that intakes of n-3 PUFAs are far below recommended levels and are amenable to improvement. In the US adult population, intake of DHA and EPA in 2000 was more than 70% below recommendations from the National Institutes of Health.[123] A 4-fold increase in fish consumption would be required to bring EPA and DHA intake to recommended levels. In Canada and Australia, maternal milk

concentrations of DHA appear to have decreased by about 50% over the 15-year period ending in 1999.[124]

Inadequate n-3 PUFA levels are of even greater concern in pregnant women. In a cross-sectional survey[125] of pregnant women in central Mexico, the median DHA and EPA intakes, as calculated from a food frequency questionnaire, were 55 and 18 mg/day, respectively. This compares with recommendations by the American Dietetic Association and Dietitians of Canada of 500 mg/day DHA and EPA combined.[126] A Canadian study[127] of adults in Quebec found that 85% had an EPA and DHA intake lower than this recommendation. Among the women of childbearing age in that study, median intake of DHA was 126 mg/day,[127] while a study[124] of pregnant women in British Columbia showed a mean DHA intake of 160 mg/day.

Because maternal plasma n-3 PUFA concentrations decline substantially after delivery, [128,129] maintaining a sufficient intake of n-3 PUFAs is important to ensure adequate fatty acid stores during the postpartum period. In addition to the implications for maternal mental health, n-3 PUFAs are essential for infant neural and visual development.[130] n-3 PUFA intake is thus critical for lactating mothers. While there has been considerable focus on n-3 PUFA status in adolescent mothers owing to the enhanced nutritional risks associated with adolescence,[131] several studies have also examined n-3 PUFA levels in adult postpartum women. Two studies found DHA intake of 30 to 58 mg/day and concentration in breast milk of about 0.10%, well below recommendations of 0.2% to 0.4%.[132,133] A study comparing lactating and nonlactating women found a DHA intake of 29 to 47 mg/day and EPA intake of 52 to 91 mg/day,[128] again well below recommendations. These results suggest poor maternal n-3 PUFA intake to be a significant problem, not only during pregnancy but also in the postpartum period.

n-3 PUFA, 5-HTT Genotype, and PPD

A growing body of literature is exploring nutritional aspects of depression[134] and PPD specifically.[25,51] However, little research has addressed interactions between nutritional and genetic risk factors in the prediction and etiology of depression. There has been considerable focus on interactions between the 5-HTT gene and psychosocial stress[68,135] but little investigation into genetic interactions with nutritional exposures that may exhibit some of the same effects as stress on brain function. Two studies examining the seasonal variation in n-3 PUFAs, plasma tryptophan, and serotonergic markers[136,137] suggest that fatty acid levels in the brain may modulate 5-HT release and reuptake. These findings support research into interactions between n-3 PUFAs and the 5-HTT gene and suggest that these 2 seemingly disparate exposures may affect the risk of PPD through a common neurobiological mechanism. Accordingly, studying their association in the prediction of PPD may help further elucidate the neurobiological underpinnings of this condition while helping to target prevention and treatment efforts.

Conclusion

There is a growing awareness of the importance of nutritional and genetic exposures as risk factors for PPD. The 5-HTT gene is a promising avenue for genetic research, and it appears highly likely that this gene affects the risk of depression and other psychiatric conditions. However, it is unclear which genotypes are associated with elevated risk in which populations, and specifically how associations between 5-HTT genotype and depression may differ during the perinatal period from other time points across the life course. Similarly, increasing evidence links n-3 PUFAs and depression in diverse populations. However, the biological mechanisms through which these links function, and the ways in which they may be modified in pregnancy, are not clearly understood.

One of these mechanisms could operate through a gene–environment interaction. Because it can be reasonably hypothesized that the 5-HTT genotype and n-3 PUFAs impact on the risk of PPD, in part through the same mechanism, studying them jointly would present an opportunity to advance our understanding of how genetic and dietary exposures may interact in the etiology of PPD. Knowledge garnered from this effort has the potential to improve the prediction, prevention, and treatment of this significant public health problem. This is particularly important as current intake of n-3 PUFAs in pregnant women is well below recommendations and is thus amenable to improvement.

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Abbreviations

5-HT	serotonin
5-HTT	serotonin transporter
5-HTTLPR	serotonin transporter gene linked polymorphic region
AD	antidepressant
DHA	docosahexaenoic acid
EPA	eicosapentaenoic acid
MDD	major depressive disorder
PPD	postpartum depression
n-3 PUFA	omega-3 polyunsaturated fatty acid
SES	socioeconomic status

References

1. Caron J, Liu A. A descriptive study of the prevalence of psychological distress and mental disorders in the Canadian population: comparison between low-income and non-low-income populations. Chronic Dis Can. 2010; 30:84–94. [PubMed: 20609292]
2. Health Canada. A report on mental illnesses in Canada. Ottawa (ON): Health Canada; 2002.
3. Olfson M, Marcus SC, Druss B, et al. National trends in the outpatient treatment of depression. JAMA. 2002; 287:203–209. [PubMed: 11779262]
4. World Health Organization (WHO). The world health report 2001—mental health: new understanding, new hope. Geneva (CH): WHO; 2001.
5. Jiang, HJ., Elixhauser, A., Nicholas, J., et al. Care of women in US hospitals, 2000. Rockville (MD): Agency for Healthcare Research and Quality; 2002.
6. Statistics Canada. Canadian Community Health Survey: mental health and well-being. Ottawa (ON): Statistics Canada; 2002.
7. Moses-Kolko EL, Roth EK. Antepartum and postpartum depression: healthy mom, healthy baby. J Am Med Womens Assoc. 2004; 59:181–191.
8. Henshaw C. Mood disturbance in the early puerperium: a review. Arch Womens Ment Health. 2003; 6(Suppl 2):S33–S42. [PubMed: 14615921]
9. Sit D, Rothschild AJ, Wisner KL. A review of postpartum psychosis. J Womens Health (Larchmt). 2006; 15:352–368. [PubMed: 16724884]
10. O'Hara MW, Swain AM. Rates and risk of postpartum depression—a meta-analysis. Int Rev Psychiatry. 1996; 8:37–54.
11. Posmontier B. Functional status outcomes in mothers with and without postpartum depression. J Midwifery Womens Health. 2008; 53:310–318. [PubMed: 18586183]
12. Josefsson A, Sydsjo G. A follow-up study of postpartum depressed women: recurrent maternal depressive symptoms and child behavior after four years. Arch Womens Ment Health. 2007; 10:141–145. [PubMed: 17533557]
13. Darcy JM, Grzywacz JG, Stephens RL, et al. Maternal depressive symptomatology: 16-month follow-up of infant and maternal health-related quality of life. J Am Board Fam Med. 2011; 24:249–257. [PubMed: 21551396]
14. Driscoll JW. Postpartum depression: the state of the science. J Perinat Neonatal Nurs. 2006; 20:40–42. [PubMed: 16508460]
15. Pearlstein T, Howard M, Salisbury A, et al. Postpartum depression. Am J Obstet Gynecol. 2009; 200:357–364. [PubMed: 19318144]
16. Campbell SB, Brownell CA, Hungerford A, et al. The course of maternal depressive symptoms and maternal sensitivity as predictors of attachment security at 36 months. Dev Psychopathol. 2004; 16:231–252. [PubMed: 15487594]
17. Lovejoy MC, Graczyk PA, O'Hare E, et al. Maternal depression and parenting behavior: a meta-analytic review. Clin Psychol Rev. 2000; 20:561–592. [PubMed: 10860167]
18. Field T. Infants of depressed mothers. Infant Behav Dev. 1995; 18:1–13.
19. Marcus SM. Depression during pregnancy: rates, risks and consequences—Motherisk update 2008. Can J Clin Pharmacol. 2009; 16:e15–e22. [PubMed: 19164843]
20. Lupien SJ, Parent S, Evans AC, et al. Larger amygdala but no change in hippocampal volume in 10-year-old children exposed to maternal depressive symptomatology since birth. Proc Natl Acad Sci USA. 2011; 108:14324–14329. [PubMed: 21844357]
21. Hay DF, Pawlby S, Waters CS, et al. Antepartum and postpartum exposure to maternal depression: different effects on different adolescent outcomes. J Child Psychol Psychiatry. 2008; 49:1079–1088. [PubMed: 19017024]
22. Glover V. Do biochemical factors play a part in postnatal depression? Prog Neuropsychopharmacol Biol Psychiatry. 1992; 16:605–615. [PubMed: 1496122]
23. Payne JL, MacKinnon DF, Mondimore FM, et al. Familial aggregation of postpartum mood symptoms in bipolar disorder pedigrees. Bipolar Disord. 2008; 10:38–44. [PubMed: 18199240]

24. Zonana J, Gorman JM. The neurobiology of postpartum depression. CNS Spectr. 2005; 10:792–799. 805. [PubMed: 16400241]
25. Leung BM, Kaplan BJ. Perinatal depression: prevalence, risks, and the nutrition link—a review of the literature. J Am Diet Assoc. 2009; 109:1566–1575. [PubMed: 19699836]
26. Bloch M, Daly RC, Rubinow DR. Endocrine factors in the etiology of postpartum depression. Compr Psychiatry. 2003; 44:234–246. [PubMed: 12764712]
27. Bloch M, Schmidt PJ, Danaceau M, et al. Effects of gonadal steroids in women with a history of postpartum depression. Am J Psychiatry. 2000; 157:924–930. [PubMed: 10831472]
28. Payne JL. The role of estrogen in mood disorders in women. Int Rev Psychiatry. 2003; 15:280–290. [PubMed: 15276966]
29. Maletic V, Robinson M, Oakes T, et al. Neurobiology of depression: an integrated view of key findings. Int J Clin Pract. 2007; 61:2030–2040. [PubMed: 17944926]
30. Joffe H, Cohen LS. Estrogen, serotonin, and mood disturbance: where is the therapeutic bridge? Biol Psychiatry. 1998; 44:798–811. [PubMed: 9807636]
31. McEwen BS. Non-genomic and genomic effects of steroids on neural activity. Trends Pharmacol Sci. 1991; 12:141–147. [PubMed: 2063480]
32. Ogrodniczuk JS, Piper WE. Preventing postnatal depression: a review of research findings. Harv Rev Psychiatry. 2003; 11:291–307. [PubMed: 14713566]
33. Hendrick V, Altshuler LL, Suri R. Hormonal changes in the postpartum and implications for postpartum depression. Psychosomatics. 1998; 39:93–101. [PubMed: 9584534]
34. Boath E, Bradley E, Henshaw C. Women's views of antidepressants in the treatment of postnatal depression. J Psychosom Obstet Gynaecol. 2004; 25:221–233. [PubMed: 15715021]
35. Dennis CL, Stewart DE. Treatment of postpartum depression, part 1: a critical review of biological interventions. J Clin Psychiatry. 2004; 65:1242–1251. [PubMed: 15367053]
36. di Scalea TL, Wisner KL. Pharmacotherapy of postpartum depression. Expert Opin Pharmacother. 2009; 10:2593–2607. [PubMed: 19874247]
37. Yonkers KA, Lin HQ, Howell HB, et al. Pharmacologic treatment of postpartum women with new-onset major depressive disorder: a randomized controlled trial with paroxetine. J Clin Psychiatry. 2008; 69:659–665. [PubMed: 18363420]
38. Appleby L, Warner R, Whitton A, et al. A controlled study of fluoxetine and cognitive-behavioural counselling in the treatment of postnatal depression. BMJ. 1997; 314:932–936. [PubMed: 9099116]
39. Fitelson E, Kim S, Baker AS, et al. Treatment of postpartum depression: clinical, psychological and pharmacological options. Int J Womens Health. 2010; 3:1–14. [PubMed: 21339932]
40. Dennis CL. Treatment of postpartum depression, part 2: a critical review of nonbiological interventions. J Clin Psychiatry. 2004; 65:1252–1265. [PubMed: 15367054]
41. Dimidjian S, Goodman S. Nonpharmacologic intervention and prevention strategies for depression during pregnancy and the postpartum. Clin Obstet Gynecol. 2009; 52:498–515. [PubMed: 19661764]
42. Beck CT. Revision of the postpartum depression predictors inventory. J Obstet Gynecol Neonatal Nurs. 2002; 31:394–402.
43. Robertson E, Grace S, Wallington T, et al. Antenatal risk factors for postpartum depression: a synthesis of recent literature. Gen Hosp Psychiatry. 2004; 26:289–295. [PubMed: 15234824]
44. Verdoux H, Sutter AL, Glatigny-Dallay E, et al. Obstetrical complications and the development of postpartum depressive symptoms: a prospective survey of the MATQUID cohort. Acta Psychiatr Scand. 2002; 106:212–219. [PubMed: 12197859]
45. Josefsson A, Angelsioo L, Berg G, et al. Obstetric, somatic, and demographic risk factors for postpartum depressive symptoms. Obstet Gynecol. 2002; 99:223–228. [PubMed: 11814501]
46. Blom EA, Jansen PW, Verhulst FC, et al. Perinatal complications increase the risk of postpartum depression. The Generation R Study. BJOG. 2010; 117:1390–1398. [PubMed: 20682022]
47. Vigod SN, Villegas L, Dennis CL, et al. Prevalence and risk factors for postpartum depression among women with preterm and low-birth-weight infants: a systematic review. BJOG. 2010; 117:540–550. [PubMed: 20121831]

48. Murray L, Stanley C, Hooper R, et al. The role of infant factors in postnatal depression and mother–infant interactions. Dev Med Child Neurol. 1996; 38:109–119. [PubMed: 8603778]
49. Nestler EJ, Barrot M, DiLeone RJ, et al. Neurobiology of depression. Neuron. 2002; 34:13–25. [PubMed: 11931738]
50. Duffy A, Grof P, Robertson C, et al. The implications of genetics studies of major mood disorders for clinical practice. J Clin Psychiatry. 2000; 61:630–637. [PubMed: 11030482]
51. Bodnar LM, Wisner KL. Nutrition and depression: implications for improving mental health among childbearing-aged women. Biol Psychiatry. 2005; 58:679–685. [PubMed: 16040007]
52. Caspi A, Hariri AR, Holmes A, et al. Genetic sensitivity to the environment: the case of the serotonin transporter gene and its implications for studying complex diseases and traits. Am J Psychiatry. 2010; 167:509–527. [PubMed: 20231323]
53. Hosli I, Zanetti-Daellenbach R, Holzgreve W, et al. Role of omega 3-fatty acids and multivitamins in gestation. J Perinat Med. 2007; 35(Suppl 1):S19–S24. [PubMed: 17302536]
54. Hibbeln JR. Seafood consumption, the DHA content of mothers' milk and prevalence rates of postpartum depression: a cross-national, ecological analysis. J Affect Disord. 2002; 69:15–29. [PubMed: 12103448]
55. De Vriese SR, Christophe AB, Maes M. Lowered serum n-3 polyunsaturated fatty acid (PUFA) levels predict the occurrence of postpartum depression: further evidence that lowered n-PUFAs are related to major depression. Life Sci. 2003; 73:3181–3187. [PubMed: 14561523]
56. Otto SJ, de Groot RH, Hornstra G. Increased risk of postpartum depressive symptoms is associated with slower normalization after pregnancy of the functional docosahexaenoic acid status. Prostaglandins Leukot Essent Fatty Acids. 2003; 69:237–243. [PubMed: 12907133]
57. Widen E, Siega-Riz AM. Prenatal nutrition: a practical guide for assessment and counseling. J Midwifery Womens Health. 2010; 55:540–549. [PubMed: 20974416]
58. Lesch KP, Bengel D, Heils A, et al. Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. Science. 1996; 274:1527–1531. [PubMed: 8929413]
59. Hoefgen B, Schulze TG, Ohlraun S, et al. The power of sample size and homogenous sampling: association between the 5-HTTLPR serotonin transporter polymorphism and major depressive disorder. Biol Psychiatry. 2005; 57:247–251. [PubMed: 15691525]
60. Caspi A, Sugden K, Moffitt TE, et al. Influence of life stress on depression: moderation by a polymorphism in the 5-HTT gene. Science. 2003; 301:386–389. [PubMed: 12869766]
61. Risch N, Herrell R, Lehner T, et al. Interaction between the serotonin transporter gene (5-HTTLPR), stressful life events, and risk of depression: a meta-analysis. JAMA. 2009; 301:2462–2471. [PubMed: 19531786]
62. Lotrich FE, Lenze E. Gene–environment interactions and depression. JAMA. 2009; 302:1859–1860. author reply 1861–1862.
63. Koenen KC, Galea S. Gene–environment interactions and depression. JAMA. 2009; 302:1859. author reply 1861–1862.
64. Rutter M, Thapar A, Pickles A. Gene–environment interactions: biologically valid pathway or artifact? Arch Gen Psychiatry. 2009; 66:1287–1289. [PubMed: 19996033]
65. Schwahn C, Grabe HJ. Gene–environment interactions and depression. JAMA. 2009; 302:1860–1861. author reply 1861–1862. [PubMed: 19887660]
66. Munafo MR, Durrant C, Lewis G, et al. Gene × environment interactions at the serotonin transporter locus. Biol Psychiatry. 2009; 65:211–219. [PubMed: 18691701]
67. Kaufman J, Gelernter J, Kaffman A, et al. Arguable assumptions, debatable conclusions. Biol Psychiatry. 2010; 67:e19–e20. author reply e1–e3. [PubMed: 20006323]
68. Karg K, Burmeister M, Shedden K, et al. The serotonin transporter promoter variant (5-HTTLPR), stress, and depression meta-analysis revisited: evidence of genetic moderation. Arch Gen Psychiatry. 2011; 68:444–454. [PubMed: 21199959]
69. Clarke H, Flint J, Attwood AS, et al. Association of the 5-HTTLPR genotype and unipolar depression: a meta-analysis. Psychol Med. 2010; 40:1767–1778. [PubMed: 20380781]

70. Kiyohara C, Yoshimasu K. Association between major depressive disorder and a functional polymorphism of the 5-hydroxytryptamine (serotonin) transporter gene: a meta-analysis. Psychiatr Genet. 2010; 20:49–58. [PubMed: 20016401]
71. Newport DJ, Owens MJ, Knight DL, et al. Alterations in platelet serotonin transporter binding in women with postpartum onset major depression. J Psychiatr Res. 2004; 38:467–473. [PubMed: 15380396]
72. Doornbos B, Dijck-Brouwer DA, Kema IP, et al. The development of peripartum depressive symptoms is associated with gene polymorphisms of MAOA, 5-HTT and COMT. Prog Neuropsychopharmacol Biol Psychiatry. 2009; 33:1250–1254. [PubMed: 19625011]
73. Maes M, Verkerk R, Bonaccorso S, et al. Depressive and anxiety symptoms in the early puerperium are related to increased degradation of tryptophan into kynurenine, a phenomenon which is related to immune activation. Life Sci. 2002; 71:1837–1848. [PubMed: 12175700]
74. Eley TC, Sugden K, Corsico A, et al. Gene–environment interaction analysis of serotonin system markers with adolescent depression. Mol Psychiatry. 2004; 9:908–915. [PubMed: 15241435]
75. Sjoberg RL, Nilsson KW, Nordquist N, et al. Development of depression: sex and the interaction between environment and a promoter polymorphism of the serotonin transporter gene. Int J Neuropsychopharmacol. 2006; 9:443–449. [PubMed: 16212676]
76. Brummett BH, Boyle SH, Siegler IC, et al. Effects of environmental stress and gender on associations among symptoms of depression and the serotonin transporter gene linked polymorphic region (5-HTTLPR). Behav Genet. 2008; 38:34–43. [PubMed: 17955359]
77. Sanjuan J, Martin-Santos R, Garcia-Esteve L, et al. Mood changes after delivery: role of the serotonin transporter gene. Br J Psychiatry. 2008; 193:383–388. [PubMed: 18978318]
78. Binder EB, Jeffrey Newport D, Zach EB, et al. A serotonin transporter gene polymorphism predicts peripartum depressive symptoms in an at-risk psychiatric cohort. J Psychiatr Res. 2010; 44:640–646. [PubMed: 20045118]
79. Mitchell C, Notterman D, Brooks-Gunn J, et al. Role of mother's genes and environment in postpartum depression. Proc Natl Acad Sci USA. 2011; 108:8189–8193. [PubMed: 21576482]
80. Gillespie NA, Whitfield JB, Williams B, et al. The relationship between stressful life events, the serotonin transporter (5-HTTLPR) genotype and major depression. Psychol Med. 2005; 35:101–111. [PubMed: 15842033]
81. Surtees PG, Wainwright NW, Willis-Owen SA, et al. Social adversity, the serotonin transporter (5-HTTLPR) polymorphism and major depressive disorder. Biol Psychiatry. 2006; 59:224–229. [PubMed: 16154545]
82. Genuis SJ, Schwalfenberg GK. Time for an oil check: the role of essential omega-3 fatty acids in maternal and pediatric health. J Perinatol. 2006; 26:359–365. [PubMed: 16688204]
83. Appleton KM, Rogers PJ, Ness AR. Updated systematic review and meta-analysis of the effects of n-3 long-chain polyunsaturated fatty acids on depressed mood. Am J Clin Nutr. 2010; 91:757–770. [PubMed: 20130098]
84. Lin PY, Su KP. A meta-analytic review of double-blind, placebo-controlled trials of antidepressant efficacy of omega-3 fatty acids. J Clin Psychiatry. 2007; 68:1056–1061. [PubMed: 17685742]
85. Sontrop J, Campbell MK. Omega-3 polyunsaturated fatty acids and depression: a review of the evidence and a methodological critique. Prev Med. 2006; 42:4–13. [PubMed: 16337677]
86. Simopoulos AP. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed Pharmacother. 2002; 56:365–379. [PubMed: 12442909]
87. Holman RT, Johnson SB, Ogburn PL. Deficiency of essential fatty acids and membrane fluidity during pregnancy and lactation. Proc Natl Acad Sci USA. 1991; 88:4835–4839. [PubMed: 2052562]
88. Puri BK. Cardiovascular disease and depression: the PUFA connection. Int J Clin Pract. 2008; 62:355–357. [PubMed: 18261068]
89. Severus WE, Littman AB, Stoll AL. Omega-3 fatty acids, homocysteine, and the increased risk of cardiovascular mortality in major depressive disorder. Harv Rev Psychiatry. 2001; 9:280–293. [PubMed: 11600487]

90. Amin AA, Menon RA, Reid KJ, et al. Acute coronary syndrome patients with depression have low blood cell membrane omega-3 fatty acid levels. Psychosom Med. 2008; 70:856–862. [PubMed: 18842751]
91. Frasure-Smith N, Lesperance F, Julien P. Major depression is associated with lower omega-3 fatty acid levels in patients with recent acute coronary syndromes. Biol Psychiatry. 2004; 55:891–896. [PubMed: 15110732]
92. Mosovich SA, Boone RT, Reichenberg A, et al. New insights into the link between cardiovascular disease and depression. Int J Clin Pract. 2008; 62:423–432. [PubMed: 18028386]
93. Schins A, Crijns HJ, Brummer RJ, et al. Altered omega-3 polyunsaturated fatty acid status in depressed post-myocardial infarction patients. Acta Psychiatr Scand. 2007; 115:35–40. [PubMed: 17201864]
94. Dinan TG. Inflammatory markers in depression. Curr Opin Psychiatry. 2009; 22:32–36. [PubMed: 19122532]
95. Licinio J, Wong ML. The role of inflammatory mediators in the biology of major depression: central nervous system cytokines modulate the biological substrate of depressive symptoms, regulate stress-responsive systems, and contribute to neurotoxicity and neuroprotection. Mol Psychiatry. 1999; 4:317–327. [PubMed: 10483047]
96. Miller AH, Maletic V, Raison CL. Inflammation and its discontents: the role of cytokines in the pathophysiology of major depression. Biol Psychiatry. 2009; 65:732–741. [PubMed: 19150053]
97. Raison CL, Capuron L, Miller AH. Cytokines sing the blues: inflammation and the pathogenesis of depression. Trends Immunol. 2006; 27:24–31. [PubMed: 16316783]
98. McNamara RK. Evaluation of docosahexaenoic acid deficiency as a preventable risk factor for recurrent affective disorders: current status, future directions, and dietary recommendations. Prostaglandins Leukot Essent Fatty Acids. 2009; 81:223–231. [PubMed: 19515544]
99. Young G, Conquer J. Omega-3 fatty acids and neuropsychiatric disorders. Reprod Nutr Dev. 2005; 45:1–28. [PubMed: 15865053]
100. Edwards R, Peet M, Shay J, et al. Omega-3 polyunsaturated fatty acid levels in the diet and in red blood cell membranes of depressed patients. J Affect Disord. 1998; 48:149–155. [PubMed: 9543204]
101. McNamara RK, Hahn CG, Jandacek R, et al. Selective deficits in the omega-3 fatty acid docosahexaenoic acid in the postmortem orbitofrontal cortex of patients with major depressive disorder. Biol Psychiatry. 2007; 62:17–24. [PubMed: 17188654]
102. Freeman MP. Omega-3 fatty acids and perinatal depression: a review of the literature and recommendations for future research. Prostaglandins Leukot Essent Fatty Acids. 2006; 75:291–297. [PubMed: 16930971]
103. Al MD, van Houwelingen AC, Kester AD, et al. Maternal essential fatty acid patterns during normal pregnancy and their relationship to the neonatal essential fatty acid status. Br J Nutr. 1995; 74:55–68. [PubMed: 7547829]
104. Maes M, Christophe A, Delanghe J, et al. Lowered omega3 polyunsaturated fatty acids in serum phospholipids and cholesteryl esters of depressed patients. Psychiatry Res. 1999; 85:275–291. [PubMed: 10333380]
105. Shelton RC, Osuntokun O, Heinloth AN, et al. Therapeutic options for treatment-resistant depression. CNS Drugs. 2010; 24:131–161. [PubMed: 20088620]
106. Lesa GM, Palfreyman M, Hall DH, et al. Long chain polyunsaturated fatty acids are required for efficient neurotransmission in C. elegans. J Cell Sci. 2003; 116:4965–4975. [PubMed: 14625390]
107. Freeman MP, Hibbeln JR, Wisner KL, et al. Omega-3 fatty acids: evidence basis for treatment and future research in psychiatry. J Clin Psychiatry. 2006; 67:1954–1967. [PubMed: 17194275]
108. Arab L. Biomarkers of fat and fatty acid intake. J Nutr. 2003; 133(Suppl 3):925S–932S. [PubMed: 12612178]
109. Innis SM. Perinatal biochemistry and physiology of long-chain polyunsaturated fatty acids. J Pediatr. 2003; 143:S1–S8.
110. Innis SM, Hansen JW. Plasma fatty acid responses, metabolic effects, and safety of microalgal and fungal oils rich in arachidonic and docosahexaenoic acids in healthy adults. Am J Clin Nutr. 1996; 64:159–167. [PubMed: 8694015]

111. McNamara RK, Carlson SE. Role of omega-3 fatty acids in brain development and function: potential implications for the pathogenesis and prevention of psychopathology. Prostaglandins Leukot Essent Fatty Acids. 2006; 75:329–349. [PubMed: 16949263]
112. Lin PY, Huang SY, Su KP. A meta-analytic review of polyunsaturated fatty acid compositions in patients with depression. Biol Psychiatry. 2010; 68:140–147. [PubMed: 20452573]
113. Edmond J, Higa TA, Korsak RA, et al. Fatty acid transport and utilization for the developing brain. J Neurochem. 1998; 70:1227–1234. [PubMed: 9489745]
114. Rapoport SI. In vivo fatty acid incorporation into brain phosholipids in relation to plasma availability, signal transduction and membrane remodeling. J Mol Neurosci. 2001; 16:243–261. discussion 279–284. [PubMed: 11478380]
115. Rapoport SI, Chang MC, Spector AA. Delivery and turnover of plasma-derived essential PUFAs in mammalian brain. J Lipid Res. 2001; 42:678–685. [PubMed: 11352974]
116. Wojcicki JM, Heyman MB. Maternal omega-3 fatty acid supplementation and risk for perinatal maternal depression. J Matern Fetal Neonatal Med. 2011; 24:680–686. [PubMed: 20925595]
117. Llorente AM, Jensen CL, Voigt RG, et al. Effect of maternal docosahexaenoic acid supplementation on postpartum depression and information processing. Am J Obstet Gynecol. 2003; 188:1348–1353. [PubMed: 12748510]
118. Moore SA, Yoder E, Murphy S, et al. Astrocytes, not neurons, produce docosahexaenoic acid (22:6 omega-3) and arachidonic acid (20:4 omega-6). J Neurochem. 1991; 56:518–524. [PubMed: 1824862]
119. Anderson GJ. Developmental sensitivity of the brain to dietary n-3 fatty acids. J Lipid Res. 1994; 35:105–111. [PubMed: 8138711]
120. Anderson GJ, Van Winkle S, Connor WE. Reversibility of the effects of dietary fish oil on the fatty acid composition of the brain and retina of growing chicks. Biochim Biophys Acta. 1992; 1126:237–246. [PubMed: 1627628]
121. Youdim KA, Martin A, Joseph JA. Essential fatty acids and the brain: possible health implications. Int J Dev Neurosci. 2000; 18:383–399. [PubMed: 10817922]
122. Levant B, Ozias MK, Carlson SE. Diet (n-3) polyunsaturated fatty acid content and parity interact to alter maternal rat brain phospholipid fatty acid composition. J Nutr. 2006; 136:2236–2242. [PubMed: 16857847]
123. Kris-Etherton PM, Taylor DS, Yu-Poth S, et al. Polyunsaturated fatty acids in the food chain in the United States. Am J Clin Nutr. 2000; 71:179S–188S. [PubMed: 10617969]
124. Innis SM, Elias SL. Intakes of essential n-6 and n-3 polyunsaturated fatty acids among pregnant Canadian women. Am J Clin Nutr. 2003; 77:473–478. [PubMed: 12540410]
125. Parra-Cabrera S, Stein AD, Wang M, et al. Dietary intakes of polyunsaturated fatty acids among pregnant Mexican women. Matern Child Nutr. 2011; 7:140–147. [PubMed: 21410881]
126. Kris-Etherton PM, Innis S, et al. American Dietetic Association. Position of the American Dietetic Association and Dietitians of Canada: dietary fatty acids. J Am Diet Assoc. 2007; 107:1599–1611. [PubMed: 17936958]
127. Lucas M, Asselin G, Plourde M, et al. n-3 Fatty acid intake from marine food products among Quebecers: comparison to worldwide recommendations. Public Health Nutr. 2010; 13:63–70. [PubMed: 19433004]
128. Otto SJ, van Houwelingen AC, Badart-Smook A, et al. Comparison of the peripartum and postpartum phospholipid polyunsaturated fatty acid profiles of lactating and nonlactating women. Am J Clin Nutr. 2001; 73:1074–1079. [PubMed: 11382662]
129. Makrides M, Gibson RA. Long-chain polyunsaturated fatty acid requirements during pregnancy and lactation. Am J Clin Nutr. 2000; 71:307S–311S. [PubMed: 10617987]
130. Innis SM. Human milk: maternal dietary lipids and infant development. Proc Nutr Soc. 2007; 66:397–404. [PubMed: 17637092]
131. Meneses F, Torres AG, Trugo NM. Essential and long-chain polyunsaturated fatty acid status and fatty acid composition of breast milk of lactating adolescents. Br J Nutr. 2008; 100:1029–1037. [PubMed: 18307833]
132. Glew RH, Wold RS, Corl B, et al. Low docosahexaenoic acid in the diet and milk of American Indian women in New Mexico. J Am Diet Assoc. 2011; 111:744–748. [PubMed: 21515123]

133. Glew RH, Wold RS, Herbein JH, et al. Low docosahexaenoic acid in the diet and milk of women in New Mexico. J Am Diet Assoc. 2008; 108:1693–1699. [PubMed: 18926136]

134. Harbottle L, Schonfelder N. Nutrition and depression: a review of the evidence. J Ment Health. 2008; 17:576–587.

135. Kaufman J, Yang BZ, Douglas-Palumberi H, et al. Social supports and serotonin transporter gene moderate depression in maltreated children. Proc Natl Acad Sci USA. 2004; 101:17316–17321. [PubMed: 15563601]

136. De Vriese SR, Christophe AB, Maes M. In humans, the seasonal variation in poly-unsaturated fatty acids is related to the seasonal variation in violent suicide and serotonergic markers of violent suicide. Prostaglandins Leukot Essent Fatty Acids. 2004; 71:13–18. [PubMed: 15172679]

137. Maes M, Scharpe S, Verkerk R, et al. Seasonal variation in plasma L-tryptophan availability in healthy volunteers. Relationships to violent suicide occurrence. Arch Gen Psychiatry. 1995; 52:937–946. [PubMed: 7487342]