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A systematic review of the effects of postnatal maternal anxiety on children

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Abstract

Several decades of research have focused on the impact of exposure to postnatal depression on children, while anxiety has been largely overlooked. Estimates of the prevalence of postnatal maternal anxiety (PMA) range from 3% to 43%, suggesting PMA may be an important risk factor for adverse outcomes in children. This review summarizes what is known about the effects of PMA exposure on children and makes recommendations for future research. A systematic search of Ovid MEDLINE® and PsychINFO® through 2008 identified 18 studies that evaluated child outcomes associated with PMA exposure. Identified studies covered three domains: somatic, developmental, and psychological outcomes. The strongest evidence for an adverse effect of PMA exposure is in somatic and psychological outcomes; the evidence for an effect of PMA on child development is inconclusive. Methodological differences among the studies make comparisons difficult and there are a number of common limitations that challenge the validity of these studies.

Keywords

Postnatal; Postpartum; Anxiety; Depression; Review; Child development

Introduction

Research suggests that postnatal maternal psychiatric problems are associated with disruption of maternal–child attachments, thereby increasing the risk of mental illness in the child (Dawson et al. 2000; McMahon et al. 2001; Nicol-Harper et al. 2007). The majority of research has focused on the effects of postnatal depression. Symptoms of anxiety during the postnatal time period have often been overlooked despite their ability to disrupt mother–child bonding and attachment formation (Barnett and Parker 1986; Dawson et al. 2000). Solely focusing on depression is problematic because anxiety symptoms and depression symptoms often co-occur and the presence of comorbidity is a marker of severity (Andrews et al. 2000; Masi et al. 2004). One study found that 16% of postpartum mothers had pure anxiety symptoms, while only 6% had pure depression; 4% of the sample had comorbid anxiety and depression (Matthey et al. 2003). Estimates of the prevalence of PMA range

from 3% (Wenzel et al. 2003) to 43% (Kuo et al. 2004). Thus, anxiety may be as significant a risk for adverse child outcomes as depression symptoms.

Recent attention to the importance of anxiety in the postnatal period has led some researchers to examine the prevalence, patterns, and impact of postnatal anxiety. However, the studies are few in number and have mixed results. The purpose of this review is to synthesize the current research on the effects of postnatal maternal anxiety (PMA) on children, highlighting the strengths and weaknesses of the literature and making recommendations for future research.

Methods

A combined Ovid MEDLINE® and PsycINFO® search was performed, covering 1950 through 2008. Search terms included *anxiety* or *stress*, *postnatal* or *postpartum*, and *maternal* or *mother(s)*. The database search was restricted to human research articles, written in English, and published in peer-reviewed journals. The database search was followed by a title review of the retrieved records. Titles were evaluated against the following exclusion criteria: animal research; studies that examined prevalence or course only; articles that focused on maternal effects and not child outcomes; and studies that did not assess anxiety during the postnatal period. The title search was conservative; if the title did not obviously violate one of the exclusion criteria, it was retained for the abstract review. The exclusion criteria that were used with the title review were also utilized in the abstract examination, with one addition: reviews and commentaries were removed and their reference lists evaluated for additional studies. Finally, the article texts were evaluated to ensure that they met the previous criteria.

The database search identified 1,531 articles using the terms “anxiety” or “stress”, “postpartum” or “postnatal”, and “maternal” or “mother(s)”. This number was reduced to 539 after the database restrictions were applied. Evaluation of the titles according to the exclusion criteria further decreased this to 162 articles. The abstract review identified 29 articles for potential inclusion and two review articles to check for additional references. No additional publications were identified through examination of the reference lists. Evaluation of the articles’ text reduced the 29 articles to 18. Because the prior steps were conservative (if the titles and abstracts did not specify a violation of the review criteria, they were retained), several articles that did not meet the review criteria were retained until the text review because the titles and abstracts were not specific enough to judge for inclusion. Seven articles were excluded because they did not evaluate the impact of PMA symptoms on child outcomes. Four additional articles were excluded because they reported on composite measures of “distress” during the postnatal periods, which made it impossible to isolate the effects of PMA from other forms of distress, such as depression symptoms.

Results

Search findings

Table 1 provides an overview of study characteristics of the articles included in this review. Eighteen articles represented 14 studies; 12 examined separate study populations, while six reported on different analyses of the same cohort (three on one cohort and three on another). Most studies were prospective cohort studies, seven were cross-sectional analyses, and one was a nested case-control study (a case-control analysis based on data from a cohort study). The majority of studies involved community-based samples of healthy mother–infant dyads without pregnancy complications. One study contained a clinical sample as well as a demographically matched sample of community-based women. Studies had a wide range of sample sizes, ranging from 22 to 8,272 mother–infant pairs (median = 102 pairs). The

reported mean maternal ages ranged from 21 to 35 years, although several studies did not report data on maternal age.

A number of different measures were used to evaluate PMA including open interviews and several self-report scales. The most frequently used self-report measure was the State Trait Anxiety Inventory (STAI) (Spielberger 1977; Spielberger et al. 1983). The STAI provides a measure of two anxiety factors: trait anxiety, which measures the more stable, overall level of anxiety a person experiences, and state anxiety, which evaluates the more transient anxiety caused by situational factors. The STAI has acceptable reliability and established validity and is one of the most commonly used measures of anxiety symptoms (Barnes et al. 2002). All of the studies utilized symptom assessments as their measure of exposure. Structured psychiatric interviews were not used to assess anxiety disorders. Anxiety disorders, such as social phobia, panic disorder, generalized anxiety disorder, and obsessive compulsive disorder, are a heterogeneous group of psychiatric illnesses brought together by the common symptom of anxiety. Elevated anxiety is not sufficient to meet clinical diagnostic criteria. Each anxiety disorder has a number of other relevant features that must be present to be considered a psychiatric disorder, as well as duration criteria and functional impairment. Thus, studies using anxiety symptom assessments cannot be generalized to the effects of postpartum maternal anxiety disorders on children, which may be qualitatively different or more severe. The field, thus far, has relied on symptom assessments for assessing PMA and it is reasonable to infer that symptom assessments, while lacking specificity, have acceptable sensitivity for capturing clinical and subclinical anxiety levels.

The identified studies examined a number of different child outcomes, which can be considered as three different domains: somatic, developmental, and psychological. Four studies examined somatic outcomes, including: infant colic (Akman et al. 2006; Carey 1963), feeding refusal (Coulthard and Harris 2003), and childhood recurrent abdominal pain (RAP) (Ramchandani et al. 2006). The three developmental outcome-based articles examined developmental delay at 12 months (Slykerman et al. 2007), cognitive development (Galler et al. 2000), and scores on a standardized scholastic exam (Galler et al. 2004b). Eleven studies examined psychological outcomes including: infant emotional tone during mother–infant interactions (Nicol-Harper et al. 2007), psychological problems (Barnett et al. 1991; O'Connor et al. 2002, 2003), and temperament (Coplan et al. 2005; Davis et al. 2004; Diener et al. 1995; Galler et al. 2004a; McMahon et al. 2001; Pesonen et al. 2005; Susman et al. 2001). The children's ages depended on the outcome examined; assessments were performed from a week after birth through 6.5 years for somatic outcomes, between 3 months and 11 years for developmental outcomes, and between 3 months and 6.5 years for psychological outcomes.

Study results

a) Somatic Outcomes—Two studies were identified that evaluated the association between PMA and infant colic. The earliest was in 1963 by the obstetrician William Carey, which was a cross-sectional analysis of 103 of his patients (Carey 1963). No other demographic data were reported. Anxiety symptoms were assessed by clinical interview. Colic was defined as periods of irritability, fussing or crying for more than 3 h a day at least three times a week. Chi-square analysis suggested that anxiety was more common in mothers of colicky children. The study contained several limitations putting into question the validity of the results. Anxiety and colic were both evaluated by one unmasked researcher, potentially biasing the assessment. Furthermore, all participants were recruited from a single clinical practice, introducing concerns of selection bias and limiting generalizability. In addition, no confounding variables were examined.

Akman et al. (2006) conducted a replication of the Carey study. This nested case-control analysis (a case-control analysis performed retrospectively on data obtained in a cohort study) reported on 78 healthy mother–infant dyads. Anxiety was assessed using the STAI during the first postnatal month. Infantile colic was defined in the same manner as in Carey’s study, with the exception that the assessment was masked, and physical examinations of the infants were performed to ensure that fussiness was not due to a medical condition. The median trait anxiety score and the median STAI total were higher among mothers of colicky infants, but the difference was not statistically significant. However, this study involved a small sample of women, which may have lead to a lack of sufficient power to detect an association. Furthermore, anxiety was assessed at only one time point, which may not be representative of the mothers’ overall anxiety during this period.

Coulthard and Harris (2003) reported on a prospective study examining the association between maternal mood and food refusal at 11 months postpartum. Mothers were primiparous with low-risk pregnancies, who gave birth to healthy singleton infants. Anxiety was measured using the STAI at 1, 5, and 11 months postpartum. Food refusal was measured using a study-specific scale. An episode of food refusal had to occur at least once a day for a month or longer to qualify as a feeding refusal period. During the study period, 54 of the 106 infants experienced a period of food refusal. There was no significant association between PMA and food refusal. However, when the researchers examined whether the food refusal period had resolved, they found that maternal state anxiety at both 1 and 11 months was related to unresolved food refusal at 11 months. Maternal trait anxiety was not significantly associated with unresolved food refusal at 11 months. The duration of food refusal was not related to PMA.

These inconsistent results make drawing conclusions difficult, particularly as no replication has been performed. Neither the occurrence of food refusal, nor the duration of food refusal, was associated with anxiety. However, state anxiety at two of the three time points was associated with having unresolved food refusal at 11 months postpartum. It is possible that the association between 11-month state anxiety and 11-month unresolved food refusal is reflecting the increased stress the mother is under due to having an infant with an unresolved food issue. If this is the case, it is likely that the 1-month association of PMA with unresolved food refusal is a statistical anomaly due to the number of uncontrolled comparisons. This is in line with the finding that duration of food refusal was not related to anxiety, nor was trait anxiety related to any aspect of food refusal.

The most recent study of somatic outcomes was reported by Ramchandani et al. (2006) who evaluated PMA and the occurrence of RAP in 6.5 year old children. Not only is this the only study of PMA and RAP, it is the oldest population in which somatic complaints were evaluated. The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective population-based cohort of approximately 13,000 women recruited during the prenatal period. It was designed to evaluate pre- and postnatal factors that may influence child development. Ramchandani et al. (2006) evaluated exposure to a number of maternal factors including anxiety. This analysis included 8,272 mother–child pairs who had been followed for almost 7 years to determine if PMA is associated with RAP.

Maternal anxiety was measured between 6 and 8 months postpartum using the self-reported general anxiety subscale of the Crown-Crisp index (Birtchnell et al. 1988). Mothers in the top 15% of scores were considered “anxious” based upon previous ALSPAC reports. Recurrent abdominal pain was based on parental report of the child seeming to have stomach pain in the previous 12 months, followed by how frequently this occurred. Five or more times of stomach pain in the past year was considered RAP. Six-month PMA was associated with RAP, after controlling for potential confounders. Chi-square tests for an

increasing linear trend of PMA over time were also significant, with higher levels of PMA associated with increasing risk for RAP (Ramchandani et al. 2006).

Results of this study must be considered preliminary due to the lack of replication. However, several factors point toward the validity of these results. First, the test for trend was strong (Chi-square=90.86, df=3), suggesting a dose-response relationship. Second, the use of a population-based cohort helps avoid selection bias and improves generalizability. Finally, the observation of this association 6 years after exposure is particularly compelling, highlighting the need for replication and expansion on this topic.

b) Developmental outcomes—Three studies examined developmental and cognitive delay. Slykerman et al. (2007) evaluated 12-month development among small-for-gestational age (SGA) and normal size infants. At 12 months postpartum, mothers were administered the Perceived Stress Scale (PSS) (Cohen et al. 1983), which examines maternal perceptions of stress during the past month. Mothers were categorized as high stress if they were in the top 25% of the distribution. Developmental delay was reported by parents, using the Revised Denver Prescreening Developmental Questionnaire (R-PDQ) (Frankenburg et al. 1987), which assesses 22 developmental milestones. A child who had not met a milestone that 90% of the other children had met at the same age was considered delayed. In both the SGA and normal groups, 12-month perceived stress was not associated with developmental delay. One concern when interpreting this study, in the context of PMA, is the use of the PSS. Perceived stress is not equivalent to anxiety, although the two are correlated. Anxiety is one of several possible reactions to stress (Morissette et al. 2007). Thus, stress is an inexact proxy for anxiety.

Two cognitive-based developmental outcomes were evaluated. The first was an analysis of a prospective population-based cohort of Barbados women and children (Galler et al. 2000). Three of the reports presented in this review were based upon the Barbados study, which was designed to examine the effect of postpartum maternal moods on various child and parent outcomes. In 1986, this longitudinal study recruited every other healthy mother–infant dyad over a 2-month period from the hospital in Barbados that handles 99% of all births. Galler et al. (2000) examined cognitive development in the Barbados study. This analysis included 92 of the original 226 mother–infant dyads; no reasons were given for the reduced sample size. Anxiety was measured using the Zung Anxiety Scale (ZAS), previously validated in developing countries (Zung 1971), at 7 weeks and 6 months postpartum. Infant developmental progress was measured at 3 months using the Griffiths Mental Development Scale, which includes five subscales: motor development, personal-social development, hearing and speech, hand-eye coordination, and performance (Griffiths 1954). The practical reasoning subscale was not included because it was not age appropriate. The Total Griffiths score was significantly associated with PMA exposure. This difference was related solely to the significant association between PMA and personal-social development. Infants exposed to PMA had poorer personal-social development. No other subscale was correlated with PMA. This study has a number of strengths, including being a population-based cohort, controlling for a number of potential confounding variables, and measuring exposure and outcome prospectively. While the Griffiths Scale measures a number of factors, only personal-social development was significant. This may indicate a precursor to later adverse psychological outcomes. The lack of an association found with the other subscales may represent a true null association. Alternatively, it is possible that alterations in development due to PMA are too subtle to be detected in this age group.

The second cognitively-based outcome report was also from the Barbados cohort (Galler et al. 2004b). The study included 169 mother–infant dyads from the original sample. It presented data from an analysis that examined PMA and later scores on the standardized

school common entrance exam (CEE) administered to all 11-year-old children in Barbados. The CEE consists of 140 English questions, 80 mathematics questions, and an essay. After controlling for potential confounders, the ZAS score at 7 weeks postpartum was associated with significantly lower English scores and lower total CEE scores. PMA at 6 months was not associated with the CEE score. However, both 7-week and 6-month PMA demonstrated a negative linear relationship when English scores were plotted as a function of PMA distribution (significance not reported). As no other studies have evaluated a similar outcome as CEE exam scores (such as IQ, etc.), drawing conclusions is difficult, particularly because of the inconsistencies within the study itself. While the English scores are suggestive of poorer development associated with PMA at 7 weeks, the lack of statistical significance with 6-month PMA makes results questionable. It is possible that only early anxiety exposure is important to this outcome or the significant association may be spurious. It is also possible that the sample size is too small to identify a significant association.

c) Psychological outcomes—Eleven studies evaluated psychological outcomes. One study evaluated infant emotional tone (Nicol-Harper et al. 2007), two reported on behavioral and emotional problems at ages 4 and 6.5 (O'Connor et al. 2002, 2003), one study evaluated child psychopathology at 5 years (Barnett et al. 1991), and seven studies evaluated child temperament in ages ranging from 3 months to 3 years (Coplan et al. 2005; Davis et al. 2004; Diener et al. 1995; Galler et al. 2004a; McMahon et al. 2001; Pesonen et al. 2005; Susman et al. 2001).

Nicol-Harper et al. (2007) performed a cross-sectional analysis of 64 mother–child pairs. Mothers were categorized as either high ($n=32$) or low ($n=32$) trait anxious based on the STAI. Assessment of mother–child interactions was done in the home and consisted of videotaping mothers playing with their children using a predetermined sequence of toys. Videotapes were coded for infant emotional tone, described as “a behavioral measure of infant positive emotion” (Nicol-Harper et al. 2007, p. 163). Infant emotional tone was not significantly different between high and low anxiety-exposed infants. In an attempt to control for the influence of postnatal depression, the authors performed a subsample analysis of women who scored below their respective medians on the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al. 1987). The subsample included high anxious women who scored below 8.5 on the EPDS and low anxious women who scored below a 3 on the EPDS. No differences in emotional tone were found in this analysis. While this was one of the few studies that attempted to control for depression, the use of different stratification levels on the EPDS does not lead to similar depression levels between groups. Furthermore, with the small number of participants in the subsamples, the secondary analysis is underpowered.

Two articles presented reports on behavioral and emotional problems in children. Both were reports from the ALSPAC study, previously described. PMA was evaluated using the Crown-Crisp anxiety subscale at 8 weeks postpartum. Psychological problems were assessed first in 4-year-olds (O'Connor et al. 2002), then at 6.5 years (O'Connor et al. 2003) using the Strengths and Difficulties Questionnaire (SDQ), which measures conduct problems, emotional problems, and hyperactivity/inattention (Goodman and Scott 1999). For the 4-year follow-up report, 8-week PMA exposure was associated with an increased risk of emotional problems in boys and girls and conduct problems in 4-year-old girls. There was no significant association between PMA and hyperactivity/inattention. At the 6.5-year follow-up, a similar pattern was found. Risk of emotional problems was higher in boys exposed to PMA and conduct problems were more likely among girls exposed to PMA. Again, there was no significant association with hyperactivity/inattention. Unlike the 4-year follow-up, emotional problems in 6.5-year-old girls were not significantly associated with PMA.

The consistent finding across the two age groups supports the validity of the ALSPAC findings, as does their use of a population-based prospectively recruited sample. This is further supported by the findings of Barnett et al. (1991), who examined child psychopathology in 5-year-old children. This Australian prospective cohort/intervention study was an evaluation of an intervention program to address PMA. However, their inclusion of a non-anxious control group provides a prospective cohort-like evaluation. The study used the STAI to measure trait anxiety. High anxiety women received support for the first 12 months postpartum. At year 5, mothers and children were assessed for a number of outcomes including child behavior problems using the Child Behavior Checklist (CBCL) (Achenbach 1991a) and Teacher Report Form (TRF) (Achenbach 1991b) as reported by parents and teachers, respectively. At 5 years, parental ratings on the CBCL were related to PMA. Children exposed to PMA were rated as less active and lower in social competence than unexposed children. Boys exposed to PMA were also rated as more immature, delinquent, and schizoid than their unexposed counterparts. By contrast, TRF scores did not indicate any difference between PMA-exposed children and those unexposed. It is possible that maternal anxiety levels biased the mothers' ratings of their children. The majority of studies have relied on maternal reporting of child outcomes without obtaining ratings by other informants. However, it may be that PMA affects behaviors in ways that are more evident in the home environment than at school.

By far, the most thoroughly evaluated outcome has been temperament. These studies have evaluated temperament in a broad range of ages. The youngest age assessed has been 3-month-olds. In 2005, Coplan et al. reported on a prospective study in Ontario, Canada. Although this was a prospective study, assessments were done in the third trimester and 3 months postpartum; therefore the postpartum assessment was cross-sectional. Anxiety was measured using the STAI. Infant temperament was examined using the Infant Behavior Questionnaire (IBQ) (Rothbart 1981). The IBQ measures seven subscales: attention span, activity level, distress to novelty, distress to limitations, soothability, and positive affect. Initial evaluation of correlations between PMA and temperament found that postnatal state anxiety was associated with higher activity level and more distress to limitations. Postnatal trait anxiety was associated with more distress to limitations and lower soothability. Linear regression analysis found that after controlling for levels of trait anxiety, state anxiety was still significantly associated with higher activity levels, but not with distress to limitations. This suggests that the more stable trait anxiety was more important to distress to limitations (Coplan et al. 2005).

Findings of the Coplan study were cross-sectional, however, and the use of mothers' reports of temperament may have biased the assessment. This is of particular concern because another cross-sectional study performed in the U.S. found no association between PMA and temperament (Diener et al. 1995). Similar to the Canadian study, PMA was assessed using the STAI at 3 months postpartum. Unlike the Canadian study, Diener et al. (1995) measured infant temperament using the Bates Infant Characteristics Questionnaire (ICQ) (Bates et al. 1979). The ICQ measures four temperament traits: fussy, unadaptable, unpredictable, and dull. At 3 months postpartum, perceived temperament was not associated with maternal STAI scores.

Studies in infants at 4 months of age are likewise contradictory. A cross-sectional analysis by McMahon et al. (2001) examined the correlation between 4-month PMA and temperament in a sample of women admitted to a residential care unit of a Parentcraft Hospital in Australia and a community-based sample of women. This was the only study to include a clinical sample. PMA was examined using the STAI. State and trait anxiety were significantly higher in the residential care group. Child temperament was assessed with the Short Temperament Scale for Infants (STSI) (Oberklaid et al. 1986), designed to examine

mothers' appraisals of their infants' temperament. The STSI has five established factors: approach, rhythmicity, cooperation–manageability, activity–reactivity, and irritability. An overall infant difficulty score is also calculated. To examine the influence of maternal psychiatric symptoms on child temperament ratings, McMahon et al. (2001) compared father's and mother's ratings. There was a high level of agreement between the two ratings, which was stronger for the residential care group than the community group. While this helps to support the cross-sectional conclusions, it does not eliminate the temporality problem. It may be that more difficult children produce higher levels of anxiety in their parents. A prospective cohort study in the U.S. suggests this might be the case.

Davis et al. (2004) reported on the longitudinal results of the effect of maternal psychological states in pregnancy and the early postpartum on temperament at 4 months of age. The sample was recruited from a group of low-risk pregnancies seen at a hospital clinic. Anxiety was measured at 8 weeks postpartum using the STAI. Temperament was assessed at 4 months using video tapes of infant behavior, coded by masked raters using an established protocol known as the Harvard Infant Behavioral Reactivity Protocol, which measures activity and fussiness (Kagan and Snidman 1991). No association was found between 8-week PMA and 4-month activity or fussiness. One concern with this study is the small sample size ($n=22$). It may be underpowered to detect a statistical association between PMA and temperament. Also, anxiety was only measured at a single time point and may not be representative of the anxiety levels overall during the postnatal period.

Two studies evaluated temperament in 6-month-old infants. Galler et al. (2004a) reported on the Barbados cohort, previously described. Exposure to PMA was measured using the ZAS (Zung 1971) and infant temperament was measured at 6 months using the Carey-Revised Infant Temperament Questionnaire (RITQ) (Carey and McDevitt 1978). The RITQ assesses nine domains of infant temperament: mood, intensity, adaptability, approach, activity level, rhythmicity, persistence, distractibility, and sensory threshold. It also provides an overall infant difficulty score. In addition to using the traditional factor structure of the RITQ, the researchers performed a principal component factor (PCF) analysis in an attempt to adjust for "possible cultural biases" (Galler et al. 2004a, p. 271). This identified 12 factors: outgoing engagement, unpredictability, reactivity, irregularity, adaptability, internal locus of control, soothability, emotional intensity, cooperativeness, preference for consistency, resistance to change, and persistence. Maternal PMA at 7 weeks was significantly associated with temperament at 6 months before controlling for potential confounders. The association was attenuated once these factors were taken into account. The cross-sectional 6-month analysis, however, was significant before and after controlling for confounders. Subscale analysis using the original RITQ subscales found that PMA was associated with lower adaptability, poorer mood, and higher sensory threshold. Evaluation of the 12-factor structure found significant associations with every factor except outgoing engagement, adaptability, and cooperation. Inspection of the questions included in each factor after the PCF analysis suggested that not all items in each factor held a unifying theme, suggesting that the 12-factor solution was not necessarily appropriate.

Pesonen et al. (2005) reported on the results of a cross-sectional analysis of maternal perceived stress and temperament in 6-month-old Finnish infants. In this study, maternal stress was measured using the PSS and temperament was measured by the IBQ. Perceived stress at 6 months postpartum was associated with distress to limitations, fear, negative reactivity, and smiling/laughter. Perceived stress was not associated with activity, positive reactivity, or overall reactivity.

While the use of different outcome measures makes direct comparisons difficult, results suggest that temperament at 6 months is related to PMA exposure. The association with

negative reactivity and smiling/laughter in the Pesonen et al. (2005) study is similar to the finding of poorer mood in the Galler and Harrison (Galler et al. 2004a) study. Similarly, the null relationship between stress and activity, positive reactivity, and overall reactivity in the Finland study (Pesonen et al. 2005) is similar to the null findings in the Galler and Harrison (Galler et al. 2004a) study regarding outgoing engagement.

Only one study evaluated child temperament beyond the infancy period. Susman et al. (2001) reported on a prospective cohort study of 67 primiparous women recruited during pregnancy. Women had to be less than 20 years of age at the expected time of delivery. This study measured anxiety using the STAI. Child temperament was assessed at 3 years of age using the Children's Behavior Questionnaire (CBQ) (Rothbart et al. 2001). The CBQ was completed by parents, while reactivity and regulation was assessed using a videotape of child behavior and coded using a standardized scheme. No significant association was detected between high, medium, or low postnatal STAI scores and child temperament.

Discussion

While there is some evidence that PMA exposure may lead to adverse outcomes, the evidence is far from conclusive. Results suggest that somatic complaints such as colic and recurrent abdominal pain may be related to PMA; however, the limited number of studies makes this an unreliable conclusion. Conclusions regarding behavioural problems and child psychopathology, which has the most conclusive evidence for adverse outcomes related to PMA, are also weakened by the small number of studies. While only three studies have examined PMA with behavioural problems and child psychopathology, two of which examined the same cohort, there is a strong methodology used in these studies. The ALSPAC study in England recruited over 7,000 women from the community from 1991 to 1992 (O'Connor et al. 2002, 2003). Reports at both the 4- and 6.5-year follow-ups found PMA to be associated with alterations in emotional and conduct problems, but not with hyperactivity. Their recruitment began during the prenatal period, thus they were able to control for antenatal anxiety exposure, which may have biological effects on fetal HPA-axis development (de Weerth and Buitelaar 2005; Seckl and Holmes 2007). They were also able to control for the high depression/anxiety comorbidity, unlike the majority of other studies (Matthey et al. 2003). Furthermore, similar findings by Barnett et al. (1991), who recruited Australian women and utilized a well-established outcome measure (the CBCL), further supports the idea that PMA exposure is related to adverse psychological problems in children.

Cognitive and developmental outcomes have only been examined in a few studies, and the results have been inconsistent. Interpretation is made more difficult by the use of different outcome measures, administered at different ages. While there is some evidence that cognitive and social developments are affected negatively by PMA exposure, future research is needed to draw more firm conclusions.

Infant temperament has been the most frequently evaluated outcome. However, assessment at different ages and the use of different exposure and outcome measures have made the studies incomparable. There is as much evidence that some aspects of temperament are associated with PMA exposure as there is evidence that there is no association with PMA. Moreover, the frequent use of cross-sectional designs, failure to control for confounders, such as depression during pregnancy and the postnatal period and anxiety during the antenatal period, make these study results inconclusive.

Conclusion

There is a fair amount of evidence that exposure to PMA may have negative effects on somatic and psychological outcomes in children. However, the current research has a number of methodological limitations that need to be considered in future studies. Future research should address the five following areas to increase the validity of the results: 1) use of longitudinal analytic methods, 2) consistency and validity in exposure assessment, 3) consistency in outcome assessment, 4) control of confounders, and 5) use of multiple informant information. Given the complexity and expense of longitudinal studies, it is imperative that prospective designs capture the best quality data and analyze it in the most appropriate ways. When longitudinal data are available, analyses should take time into account. Analytic methods such as survival analysis, modeling with time-dependent covariates, structural equation modeling, repeated measure analysis, and trajectory methods such as semi-parametric group-based analysis (SGA) (Nagin 1999) and growth mixture modeling (GMM) (Muthén 2004) should be considered. Use of these modeling techniques will allow a more accurate assessment of the typical patterns of anxiety that children may be exposed to, and assist in determining which exposures are of concern.

Consistency and validity in the exposure assessment is needed in the measures that are used, as well as in the timing of the assessment. Exposure during the first postnatal week may have a very different impact than exposure 6 months after delivery; sampling methods, sample size, and statistical analyses must be adequate to examine differences in the timing of exposures. The majority of studies did not evaluate the length of anxiety symptoms, nor did they control for exposure beyond the immediate postnatal period. Analyses of maternal anxiety, based upon symptom scales, should not be limited to a single cross-sectional assessment. Chronic anxiety is more likely to interfere with mother–infant bonding (Dawson et al. 2000) than occasional elevations in anxiety. Thus, utilizing methods that can detect those with chronically higher anxiety levels will improve exposure specificity. For example, the use of SGA and GMM permits the evaluation of trajectories of symptoms and the identification of individuals with repeatedly high anxiety. SGA and GMM methods also eliminate the tendency to choose cut-off scores for a continuous scale, as they allow for the evaluation of continuous data, which is more informative than dichotomizing a scale. As there is no standardized cutoff for the STAI, many of the current studies chose cut-points based upon the distribution of scores in their sample, making it difficult to compare across studies.

A further concern is the validity of the exposure assessments used. While the STAI has been widely used, its validity in pregnant and postpartum populations has not been tested. When using scales developed for different populations, validity and reliability become a concern and need to be evaluated in the study population. For example, studies using the PSS may inflate the exposure assessment and create a ceiling effect because the postnatal period is filled with many new stresses related to the birth of a baby and it is likely that all women would have elevated scores. This problem is in addition to not being able to differentiate anxiety from other stress reactions.

The question of exposure validity is complicated by the difficulty in distinguishing anxiety and depression using existing scales. For instance, the Edinburgh Postnatal Depression Scale has an anxiety subscale consisting of three items. However, these items are better at detecting depression in a screening situation than the entire scale and do not correlate well with other anxiety measures, suggesting that discriminant validity is a problem (Brouwers et al. 2001; Kabir et al. 2008). This complicates being able to differentiate the effects of anxiety versus depression. One recent attempt to address this measurement issue was the development of the Inventory of Depression and Anxiety Symptoms (IDAS), which has also

been validated and performs well in postpartum women (Watson et al. 2007). Future studies should utilize measures validated in postpartum women that can distinguish depression and anxiety symptoms. A thorough review and evaluation of anxiety measures is beyond the scope of this review. For further information, the reader is referred to Ayers (2001) for an evaluation of different measures for anxiety, depression, and stress in pregnancy and the postnatal period.

Consistency in the outcome assessment is also a concern. While consistent results among multiple methods can strengthen the validity of conclusions, the outcomes studied must also be comparable. This was particularly evident with the evaluation of infant temperament, where even when the same outcome measure was used, different factor structures were reported, different ages were evaluated, and subscale analyses were not always reported. While seven studies examined temperament, it was impossible to draw any conclusions based upon the data because of the variation in outcome assessment and study designs.

The control of potential confounders is a significant problem in the studies evaluated here. Only the ALSPAC studies controlled for relevant environmental, social, and psychological factors. While other studies controlled for some background variables, such as parity or maternal age and socioeconomic status, only ALSPAC controlled for pre- and postnatal depression and prenatal anxiety exposure. As mentioned previously, depression and anxiety are highly comorbid and postnatal psychiatric symptoms are usually preceded by prenatal symptoms (Heron et al. 2004). Unfortunately, none of the studies analyzed the impact of co-occurring postnatal anxiety and depression exposure to determine if a differential effect was evident due to higher symptom exposure. Future research needs to evaluate both depression and anxiety symptoms and use sampling methods and statistical analyses that will enable differentiating anxiety effects, depression effects, and co-occurring anxiety and depression effects on children.

Both diversity and consistency in the outcome assessment is also important. With respect to diversity, multiple assessments from multiple perspectives are important. Teachers, parents, and researchers each have a unique view of the child in each setting. In the studies identified, there were a number of assessment perspectives including teacher, independent researcher, and maternal and paternal reports. This needs to be continued in future research. Finally, it is important to validate the reports of child outcomes, particularly when utilizing a cross-sectional design and when the mothers are rating the child. Current psychological symptoms may lead to more negative interpretation of children's behaviors, thus biasing results to seem more strongly associated with PMA. As parents are heavily influenced by each other's attitudes, it is advisable to obtain outside validation whenever possible.

Expanding upon the current literature and improving the methodological rigor of such studies will enable a better understanding of the effects of PMA on children. Ideally, this will lead to better identification of at-risk children and points for prevention.

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Table 1

Summary of studies examining exposure to postnatal maternal anxiety symptoms and child outcomes

Study, location, and design	Measures	Participants	Primary results	Main limitations
Somatic outcomes				
1. Carey (1963) Location not reported Cross-sectional	Anxiety—clinical interview Infant colic—paroxysms of irritability, fussing, or crying in a healthy, well-fed infant occurring for >3 h a day and ≥ 3 days in any 1 week in infants under 4 months old	Recruited from one physician's private practice 103 mother–infant pairs	Maternal anxiety during the postnatal period was associated with <i>infant colic</i> ($\chi^2=13.4$, $p<0.01$)	Unmasked assessment Cross-sectional design leaves temporality questionable Not generalizable No control of depression Article lacks sufficient detail for thorough evaluation
2. Akman et al. (2006) Turkey Nested case-control	Anxiety—State Trait Anxiety Inventory (STAI) at 1 month postpartum Infant colic—periods of irritability, fussing, or crying for >3 h a day, ≥ 3 days a week for at least 1 week in infants up to 6 months of age	Women with unevenful pregnancies recruited from one university hospital Maternal age: cases = 31.1 years ± 6.0 ^a ; controls=29.6 years ± 4.8 ^a 78 mother–infant dyads	Mothers of infants with colic had higher median trait anxiety score [42.0 (IQR=33.5–51.0) versus 36 (IQR=31.5–44.5); NS] Overall STAI median was higher in colic group [44.0 (IQR=41.5–51.0) versus 41 (IQR=33.0–49.5); NS]	Small sample size No control of depression Not generalizable Single time point anxiety assessment may not be generalizable to entire postpartum period
3. Coulthard and Harris (2003) United Kingdom Prospective cohort	Anxiety—STAI Food refusal—Child Feeding Assessment Form (developed for study) at 1, 5, and 11 months postnatal	Primiparous women Recruited from one hospital Uncomplicated, singleton pregnancies Mean maternal age=28, range 17–40 years 106 mother–infant dyads	Association between incidence of food refusal and state anxiety at 1, 5, or 11 months, NS <i>Unresolved food refusal</i> was associated with State anxiety at 1 month [$F(1,59)=3.88$, $p<0.05$] and 11 months [$F(1,59)=8.04$, $p<0.005$]	Small sample size
4. Ramchandani et al. (2006) United Kingdom Prospective cohort	Anxiety—Crown-Crisp Anxiety subscale Recurrent abdominal pain—Recurrent Abdominal Pain Assessment (developed for study) in children 6.5 years of age	Children born in Avon, England Singleton births Child survived first year of life Mean maternal age 28, range 14–46 years 8,272 mother–infant dyads	Maternal anxiety in the first year of life was associated with <i>risk of recurrent abdominal pain</i> (RAP) at 6.5 years (OR=1.53, $p<0.001$) Increasing levels of maternal anxiety were associated with an increasing trend for RAP risk ($\chi^2=90.86$, 3 df, $p<0.001$)	Single time point anxiety assessment may not be generalizable to entire postpartum period
Developmental outcomes				
5. Slykerman et al. (2007) New Zealand Cross-sectional	Anxiety—Perceived Stress Scale (PSS) Developmental delay—Revised Denver Prescreening Developmental Questionnaire in babies 12 months of age	All full-term, small for gestational age infants Random sample of full-term, normal size infants Recruited in two New Zealand regions Excluded multiple births and congenital abnormalities interfering with growth 655 mother–infant dyads	Stress at 12-months and developmental delay in small for gestational age infants, NS Developmental delay in normal sized infants, NS	Cross-sectional design prevents temporal association Single time point anxiety assessment may not be generalizable to entire postpartum period
6. Galler et al. (2000) Barbados Prospective cohort	Anxiety—Zung Anxiety Scale (ZAS) Cognitive development—Griffiths Mental Development Scales administered to 3 month old infants	Every other healthy mother–infant dyad Recruited from only Barbados hospital Maternal age 25.3 ± 5.3 years ^a Parity 2.6 ± 1.6 ^a 92 mother–infant dyads	Anxiety at 7 weeks was negatively associated with <i>personal-social development</i> at 3 months ($r=-0.34$, $p<0.001$); PMA at 7 weeks and motor and cognitive development at 6 months, NS	Single time point anxiety assessment may not be generalizable to entire postpartum period

Study, location, and design	Measures	Participants	Primary results	Main limitations
7. Galler et al. (2004b) Barbados Prospective cohort	Anxiety—ZAS Performance on Common Entrance Exam—standardized national exam given to 11 year old children	Every other healthy mother–infant dyad Recruited from only Barbados hospital Maternal age 25.3±5.3 years ^a Parity 2.3±1.5 ^a 169 mother–infant pairs	Maternal anxiety at 7 weeks was associated with <i>overall exam score</i> ($r=-0.25$, $p<0.05$), and <i>English scores</i> ($r=-0.29$, $p<0.01$) Math and essay scores, NS	Single time point anxiety assessment may not be generalizable to entire postpartum period
Psychological outcomes				
8. Nicol-Harper et al. (2007) United Kingdom Cross-sectional	Anxiety—STAI Infant emotional tone—videotaped, coded interactions; examining maternal characteristics and infant emotional tone at 1 year postpartum	Mothers of infants aged 10–14 months Recruited through community advertisements Maternal age: high anxious 33.2±4.78 years ^a ; low anxious 33.62±4.04 years ^a 32 high- and 32 low-anxiety mother– infant dyads	Infant emotional tone was not associated with trait anxiety at 1 year postpartum (Mann- Whitney $U=-1.13$, $p=0.36$)	Small sample size Cross-sectional design prevents temporal association Single time point anxiety assessment may not be generalizable to entire postpartum period
9. O'Connor et al. (2002) United Kingdom Prospective cohort	Anxiety—Crown-Crisp Anxiety subscale Behavioral and emotional problems— Strengths and Difficulties Questionnaire evaluated children at 4 years of age	Children born in Avon, England Singleton births Full-term infants Child survived first year of life Mean maternal age 28, range 14–46 years 7,824 mother–infant pairs	8-weeks postnatal maternal anxiety was associated with <i>emotional problems</i> in boys (OR=1.49, $p<0.05$) and girls (OR=1.48, $p<0.05$) and <i>conduct problems</i> in girls (OR=1.45, $p<0.05$) at 4-years-old Inattention and hyperactivity, NS	Single time point anxiety assessment may not be generalizable to entire postpartum period
10. O'Connor et al. (2003) United Kingdom Prospective cohort	Anxiety—Crown-Crisp Anxiety subscale Behavioral and emotional problems— Strengths and Difficulties Questionnaire evaluated children at 6.5 years of age	Children born in Avon, England Singleton births Full-term infants Child survived first year of life Mean maternal age 28, range 14–46 years 6,493 mother–infant pairs	Maternal anxiety at 8 weeks postpartum was associated with an increase risk of <i>emotional problems</i> in boys (OR=1.6, $p<0.05$) and <i>conduct problems</i> in girls (OR=1.94, $p<0.05$) Inattention and hyperactivity, NS	Single time point anxiety assessment may not be generalizable to entire postpartum period
11. Barnett et al. (1991) Australia Prospective cohort	Anxiety—STAI Child psychopathology Child Behavior Checklist in 5-year-olds	Primiparous women recruited on the 3rd or 4th postpartum day Mean maternal age=34, range 24–49 years 100 mother–child pairs Mean parity=2.1, range 1–4	Parental ratings of children of high anxiety mothers were rated as <i>less active</i> ($t=1.7$, $p<0.05$) and lower in <i>social competence</i> ($t=1.74$, $p<0.05$). Boys were also rated as more <i>immature</i> ($t=1.76$, $p<0.05$), more <i>delinquent</i> ($t=1.89$, $p<0.05$) and more <i>schizoid</i> ($t=1.8$, $p<0.05$) Teacher reports on the CBCL were not associated with maternal anxiety	Small sample size Single time point anxiety assessment may not be generalizable to entire postpartum period
12. Coplan et al. (2005) Canada Cross-sectional	Anxiety—STAI Infant temperament—Infant Behavior Questionnaire at 3 months of age	Mothers between 26 and 38 weeks pregnant Community sample Maternal age 31.85±4.46 years ^a 46 mother–infant dyads	PMA at 3 months was associated with <i>infant activity level</i> (state anxiety $r=0.49$, $p<0.01$), <i>distress to limitations</i> (state anxiety $r=0.31$, $p<0.05$; trait anxiety $r=0.42$, $p<0.01$), and <i>soothability</i> (trait $r=-0.31$, $p<0.05$)	Small sample size Single time point anxiety assessment may not be generalizable to entire postpartum period Cross-sectional design prevents temporal association
13. Diener et al. (1995) United States Cross-sectional	Anxiety—STAI Infant temperament—Bates Infant Characteristics Questionnaire assessed at 3 months postpartum	Primiparous, married women Recruited from community sources through advertisements Full-term infants 70 mother–infant pairs	Maternal anxiety scores at 3 months were not associated with perceived infant temperament ratings at 3 months postpartum	Small sample size Cross-sectional design prevents temporal association Single time point anxiety assessment may not be generalizable to entire postpartum period

Study, location, and design	Measures	Participants	Primary results	Main limitations
14. McMahon et al. (2001) Australia Cross-sectional	Anxiety—STAI Infant temperament—Short Temperament Scale for Infants administered to 4 months old infants	Primiparous women with infants <4 months Resident women: recruited from one residential care unit Community women: recruited from one obstetrical practice Residential group maternal age 31±4.2 years ^d Community group maternal age 32±2.3 years ^d 128 residential care mothers and 58 community mothers	<i>Infant difficultness</i> at 4 months associated with both trait and state anxiety [(residential group $r=0.41$, $p<0.001$; control group $r=0.36$, $p<0.001$) (residential group $r=0.43$, $p<0.001$; control group $r=0.30$, $p<0.01$); respectively]	Small sample of controls Cross-sectional design prevents temporal association Single time point anxiety assessment may not be generalizable to entire postpartum period
15. Davis et al. (2004) United States Prospective cohort	Anxiety—STAI Infant temperament—videotapes of infants coded using the Harvard Infant Behavioral Reactivity evaluated at 4 months of age	Women recruited from 1 university obstetric clinic Healthy, singleton pregnancies No diagnosed psychological disorder No alcohol or substance use during pregnancy 22 mother–infant pairs	Infant behavior at 4 months was not associated with 8-week postpartum anxiety	Small sample size
16. Galler et al. (2004a) Barbados Prospective cohort	Anxiety—ZAS Infant temperament—Casey Revised Infant Temperament Questionnaire at 6 months of age	Every other healthy mother–infant dyad Recruited from only hospital Maternal age 25.3±5.3 years ^a Parity 2.6±1.6 ^a 106 mother–infant dyads	PMA at 7 weeks and infant temperament at 6 months, NS PMA at 6 months was correlated with <i>adaptability</i> ($r=-0.25$, $p<0.01$), <i>infant mood</i> ($r=-0.17$, $p<0.05$), and <i>threshold</i> subscales ($r=0.2$, $p<0.05$)	Single time point anxiety assessment may not be generalizable to entire postpartum period
17. Pesonen et al. (2005) Finland Cross-sectional	Anxiety—PSS Infant temperament—Infant Behavior Questionnaire tested at 6 months postpartum	Consecutive mothers recruited from one Helsinki hospital Healthy, singleton infants Maternal age 29.1±4.3 years ^a 319 mother–infant dyads	Postnatal perceived stress at 6 months was associated with <i>distress to limitations</i> ($\beta=0.23$, $t=3.1$, $p<0.001$), <i>fear</i> ($\beta=0.15$, $t=1.9$, $p<0.001$), <i>negative reactivity</i> ($\beta=0.23$, $t=3.1$, $p<0.001$) and <i>smiling and laughter</i> ($\beta=-0.15$, $t=-1.9$, $p<0.01$) Activity, positive reactivity, and overall reactivity, NS	Cross-sectional design leaves temporality questionable
18. Susman et al. (2001) United States Prospective cohort	Anxiety—STAI Child temperament—Children's Behavior Questionnaire evaluated in 3-year-olds	Primiparous mothers recruited at ≤16 weeks gestation <20 years at expected delivery date Planned to keep baby English fluency Absence of severe mental or chronic illness in mothers 67 mother–infant dyads	Association with postpartum emotions and child temperament, NS	Sample size Sample size may not be generalizable

r correlation coefficient, F ANOVA statistic, IQR Inter-Quartile Range, NS not significant, PMA postnatal maternal anxiety

^aMean ± Standard deviation