Psychological Medicine (2017), **47**, 680–689. © Cambridge University Press 2016
doi:10.1017/S003329171600283X

ORIGINAL ARTICLE

Maternal depressive symptoms and early childhood cognitive development: a meta-analysis

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Background. Previous findings have been mixed regarding the relationship between maternal depressive symptoms and child cognitive development. The objective of this study was to systematically review relevant literature and to perform a meta-analysis.

Method. Three electronic databases (PubMed, EMBASE, PsycINFO) were searched. Initial screening was conducted independently by two reviewers. Studies selected for detailed review were read in full and included based on a set of criteria. Data from selected studies were abstracted onto a standardized form. Meta-analysis using the inverse variance approach and random-effects models was conducted.

Results. The univariate analysis of 14 studies revealed that maternal depressive symptoms are related to lower cognitive scores among children aged $\leqslant$56 months (Cohen's $d = -0.25$, 95% CI −0.39 to −0.12). The synthesis of studies controlling for confounding variables showed that the mean cognitive score for children 6–8 weeks post-partum whose mothers had high depressive symptoms during the first few weeks postpartum was approximately 4.2 units lower on the Mental Developmental Index (MDI) of the Bayley Scales of Infant and Toddler Development (BSID) compared with children with non-symptomatic mothers ($\hat{B} = -4.17$, 95% CI −8.01 to −0.32).

Conclusions. The results indicated that maternal depressive symptoms are related to lower cognitive scores in early infancy, after adjusting for confounding factors. An integrated approach for supporting child cognitive development may include program efforts that promote maternal mental health in addition to family economic wellbeing, responsive caregiving, and child nutrition.

Received 7 March 2016; Revised 7 October 2016; Accepted 13 October 2016; First published online 11 November 2016

Key words: Cognitive development, maternal depressive symptoms, meta-analysis.

Introduction

Maternal depressive symptoms, whether meeting the diagnostic criteria for major depressive disorder (MDD) or not, are highly prevalent, with estimates ranging from 3% to 60% (Walker *et al.* 2011) across a variety of assessment tools, timing of screening, and study populations worldwide (Marcus, 2009). In a US population, screening of pregnant women demonstrated that over 20% have elevated depressive symptomatology (Marcus *et al.* 2003). A history of depressive symptoms, poor overall health, high alcohol use, smoking, single marital status, unemployment, and low educational attainment have been significantly associated with depressive symptoms during pregnancy (Marcus *et al.* 2003). When a woman has high depressive symptoms, it means that her score is above the cut-off point of the screening or diagnostic measure that is used to assess her depressive symptoms. Mothers with high depressive symptoms tend to be less sensitive and more negative when interacting with their infants than mothers with few or no depressive symptoms (Cooper *et al.* 1999).

Children's cognitive development in early childhood is affected by genetic, biological, social, and psychological factors, many of which are sensitive to broader contextual variables such as poverty, cultural norms, and child-rearing environments (Grantham-McGregor *et al.* 2007; Walker *et al.* 2011). Since mothers largely influence

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infants' social environments and mediate their experiences with the external world, maternal sensitivity, responsiveness and affect (emotional warmth or rejection) are consistently related to young children's cognitive and social-emotional competence (Walker *et al.* 2007).

Although a meta-analysis of 46 observational studies found that maternal depressive symptoms increased the likelihood of negative parenting behaviors including impatience, low sensitivity, hostility and overall negative parent–child interactions, (Lovejoy *et al.* 2000) findings have been mixed regarding relationships between maternal depressive symptoms and cognitive development in early childhood. Hay & Kumar (1995) reported an association between postnatal depression and impaired child cognitive abilities at 4 years of age in a North London community sample. Similarly, Cornish and colleagues showed that infants of chronically depressed mothers were 3.4 times more likely to receive a non-optimal score on the Mental Development Index (MDI) of the Bayley Scales of Infant and Toddler Development, Second Edition (BSID-II; Cornish *et al.* 2005). A recent study also found that children of mothers having had a depressive episode at 6 weeks postpartum had significantly lower BSID-II MDI scores at 18 months compared with children of mothers with no depressive episodes (Conroy *et al.* 2012). In contrast, Kurstjens & Wolke (2001) concluded that maternal depression had negligible effects on children's cognitive development at 4 years and 8 months, and Hanley *et al.* (2013) reported that there was no significant difference observed in any of the BSID-III subscales ($p > 0.05$) between infants exposed and unexposed to pre- and postnatal maternal depressed mood.

Although a few descriptive reviews have summarized the research findings linking maternal depressive symptoms to young children's cognitive development (Field, 1992; Grace *et al.* 2003; Sohr-Preston & Scaramella, 2006; Wachs *et al.* 2009), and a meta-analysis of nine studies in 1998 showed that postpartum depression had a small but significant effect on children's cognitive and emotional development at age of $\geqslant 1$ year (Beck, 1998), to the best of our knowledge, no quantitative synthesis of recent research results has been produced examining this association in early childhood. The objectives of the present study were to systematically review the literature on maternal depressive symptoms and young children's cognitive development and to summarize the associations found across populations using meta-analytical techniques.

Method

This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher *et al.* 2009) and Meta-Analysis of Observational Studies in Epidemiology (MOOSE) statement for standard reporting. (Stroup *et al.* 2000).

Study inclusion criteria

A study was considered eligible for inclusion in this meta-analysis if it: (i) quantitatively assessed relationships between maternal depression or depressive symptoms and child cognitive development; (ii) was published in a peer-reviewed journal; (iii) was not a case study; and (iv) assessed the outcome in young children aged between 0 and 7 years, since our study was designed to capture cognitive developmental process in early childhood; and (v) had a sample that was representative of the general population of young children in that context. If the study population was described as a specific subset of children (e.g. obese children), the study was considered not representative of the general population and thus excluded. We applied no other population, language or time restrictions.

Search strategy

Studies included in this meta-analysis were identified using both electronic and manual searches. Electronic databases were searched for relevant studies on maternal depressive symptoms and child cognitive development: PubMed, EMBASE (without explosion) and PsycINFO. A string of search terms was applied to the three databases: ('cognition' or 'cognitive' or 'psychomotor' or 'sensorimotor' or 'motor' or 'child development' or 'infant development' or 'intelligence' or 'IQ' or 'visual' or 'vision' or 'language' or 'executive function' or 'attention' or 'memory' or 'school readiness' or 'pre-academic' or 'academic' or 'mental' or 'brain') AND ('maternal depression' OR 'maternal depressive symptoms'). Although we were initially interested in studies capturing both motor and cognitive development, the relatively low numbers of studies examining motor processes led us to focus exclusively on cognition. Follow-up manual searches were conducted from the citations in the review and meta-analysis articles retrieved from the electronic search.

Study selection and data extraction

The selection of studies was conducted in three steps. First, titles and abstracts of the retrieved studies were screened independently by two reviewers (Y.L. and J.C.). Studies deemed by both reviewers to not fulfill the criteria were excluded. Second, the remaining studies were read in full by the two reviewers and selected for inclusion in the analysis by consensus. Authors

https://doi.org/10.1017/S003329171600283X Published online by Cambridge University Press

were contacted if the full text of a potentially relevant article was not available. Articles identified as relevant by both reviewers were included. Disagreements between the two reviewers over study eligibility were resolved by a third reviewer (M.F.), who independently reviewed the articles with discordant assessments, discussed findings with the two reviewers, and participated in the group consensus. Reasons for exclusion were recorded and reviewed by the group. Third, data from each selected study were abstracted onto a standardized form independently by the two reviewers, including the authors, year of publication, the country where the study was conducted, study population, sample size, study design, the exposure and outcome measures, the age of the child at each assessment, effect estimate, confounders, and limitations. The summary results were compared and discussed, and any discrepancies were resolved by the third reviewer.

Meta-analysis

The meta-analysis was conducted using Stata v. 14 (StataCorp., USA). All studies reported child cognitive development as continuous variables, using a variety of measures. We used 'maternal depressive symptoms' as our exposure to capture studies using either a measure of depressive symptoms or a diagnostic measure of depression. To examine the crude association of maternal depressive symptoms and child cognitive development (i.e. the unadjusted analysis), we converted estimates of effect sizes to a common metric of Cohen's *d* (Cohen, 1988), which represents the difference between two group means (cognitive scores for children of mothers with high *v.* low/no depressive symptoms) divided by the pooled standard deviation (S.D.); stratified analyses by study type and outcome measure were also conducted to minimize the heterogeneity among studies. In addition, the studies that reported regression coefficients from multivariate linear regression as their effect size measures were also synthesized (i.e. the adjusted analysis), which enabled us to assess the relationship between maternal depressive symptoms and child cognitive development, adjusting for a set of possible confounders.

Since few studies assessed specific aspects of cognitive development (e.g. memory, attention), we focused on measures of 'general' cognitive development as our outcome of interest. If a study assessed depressive symptoms at several time points, we used the postnatal assessment with the longest follow-up time due to the fact that the data was correlated between time points and the availability of data. When a study used more than one measure to screen depressive symptoms, we gave priority to the measures that were more commonly used in the literature.

We used standard meta-analytical methods to estimate the summary effect sizes using the inverse variance approach and random-effects models. Heterogeneity was assessed by calculating the Q statistic and I^2 index, and by conducting subgroup analyses to determine if point estimates differed among groups. Publication bias was assessed from funnel plots using both the Egger's linear regression test and Begg's rank correlation test to determine statistical significance.

Results

The search terms retrieved 764 citations from PubMed, 1327 citations from EMBASE, and 1443 citations from PsycINFO. Additional relevant articles were found through manual search. We identified 95 potentially relevant studies by screening the titles and abstracts retrieved from the electronic and manual searches (Fig. 1). Among these, 14 studies meeting the predefined selection criteria were included in the crude analysis (Supplementary Table S1). Studies were conducted in ten countries: three in the UK (Hay & Kumar, 1995; Conroy *et al.* 2012; Husain *et al.* 2012), two in the United States (Cicchetti *et al.* 1997; Pound, 2005), two in Australia (Milgrom *et al.* 2004; Cornish *et al.* 2005), and one each in Japan (Otake *et al.* 2014), Canada (Hanley *et al.* 2013), France (Sutter-Dallay *et al.* 2011), Germany (Kurstjens & Wolke, 2001), Greece (Koutra *et al.* 2013), India (Patel *et al.* 2003) and Bangladesh (Black *et al.* 2007) Two studies were cross-sectional, and the other 12 studies used longitudinal designs, among which eight studies assessed maternal depressive symptoms at least 4 months prior to the assessment of child cognitive development. All of these 14 studies provided enough data for us to examine the crude association between maternal depressive symptoms and young children's cognitive development, but this association could potentially be biased due to the unadjusted confounding. Among these studies, four studies that focused on the MDI from the BSID also reported unstandardized regression coefficients from multivariate linear regression, which allowed us to adjust for potential confounders. (Black *et al.* 2007; Sutter-Dallay *et al.* 2011; Conroy *et al.* 2012; Koutra *et al.* 2013) There were no studies of children beyond 56 months of age that fulfilled the criteria to be included in the analysis. Although the majority of studies employed representative samples, one study (Kurstjens & Wolke, 2001) included 1011 children (76.1%) with special health needs who were admitted to special care units within the first 10 days of life into their initial study sample of 1329 children. The removal of this study from the primary analysis did not change the results significantly [Cohen's $d = -0.28$, 95% confidence interval (CI) −0.42 to −0.13]. Two of the 14 studies (Black *et al.* 2007

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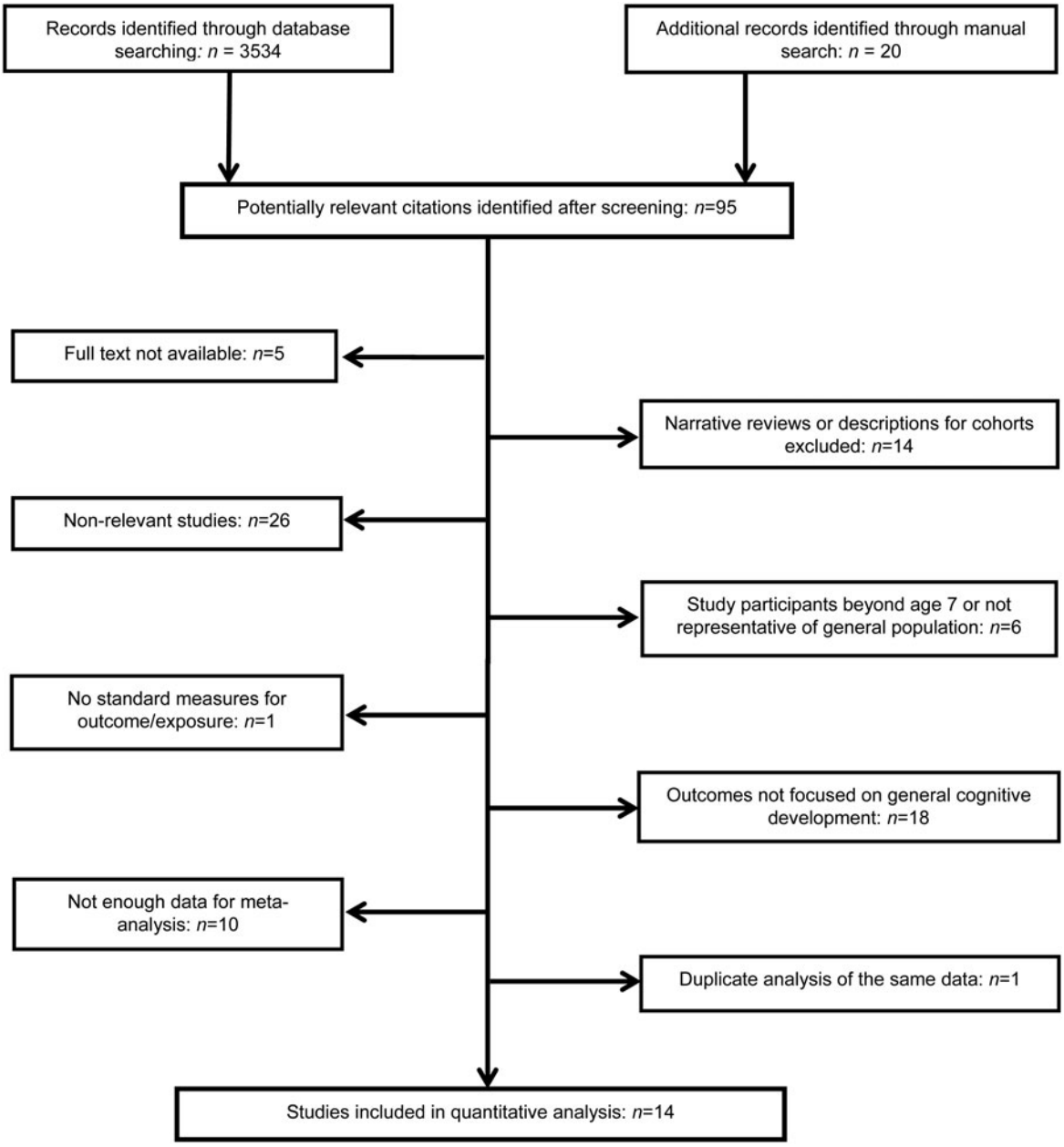

Fig. 1. Flow diagram of study selection procedure. The reasons to exclude initially identified articles to reach at $n = 95$ were: (1) the study was non-relevant to our research questions; (2) the study was a narrative review or description for a cohort; (3) study participants were beyond age range or not representative of general population; (4) study outcomes did not focus on general cognitive development.

and Sutter-Dallay *et al.* 2011) in the unadjusted analysis assessed cognitive development at multiple time points. Due to the fact that the data was correlated between time points and the availability of data, we chose the longest time point for the two studies (12 months for Black *et al.* 2007 and 24 months for Sutter-Dallay *et al.* 2011).

The majority of studies used the MDI from the BSID-II or BSID-III (Bayley, 1969, 1993, 2006*a*, *b*) to measure child cognitive development ($n = 10$). Other studies used the Developmental Assessment Scale for Indian Infants (DASII, $n = 1$) (Patel *et al.* 2003), McCarthy Scales of Children's Abilities ($n = 1$) (McCarthy, 1972), the Early Screening Profiles ($n = 1$) (Harrison *et al.* 1990), and the Columbia Mental Maturity Scales ($n = 1$) (Burgemeister *et al.* 1972). Eleven studies used a self-reported measure of maternal depressive symptoms: the Edinburgh Postnatal Depression Scale (EPDS, $n = 7$) (Cox *et al.* 1987), the Center for Epidemiologic Studies Depression Scale (CESD, $n = 2$) (Radloff, 1977), or the Beck Depression

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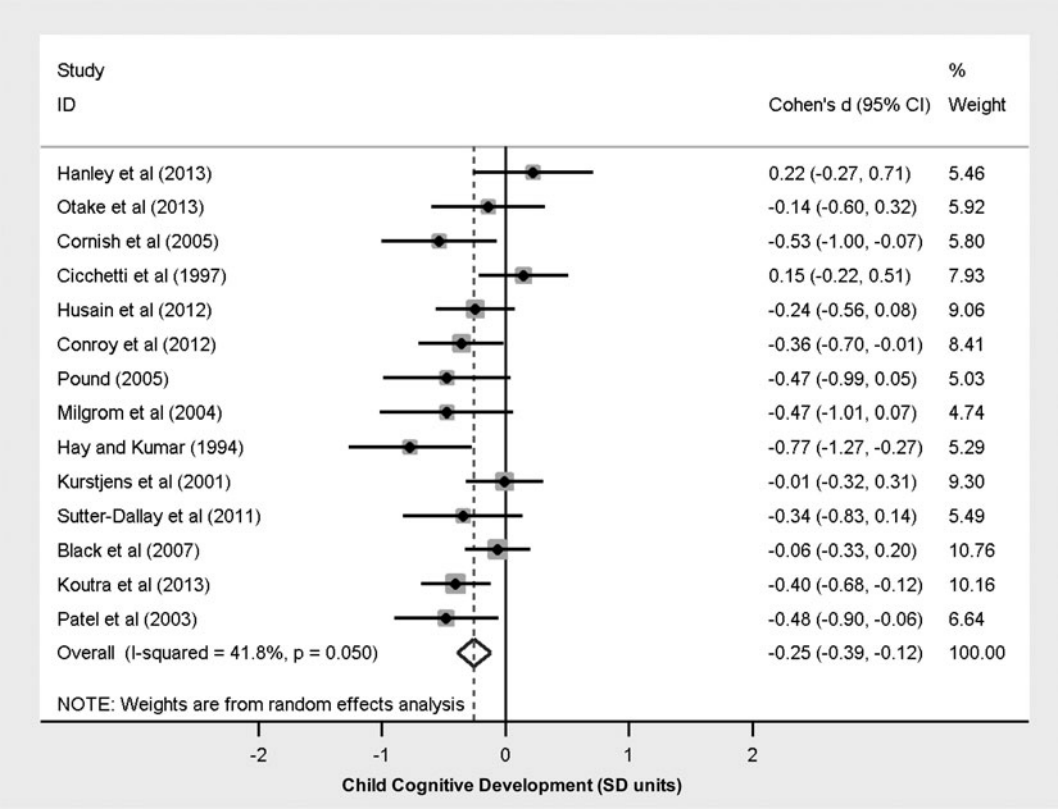

Fig. 2. Univariate associations between maternal depressive symptoms and child cognitive development.

Inventory ($n = 2$) (Beck *et al.* 1961). Clinician-based diagnostic measures of depression based on the Diagnostic and Statistical Manual of Mental Disorders III or IV (APA, 1980, 1995) were used to assess or confirm the exposure status for seven studies. The majority of studies reported a contrast between high postnatal depressive symptoms *v.* few or no symptoms with the time of measurement varying from 6 weeks to 42 months postpartum. Two studies (Husain *et al.* 2012; Otake *et al.* 2014) compared children based on maternal prenatal depressive symptoms reported in the second and third trimesters of pregnancy.

The meta-analysis of crude estimates from the 14 studies (Fig. 2) showed statistically significant relationships between maternal depressive symptoms and child cognitive development (Cohen's $d = -0.25$, 95% CI −0.39 to −0.12), indicating a −0.25 S.D. difference in the mean cognitive scores for children whose mothers had high *v.* low scores on measures of depressive symptoms. The heterogeneity of the findings was marginally significant (Q statistic = 22.34, $p = 0.05$, $I^2 = 41.8\%$), indicating possible variability in effect sizes across studies. The funnel plot was roughly symmetric with non-significant p values from both the Egger's linear regression test ($p = 0.22$) and Begg's rank correlation test ($p = 0.32$), an indication of minimal publication bias due to the possibility that the small studies are being undervalued/represented in the analysis. The synthesis of the ten studies using BSID as the outcome measure revealed a consistent association (Cohen's $d = -0.21$, 95% CI −0.36 to −0.06, $I^2 = 34.1\%$). When the meta-analysis was restricted to studies measuring postnatal depressive symptoms ($n = 12$), the association remained similar (Cohen's $d = -0.27$, 95% CI −0.43 to −0.11, $I^2 = 50.3\%$). When restricted to studies with longitudinal designs, the association was consistent (Cohen's $d = -0.27$, 95% CI −0.41 to −0.14) and the heterogeneity was non-significant (Q statistic = 17.08, $p = 0.11$, $I^2 = 35.6\%$). The synthesis of the seven studies with diagnostic measures for maternal depression or a combination of diagnostic and screening measures yielded consistent results (Cohen's $d = -0.28$, 95% CI −0.50 to −0.06, $I^2 = 55.7\%$). To establish the temporality of the association between maternal depressive symptoms and child cognitive development, a subgroup analysis on studies which assessed maternal depressive symptoms at least 4 months earlier than child cognitive development revealed similar findings (Cohen's $d = -0.31$, 95% CI −0.46 to −0.17) and the heterogeneity was non-significant (Q statistic = 8.71, $p = 0.27$, $I^2 = 19.6\%$). When we restricted the analysis to the studies where

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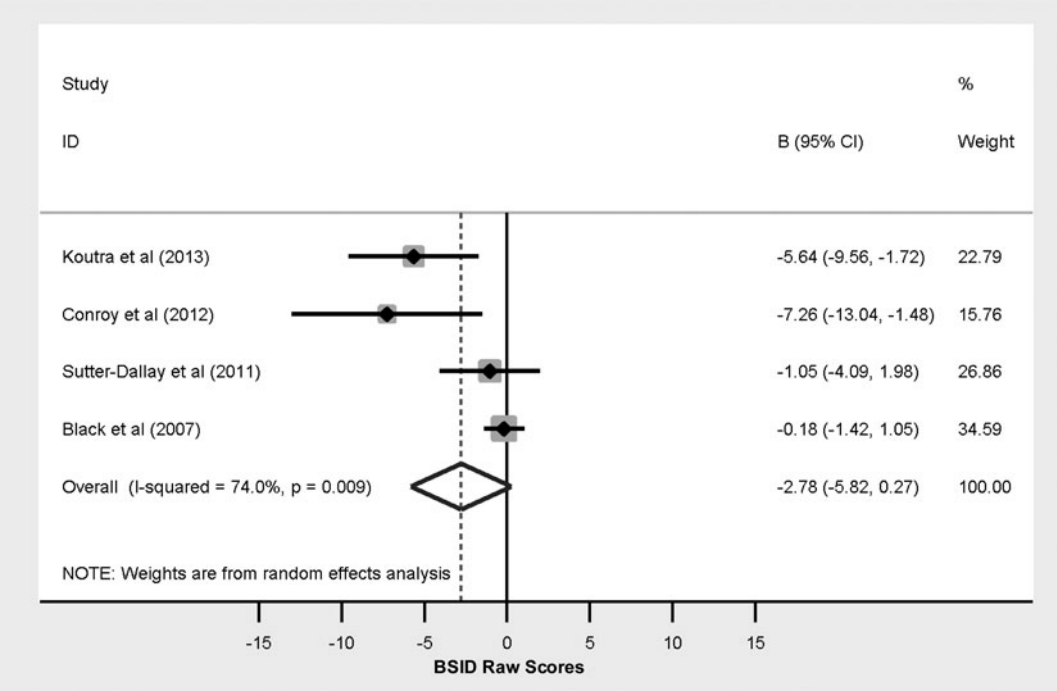

Fig. 3. Associations between maternal depressive symptoms and child cognitive development αreported in studies controlling for confounders.

maternal depressive symptoms were measured during 6–8 weeks postpartum, the association was strengthened (Cohen's $d = -0.40$, 95% CI −0.58 to −0.22, $p < 0.0005$) and the heterogeneity was greatly reduced (Q statistic = 0.24, $p = 0.97$, $I^2 = 0.0\%$).

The meta-analysis of the four studies reporting multivariate-adjusted linear regression coefficients (Fig. 3) revealed a negative association between maternal depressive symptoms and child cognitive development ($\hat{B} = -2.78$, 95% CI −5.82 to 0.27, $p = 0.074$]. This result indicates a difference of −2.8 MDI points in the mean cognitive score for children of mothers with high *v.* low depressive symptoms, controlling for additional factors such as gender, age, and income, although this finding was not significant. The heterogeneity of the findings was significant (Q statistic = 11.56, $p = 0.009$, $I^2 = 74.0\%$) across the studies. When the only cross-sectional study was removed, the association was attenuated ($\hat{B} = -1.81$, 95% CI −4.64 to 1.01) and the heterogeneity of the results remained significant (Q statistic = 6.82, $p = 0.033$, $I^2 = 70.7\%$). Nevertheless, if we restricted the analysis to the three studies where maternal depressive symptoms were measured during 6–8 week postpartum and excluded the study that measured maternal depressive symptoms at 12 months, the association became statistically significant ($\hat{B} = -4.17$, 95% CI −8.01 to −0.32, $p = 0.03$) with decreasing heterogeneity (Q statistic = 5.26, $p = 0.072$, $I^2 = 62\%$).

Discussion

Our analysis of 14 studies that focused on early childhood development revealed a statistically significant univariate relationship between maternal depressive symptoms and child cognitive development, indicating that the mean cognitive score for children whose mothers had high depressive symptoms was 0.25 S.D. lower than that for children whose mothers had few or no depressive symptoms. However, since these results do not account for confounding characteristics, care should be taken in interpreting and comparing our results.

The synthesis of the four studies reporting multivariate linear regression coefficients indicated that the mean cognitive score for children whose mothers had high maternal depressive symptoms were on average 2.8 score points lower in MDI than that for children whose mothers had few or no depressive symptoms, controlling for child gender and some socioeconomic characteristics such as family income, maternal occupation or parental education. Although this finding is not statistically significant, it is in the same direction and of a similar–though slightly attenuated–magnitude as was observed in the unadjusted analysis. It is worth noting that a high degree of variability was detected among these four studies, possibly due to their individual choice of confounders, diverse measures of depressive symptoms, and different timing

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of the exposure to maternal depressive symptoms (ranging from 6 weeks postpartum to 12 months), which may contribute to the non-significant findings from the adjusted analysis. In addition, when the adjusted analysis was restricted to three studies that included infants 6–8 weeks of age, the result became statistically significant and the magnitude of the association increased to an average score of 4.2 points lower on the MDI for infants whose mothers reported high depressive symptoms. This result is consistent with our previous findings in the unadjusted analysis and reveals the potential for a 'sensitive period' for maternal depressive symptoms' effect on cognitive development, where early post-partum depressive symptoms might impact a mother's ability to form positive attachment relationships with the child that promote later development. (Teti *et al.* 1995; Bagner *et al.* 2010).

These quantitative findings are consistent with prior qualitative reviews that did not combine results using statistical techniques: Field *et al.* (1992) reported that maternal depressive symptoms affected growth and BSID developmental scores by the end of the child's first year; and Sohr-Preston & Scaramella (2006) revealed that exposure to prenatal, postnatal and chronic depressive symptoms increased children's risk for later cognitive and language difficulties. Wachs *et al.* (2009) reported that children of mothers with high depressive symptoms are at risk for slow cognitive development both in high as well as low- and middle-income countries. In addition, our study included recently published studies and expanded the age range of children to infants, which is complementary to the quantitative findings in the meta-analysis published in 1998 (Beck, 1998).

There are a number of potential mechanisms through which maternal depressive symptoms can lead to compromised cognitive development in infants and toddlers (Goodman & Tully, 2008). Depressive symptoms such as social withdrawal and lack of sensitivity may interfere with mothers' responsivity to their infants' developmental needs, (Black *et al.* 2007; Cooper *et al.* 2009) such as missing cues for interaction and hindering their capacity to provide early learning opportunities. The negative impact of depression on maternal energy and cognitive functioning may challenge their ability to provide appropriate care (Koutra *et al.* 2013), such as parental prevention practices (McLennan & Kotelchuck, 2000) and attending to medical needs (Minkovitz *et al.* 2005). In addition to sadness, the loss of interest in daily activities may also reduce the motivation for mothers to provide opportunities for children to play or interact with the environment in ways that support cognitive growth (O'Brien Caughy *et al.* 2009). Both social support and social networks have been found to be inversely and independently related to symptoms of depression in postpartum women. (Surkan *et al.* 2006) However, withdrawal and social isolation often present with depression, which may lead to reduced social support and assistance with child care.

Maternal depressive symptoms are often compounded by co-occurring factors such as intimate partner violence (Agrawal *et al.* 2014; Stewart *et al.* 2014), other traumatic experiences (Leserman, 2008; Kukihara *et al.* 2014; Nakai *et al.* 2014) co-morbid illnesses (Kagee, 2008; Di Benedetto *et al.* 2014), poverty (Black *et al.* 2007; Grantham-McGregor *et al.* 2007), food insecurity, and child malnutrition (Baker-Henningham *et al.* 2003). Although these factors can be considered confounders, maternal depression may be an important mediating variable between these factors and child cognitive development. Interventions that promote child cognitive development have demonstrated improvements in maternal mental health, suggesting potential for bi-directionality in these relationships over time (Baker-Henningham *et al.* 2005; Boivin *et al.* 2013; Singla *et al.* 2015). Finally, access to effective mental healthcare is a critical element in reducing the suffering of perinatal women and enhancing positive interaction with their children (Poobalan *et al.* 2007). Integration of screening for maternal depression within the context of pediatric care may also aid in the identification of women and children at risk (Dubowitz *et al.* 2007; Heneghan *et al.* 2007). In addition to screening and treatment of maternal depression as well as increasing responsive caregiving to infants, concurrent strategies to address nutritional status, access to healthcare, parental education and economic security should be considered, particularly among impoverished populations. Additional research should also be pursued to provide evidence for the causality of these relationships, for example through assessing the effectiveness of interventions on maternal mental health that may result in an improvement on children's cognitive development.

This meta-analysis was limited by the modest number of studies fulfilling eligibility criteria: 14 studies were included in the unadjusted analysis, whereas only four of them with significant heterogeneity provided enough data for adjusted analysis. The studies were published from 1986 to 2013 and varied in quality. In addition, our unadjusted univariate analysis may reflect inaccurate relationships between maternal depression and child cognitive development due to confounding. The four studies included in adjusted analysis shared some confounders such as child gender and parental education, but they differed in others and were unlikely to be fully comprehensive in capturing all potential confounders. An additional challenge in interpreting the adjusted meta-analysis is to

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understand the extent to which confounding variables may be explanatory or mediating factors on the pathway from maternal depression to child cognitive development. In addition, it is possible that women's depressive symptoms may be a response to children's cognitive delays (Nicholson *et al.* 2011; Bagner *et al.* 2013), although some longitudinal studies included in this analysis found that maternal depressive symptoms preceded infant cognitive development outcomes (Hay & Kumar, 1995; Cornish *et al.* 2005; Koutra *et al.* 2013). The transactional effects of maternal depression and child cognitive development can result in an iterative process over time, whereby children's poor cognition may have an effect on maternal depression, which in turn can further impact the child negatively. As in any systematic review, publication bias may have affected our findings; significant findings may have been disproportionately reported in the literature, though the funnel plot in our univariate analysis indicated a minimal publication bias. Moreover, we were unable to evaluate the effect of severity of depressive symptoms on cognitive development due to limited data. In addition, our conclusions were largely based on depressive symptoms using screening questionnaires. Additional research using context-appropriate clinical diagnostic measures of major depression needs to be conducted to further explore the association between child cognitive development and maternal depression. Finally, the majority of studies included in our analysis came from high-income countries, which limits the generalizability of our results to low- and middle-income countries.

In conclusion, the quantitative synthesis of research results indicates that maternal depressive symptoms are related to lower cognitive scores in early childhood. An integrated approach to advancing child cognitive development can focus on addressing maternal depression, as well as strengthening the economic situation of families, promoting responsive caregiving, and supporting early child development and nutrition programs.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S003329171600283X.

Acknowledgements

The authors acknowledge Grand Challenges Canada for funding this study as a product of the Saving Brains Project. We also thank the researchers at Harvard Medical School, Harvard School of Public Health, Harvard Graduate School of Education, Muhimbili University of Health and Allied Sciences in Tanzania, Johns Hopkins Bloomberg School of Public Health, University of Maryland School of Medicine, and Bordeaux University in France, who contributed to the analysis, writing, and formatting of the manuscript.

This study was supported by Grand Challenges Canada for a proposal entitled: Poverty-related Risk Factors for Child Development and Human Capital: Comparative National and Global Assessment (grant no. 0073-03).

Declaration of Interest

None.

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