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REVIEW ARTICLE

Maternal depressive symptoms and early childhood cognitive development: a review of putative environmental mediators

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Abstract

Despite the abundance of research investigating the associations between maternal depressive symptoms (MDS) and children's cognitive development, little is known about the putative mechanisms through which depressive symptoms are associated with children's cognitive development. The aim of this review was to summarize the literature on family mediators (i.e., maternal parenting behaviors, mother-child interactions, and family stress) involved in this association in early childhood. The review includes seven studies, five longitudinal and two cross-sectional, which tested putative mediators of the association between MDS and children's cognitive development. Studies were selected from online databases (PubMed, PsycNet) and manual searches. Only studies which quantitatively assessed associations between MDS in the postnatal period and child cognitive development in early childhood (i.e., 0–5 years) and included mediator variables were included in the review. Six out of seven studies identified mediating variables. The mediators included maternal responsiveness, parenting style, family dysfunction, the quality of the home environment, and maternal caregiving practices. Different mediators were identified across the reviewed studies. Maternal depressive symptoms are partly associated with child cognitive development via family processes and parenting practices. Various mediating processes are at play. Further research is needed on the role of maternal and paternal mental health and gene-environment correlations in this association. A better understanding of the mediating pathways is needed for the design of preventative intervention targeting specific family processes.

Keywords Maternal depressive symptoms · Cognitive development · Mediators · Family environment

Introduction

Maternal depressive symptoms (MDS) can be conceptualized as the experience of sad mood or loss of pleasure accompanied by cognitive or somatic symptoms. These symptoms can occur during pregnancy and/or the early childhood years (American Psychiatric Association 2013). MDS persist for longer periods of time (months-years) than postpartum blues (hours-days) but may not necessarily reach levels of severity that qualify for major depression (Robertson et al. 2004). A wide range of prevalence estimates have been reported (Marcus 2009; Walker et al. 2011), but most recent estimates of MDS in high-income countries suggest that approximately 10% of mothers are affected in the first few years after birth (Howard et al. 2014; Lanes et al. 2011; Pearson et al. 2013).

MDS are a public health concern, not only because of their high prevalence but also because of their adverse consequences on maternal health and child development (Piteo et al. 2012). Children's early life experiences (up to age 5 years) provide the foundation for future life success, and failure to cultivate cognitive skills during this period impedes their ability to learn at later ages (Heckman 2006). Exposure to MDS in this sensitive period is a risk factor for poor cognitive development (Liu et al. 2017). There has been a recent interest in identifying the potential mediators of this association to improve our understanding of its underlying mechanisms. This review provides a summary of factors in the early childhood family environment which putatively mediate the association

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between MDS and child development. We focus primarily on the environmental mechanisms of this association, given their importance in the literature, and will therefore focus on exposure to MDS in the postnatal period.

Evidence suggests that MDS negatively affect children's cognitive, behavioral, and socio-emotional development (Goodman et al. 2011; Grace et al. 2003; Liu et al. 2017; Wachs et al. 2009). However, there is still mixed evidence for the association between MDS and cognitive development: some studies have found associations between exposure to MDS and reduced cognitive performance (Ahun et al. 2017; Brennan et al. 2000; Cornish et al. 2005; Sutter-Dallay et al. 2011; van der Waerden et al. 2016), whereas others either find no association (Cornish et al. 2005; Evans et al. 2012) or only find associations for specific groups of depressed mothers such as those with low levels of education or low socioeconomic status (Augustine and Crosnoe 2010; Murray 1992). One potential explanation for the inconsistency in results is that studies assessing MDS over a shorter period of time (i.e., first 2 years of life) are less likely to find an association given increasing evidence that it is the persistent exposure to MDS across early childhood that negatively influences children's cognitive development (Netsi et al. 2018). Differences in the moderating roles of maternal education and socioeconomic status may be due to some studies including these variables as confounding factors while others test their interactions with MDS. A summary of these studies is included in the supplementary material.

Cognitive development refers to age-related increases in language, intellectual, and executive functioning capabilities, all of which are affected by genetic, biological, social, and psychological factors that are sensitive to broader contextual determinants (Grantham-McGregor et al. 2007; Walker et al. 2011). Four reviews (Field 1995; Grace et al. 2003; Sohr-Preston and Scaramella 2006; Wachs et al. 2009) and two meta-analyses (Beck 1998; Liu et al. 2017) have summarized the research findings linking MDS and children's cognitive development; however, there is no synthesis of studies which have tested the role of putative mediating variables in this association.

A number of theoretical frameworks about the putative pathways through which MDS may influence children's cognitive development have been proposed (Bandura 1995; Belsky 1984; Bowlby 1988; Bronfenbrenner 1979; Goodman and Gotlib 1999; Minuchin 1985). An often-cited framework is Goodman and Gotlib's model of the transmission of risk for children of depressed mothers (Goodman and Gotlib 1999). This model identifies four pathways through which children could be at risk for less optimal development: (1) heritability of depression; (2) innate dysfunctional neuroregulatory mechanisms; (3) negative maternal cognitions (i.e., thoughts), behaviors, and affect; (and 4) stressful context of children's lives. Studies have empirically tested these pathways as mechanisms through which MDS are associated with children's cognitive outcomes by testing the associations either (a) between MDS and putative mediator variables or (b) between mediators and children's cognitive development. The following paragraph provides a brief summary of these studies.

Maternal parenting behaviors and mother-child interactions

Numerous studies (Beck 1995; Logsdon et al. 2006; Lovejoy et al. 2000; Murray et al. 2003a) have investigated the impact of MDS on maternal cognitions, behaviors, and affect. The minds of depressed mothers are dominated by recurrent negative thoughts which in turn interfere with their capacity to respond to their interpersonal environment (Stein et al. 2008), including their interactions with their children. Two systematic reviews (Logsdon et al. 2006; Murray et al. 2003a) found that MDS predicted negative maternal perceptions of normal child behavior and reduced mothers' sense of enjoyment in the maternal role. In addition, one meta-analysis (Beck 1995) reported that MDS have a negative, moderate to large effect on the quality of mother-child interactions (d = .68–.78). Another review (Lovejoy et al. 2000) found that depressive symptoms increased the likelihood of negative parenting practices (d = .40) such as low sensitivity, hostility, and negative parent-child interactions. Maternal sensitivity, responsiveness, and affect have in turn been consistently associated with young children's cognitive development (Sohr-Preston and Scaramella 2006; Walker et al. 2007).

There is evidence that the quality of care provided by mothers to their children, including their responsivity and cognitive stimulation, influences children's early cognitive development (Sohr-Preston and Scaramella 2006). Experimental intervention studies assessing the effect of cognitive stimulation on children report that those who received additional cognitive stimulation had higher cognitive functioning scores than non-stimulated controls (Grantham-McGregor et al. 2007; Walker et al. 2007). Furthermore, interventions which enhanced mother-child interactions and increased the provision of learning activities in the home found positive associations with children's cognitive development (Walker et al. 2011).

Family stress

There is empirical and theoretical support for the association between MDS and stressful family contexts in children's lives. Although Elder and Caspi's (1988) family stress model suggests that low income impacts maternal mental health which then influences children's development through parenting practices; the causal mechanisms of the association between low-income and maternal mental health are not clear.

Conditions of economic deprivation such as stress, worse physical health, and reduced access to health care could facilitate the development of mental ill-health (Lund et al. 2010). Or perhaps, the experience of mental ill-health could result in people drifting into or remaining in conditions of economic deprivation (Lund et al. 2010). Importantly, MDS could foster a stressful context of children's lives through its association with family functioning (Burke 2003; Letourneau et al. 2012). Thus, even if there is no clear evidence to show that MDS cause economic problems or the reverse, MDS and economic difficulties are important contributors to the levels of stress in the family and should be accounted for in models on the impact of MDS on children's outcomes.

Role of genetics

It is plausible that common genetic factors could contribute both to MDS and children's cognitive development (van der Waerden et al. 2016). Furthermore, gene-environment correlations—i.e., the process by which an individual's genotype influences, or is associated with his/her exposure to the environment (Plomin et al. 1977)—may improve our understanding of the pathways through which MDS are associated with children's cognitive development. However, to the best of our knowledge, there are no twin or genetically informed singleton studies testing for the mediating role of environmental factors in the MDS-child cognitive development association while controlling for genetic factors. It is noteworthy that even if the etiology of this association may be partly genetic, identifying relevant environmental factors is important for prevention efforts because such factors are more amenable to interventions than genetic factors.

Our study

Understanding the putative environmental pathways through which MDS influence children's cognitive development in early childhood can lead to the development of targeted interventions to minimize the impact of depressive symptoms in this critical developmental period. For example, a psychotherapeutic intervention for depressed mothers diminished the impact of depressive symptoms on children's IQ by encouraging positive mother-child interactions and maternal affect (Cichetti et al. 2000). From a public health perspective, research identifying these pathways can be used to develop population-level interventions for depressed mothers and their families which act directly on these factors and improve children's cognitive development. This review provides a summary of such research. Specifically, our objective was to summarize the empirical literature on the putative environmental mediators through which MDS are associated with children's cognitive development in early childhood.

Methods

Search strategy

Studies included in this review were identified using both electronic and manual searches. Two electronic databases, PubMed and PsycNet (through to March 2018), were searched for relevant studies on MDS and child cognitive development using the following search terms: "maternal depressive symptoms" (or "maternal depression") AND "cognitive development." Follow-up manual searches were conducted from the citations in articles retrieved from the electronic search.

Study inclusion criteria

A study was considered eligible for inclusion if it (i) quantitatively assessed associations between maternal depression or depressive symptoms and child cognitive development; (ii) assessed maternal depression or depressive symptoms in the postnatal period (iii) was published in a peer-reviewed journal; (iv) included putative mediator variables involved in the association between maternal depression or depressive symptoms and child cognitive development; (v) was published before March 2018; and (vi) was written in a language in which the authors could read scientific articles (English/French). No other restrictions were applied.

Study selection

The selection of studies was conducted in two steps. First, titles and abstracts of the retrieved studies were screened by the authors. Studies deemed to not fulfill the criteria were excluded. Second, the remaining studies were read in full by both authors and selected for (review) if the study met inclusion criteria.

Results

We retrieved 88 citations from PubMed and 306 citations from PsycNet. Additional relevant articles were found through manual search. Thirty-seven potentially relevant studies were identified by screening the titles and abstracts received from the electronic and manual searches (Fig. 1). Among these, seven studies meeting the selection criteria were included in the review. Studies were conducted across the UK, Australia, Canada, Taiwan, and the USA. Two studies were cross-sectional, and the other five used longitudinal designs, among which four assessed MDS at least twice. MDS were assessed between the ages of 6 weeks and 5 years, and cognitive development outcomes between 6 months and 5 years. Table 1 presents a summary of these

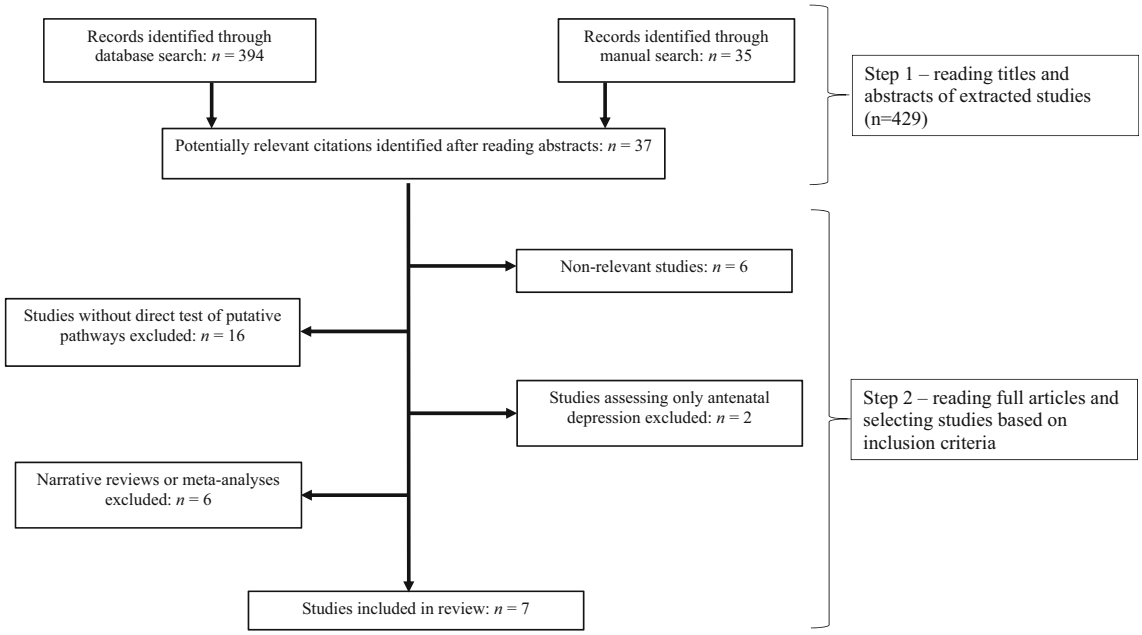

Fig. 1 Flow diagram of study selection procedure

studies. The intermediary variables tested include mother-child interactions (e.g., maternal caregiving and responsiveness), parenting styles and attitudes, the general home environment, and family dysfunction. The results of studies which included more than one variable are reported under the relevant sub-headings. Note that the term "effect" is used to refer to longitudinal and sequential associations tested in mediating models, and not to causality.

Mother-child interactions (maternal caregiving and responsiveness)

Stein et al. (2008) examined the associations between MDS, maternal caregiving—assessed by trained interviewers in 2-h home observations—and children's language development in a British sample. Using Structural Equation Modeling (SEM)—a powerful method for testing mediation—the authors found that MDS at 10 or 36 months did not directly predict children's language development at 36 months. There was, however, an indirect effect of MDS on children's language, but only for families from low socioeconomic backgrounds. In other words, higher levels of MDS were associated with lower quality of maternal caregiving, and this was in turn associated with poorer language outcomes.

Kiernan and Huerta (2008) also found no direct effect of MDS on children's comprehension of numbers, letters, sizes, etc. using data from the Millennium Cohort Study, a large-scale survey of British children born in 2001–2002. They then tested whether MDS were associated with parenting practices and mother-child interactions and whether these variables were in turn associated with child outcomes. MDS were not assessed with a direct measure; rather, they were derived from three items assessing whether or not mothers had symptoms in the postnatal period, whether or not mothers had been diagnosed by a doctor, and items derived from the Rutter Malaise Invetory (Kelly et al. 2004). Information on reading activities, mother-child interactions, and disciplinary parenting practices was self-reported by mothers. SEM path analysis revealed that depressed mothers (at age 9 months) were less likely to engage in reading activities and positive mother-child interactions at age 3 years, which in turned predicted lower concurrent cognitive scores. Thus, the association between MDS and lower child cognitive development came about via lower levels of maternal stimulation and mother-child interactions as well as less efficient parenting.

Milgrom and colleagues (2004) reported that children of depressed mothers had lower full IQ scores and lower cognitive/language profile scores than children of non-depressed mothers at 42 months in a small ($n = 56$) Australian sample. Baron and Kenny's (1986) mediation approach was used to formally test whether observed maternal responsiveness at age 6 months mediated these associations. Maternal responsiveness fully mediated the association between MDS and children's IQ; however, there was no indirect effect of MDS in the association with children's cognitive/language profile scores (Milgrom et al. 2004). That is, the association between MDS and lower cognitive profile was not mediated by maternal responsiveness. These results should be interpreted with caution as Baron and Kenny's (1986) approach does not provide a clear test of the indirect effect (Hayes 2009). Rather, it infers mediation based on the reduction of significance in the association between the exposure and the outcome once the mediator is entered into the model.

Table 1 Summary of articles testing for mediators of the association between maternal depressive symptoms and child cognitive development

Name and country	Study design	Participants	Measures[a]	Putative mediators	Strength of direct and indirect associations
Milgrom et al. 2004 Australia	Longitudinal	Mothers aged 19–39 years, infants aged 15.8 weeks (SD = 7.1) at recruitment $N = 56$	Hamilton Depression Rating Scale at recruitment, 6, 12, 24, and 42 months. Maternal responsiveness measure adapted from rating scales (Brazelton et al. 1974; Censullo et al. 1985) and assessed at 6 months Wechsler Preschool Primary Scale of Intelligence (Revised) and Early Screening Profiles at 42 months	Mother-child interactions (maternal responsiveness)	MDS to child IQ (when maternal responsiveness is in model): $b = -0.1$, $p = .44$
Kiernan and Huerta 2008 UK	Longitudinal	Millennium Cohort Study $N = 13{,}877$	Maternal depression was derived from 3 items of information at 9 months Reading activities, mother-child interactions, and disciplinary practices were assessed by maternal report at 3 years Bracken Basic Concept Scale at 3 years	Maternal parenting behaviors (disciplinary practices) Mother-child interactions	MDS to reading activities: $b = -0.05$, $p < .05$ Reading activities to child cognitive scores: $b = 0.42$, $p < .001$ MDS to mother-child interactions: $b = -0.12$, $p < .001$ Mother-child interactions to child cognitive scores: $b = 0.08$, $p < .001$ MDS to coercive disciplinary practices: $b = 0.17$, $p < .001$ Coercive disciplinary practices to children's cognitive scores: $b = 0.03$, $p > .05$
Stein et al. UK	Longitudinal	Subjects were recruited at antenatal and postnatal baby clinics $N = 944$	Edinburgh Postnatal Depression Scale and at 3 and 10 months and 12-item General Health Questionnaire at 3 months Emotional and verbal responsiveness of mother, Provision of appropriate play materials, organization of the physical and temporal environment, and opportunities for variety in daily stimulation subscales of the Home Observation for Measurement of the Environment, and Positive relationship and Detachment subscales of the Caregiver Interaction Scale at 10 and 36 months Reynell Developmental Language Scale at 36 months	Mother-child interactions (maternal caregiving)	MDS to maternal caregiving: $b = -0.21$, $p < .05$ Maternal caregiving to child language: $b = -0.27$, $p < .05$
Zajicek-Farber 2010 USA	Cross-sectional	Mothers were on average 24.6 years (SD = 5.5) and infants were 16 to 18 months old $N = 198$	Edinburgh Postnatal Depression Scale Self-reported engagement in literacy-oriented stimulating activities MacArthur Communicative Development Inventories	Maternal parenting behaviors (stimulating activities)	MDS to stimulating activities: $b = -0.39$, $p < .001$ Stimulating activities to language development: 0.61, $p < .001$
Piteo et al. 2012 Australia	Longitudinal	Subjects were from the control arm of a randomized control trial on full-term and pre-term infants in 5 perinatal centers $N = 360$	Edinburgh Postnatal Depression Scale at 6 weeks and 6 months Home Screening Questionnaire at 18 months Bayley Scales of Infant and Toddler Development at 18 months	Family stress (quality of home environment)	MDS to home environment: $b = -0.35$, $p > .05$ Home environment to cognitive scores: $b = 0.80$, $p < .01$ Home environment to language scores: $b = 1.04$, $p < .01$

Table 1 (continued)

Name and country	Study design	Participants	Measures[a]	Putative mediators	Strength of direct and indirect associations
Chen et al. 2013 Taiwan	Cross-sectional	Mothers were 20–40 years old and children were 6–24 months old $N = 60$	Edinburgh Postnatal Depression Scale Infant Toddler-Home Observation for Measurement of the Environment Comprehensive Developmental Inventory for Infants and Toddlers screening test	Family stress (quality of home environment)	MDS to home environment: $b = -0.28$, $p < .05$ Home environment to cognitive outcome: $b = 0.51$, $p < .001$
Letourneau et al. 2013 Canada	Longitudinal	Canadian National Longitudinal Survey of Children and Youth $N = 10{,}033$	12 items from the 20-item Center for Epidemiologic Studies-Depression Rating Scale at 0–1 years, 2–3 years, and 4–5 years McMaster Family Assessment Device and Western Australian Child Health Survey at 0–1 years, 2–3 years, and 4–5 years Peabody Picture Vocabulary Test-Revised at 4–5 years	Maternal parenting behaviors (parenting style) Family stress (family functioning)	MDS to receptive vocabulary scores: OR = 3.03, $p < .05$ Parenting style to receptive vocabulary scores: OR = 1.99, $p < .05$ Family functioning to receptive vocabulary scores: OR = 1.44, $p > .05$

[a] Some studies measured more than one child developmental outcome; however, only measures used to assess cognitive development are reported here

Maternal parenting behaviors

In a cross-sectional study (Zajicek-Farber 2010), MDS were indirectly associated with children's language competencies (assessed as understanding and producing age-expected vocabulary) at age 16 to 18 months in a low-income non-white sample. The results indicate that depressed mothers were less likely to engage in stimulating activities with their children, and this in turn was associated with poorer language development (Zajicek-Farber 2010). The cross-sectional nature of the study greatly limits the interpretation of a mediation process as it is plausible that there is a bi-directional association between MDS and the potential mediator, as well as between the mediator and child outcomes.

On the other hand, a longitudinal study in a Canadian sample found a direct, as well as an indirect, association between MDS and children's receptive vocabulary at ages 4 to 5 years (Letourneau et al. 2013). Children of chronically and concurrently depressed mothers had lower receptive vocabulary scores. Exposure to higher neglectful parenting style was identified as a partial mediator. This means that parenting style explained part of the association between MDS and children's vocabulary. MDS were still significantly associated with children's receptive vocabulary after parenting style was included in the model.

Kiernan and Huerta (2008) found no indirect effects of MDS through maternal disciplinary practices on children's cognitive scores. Depressed mothers were more likely to engage in coercive disciplinary practices (e.g., smacking the child, shouting at the child if they are naughty); however, these practices were not significantly associated with children's lower cognitive scores at age 3. In conclusion, parenting practices did not mediate the association between MDS and children's cognitive outcomes in this sample.

Home environment

Two studies (Chen et al. 2013; Piteo et al. 2012) used measures of the quality of the home environment (e.g., organization, learning materials, variety of daily stimulation) to test whether it mediated the association between MDS and children's cognitive development. The home environment when children were 18 months old did not mediate the association between MDS at 6 weeks and 6 months postpartum and children's concurrent cognitive development in an ethnically homogenous American sample of full-term and pre-term infants (Piteo et al. 2012). Conversely, Chen et al. (2013) found an indirect association through the quality of the home environment in a cross-sectional study of immigrant mothers in Taiwan. In other words, the home environment fully mediated the association between MDS and children's cognitive and language development. Because of the cross-sectional nature of the study, the

results do not provide information about the directionality of the exposure-mediator and mediator-outcome associations.

Family stress

Letourneau et al. (2013) tested whether family dysfunction mediated the association between MDS and children's receptive vocabulary. Family functioning (i.e., cohesiveness and adaptability of family) was reported using the McMaster Family Assessment Device (Epstein et al. 1983) by the person who knew the child best (the mother in most cases) when children were 4 to 5 years old. Similar to their results with parenting style, they found that the influence of family dysfunction reduced the negative impact of early depressive symptoms on children's receptive vocabulary. However, family dysfunction was not significantly associated with vocabulary scores and therefore did not mediate the association between MDS and vocabulary scores (Letourneau et al. 2013). Note that the authors do not report associations between MDS and the potential mediators (i.e., parenting style and family functioning).

Discussion

This review summarized the small but emerging literature investigating the pathways through which MDS are associated with children's cognitive development in early childhood. Of the seven studies included in the review, two found direct and indirect associations, four found no direct but some indirect associations, and one found no direct nor indirect associations between MDS and children's cognitive development. Among studies using statistical methods providing robust test of mediation hypotheses, such as SEM, maternal responsiveness and the quality of maternal caregiving were identified as mediators of the association between MDS and children's cognitive development in early childhood. These advance the field by identifying the aspects of the family environment likely to be affected by MDS, which can then be targeted as part of comprehensive intervention programs.

The mediator variables tested in the seven studies can be categorized into two of the four pathways identified in Goodman and Gotlib's model of transmission of risk: exposure to negative maternal cognitions, behaviors, and affect (i.e., mother-child interactions and maternal parenting behaviors) and stressful context of children's lives (i.e., family stress) (Goodman and Gotlib 1999). Four studies specifically tested the extent to which exposure to negative maternal, cognitions, behaviors, and affect—operationalized as maternal affect, mother-child interactions, maternal responsiveness, and maternal parenting practices—were pathways of transmission of risk for the development of children with depressed mothers. Kiernan and Huerta were concerned with both maternal cognitions, behaviors, and affect, and the stressful context of children's lives as measured by low-income status (Kiernan and Huerta 2008). However, they tested the role of MDS as a mediator of the association between low-income status (a proxy for stressful environments) and child development, rather than testing the mediating role of low income in the association between MDS and child development. The direction of causality in the association between low-income and mental health problems continues to be a subject of debate among researchers (Elder and Caspi 1988; Lund et al. 2010). The remaining studies focused on the stressful context of children's lives, through measurement of the quality of the home environment (e.g., organization) and family functioning, as putative pathways of risk.

Potential explanations for divergent findings

There are a few potential explanations for the conflicting results presented in the reviewed studies. The first is that MDS, the mediators, and child outcomes were measured at different ages. For example, a parenting practice that mediates the association between MDS and cognitive outcomes for an infant may not be a significant mediator for a preschooler. The time elapsed between the exposure, mediator, and outcome variables also differed across studies. Although previous research suggests that there is no effect of timing of exposure to MDS on cognitive outcomes (Ahun et al. 2017; Brennan et al. 2000), it is plausible that the strength of the association between MDS exposure at an earlier point in time and child outcomes decreases as the child gets older, especially if the symptoms are of a low severity and do not persist over time (Brennan et al. 2000). Only one of the reviewed studies accounted for the chronicity of MDS, and they reported a significant association between chronic MDS and child outcomes at 4 to 5 years, compared to a non-significant association for early MDS (Letourneau et al. 2013). One conceptual difference between studies was the choice of potential confounders included in the mediation models. Two of the reviewed studies did not include any confounders, and only three of the remaining studies considered maternal education. Failure to account for the role of potential confounds may have led to an overestimation of the direct and indirect effects of MDS on child outcomes.

Another potential explanation for the differences in results is the use of maternal report to assess putative mediators. For example, MDS were found to predict mother-reported but not externally observed mother-child interactions (Chi and Hinshaw 2002). Population-based studies typically rely on maternal ratings of MDS, child behaviors, and the overall family environment, and such ratings can be biased by depressive/negative cognitions (Chi and Hinshaw 2002; Letourneau et al. 2013). Research suggests that behaviors self-reported by depressed mothers are more likely to be identified as mediators compared to external observations of these

same behaviors (Chi and Hinshaw 2002; Gartstein et al. 2009; Herbers et al. 2017). Moving forward, researchers should prioritize multiple-informant reports and direct observations of the home environment, mother-child interactions, and parenting practices in samples of depressed mothers.

Given the correlational nature of the majority of MDS studies, it is important that robust statistical techniques be used to test associations and that conclusions are drawn with caution since causality cannot be determined. Despite its widespread use, Baron and Kenny's (1986) mediation approach has been criticized on multiple grounds, including its low power for testing intervening variable effects (Fritz and Mackinnon 2007; Hayes 2009; MacKinnon et al. 2002). It is therefore not the most appropriate means for testing mediation. Only one study used this approach. Some studies were limited by their use of a cross-sectional design, as they were unable to account for reciprocal associations between MDS, mediators, and child outcomes. For example, MDS are associated with parenting behaviors (e.g., hostility) which influence child outcomes (Goodman and Tully 2008; Lovejoy et al. 2000). Children's behavior, in turn, can exacerbate later MDS in a transactional relationship (Bagner et al. 2013). Furthermore, cross-sectional approaches to mediation generate substantially biased estimates of longitudinal parameters by implying the existence of a significant indirect effect when the true longitudinal indirect effect is zero (Maxwell and Cole 2007; Maxwell et al. 2011). It is therefore important to rely on longitudinal designs to determine the direction of associations in mediation models.

Strengths and limitations

This review provides a detailed summary of the potential pathways through which MDS are associated with children's cognitive development. It draws upon developmental theoretical models, particularly Goodman and Gotlib's model of transmission of risk (Goodman and Gotlib 1999), to understand and interpret existing empirical evidence. This model focuses specifically on pathways within the family environment, and we are therefore unable to comment on the role of putative mediators in other early childhood environments. We reviewed studies which formally tested putative mediators of the association between MDS and children's cognitive development, and thus only a small number of studies were included. These studies were limited by their use of relatively small sample sizes; lack of repeated assessments of MDS, mediators, and child outcomes over the early childhood period; and failure to include pertinent confounders in the mediation models. The latter limitation threatens the internal validity of a given study as the reported associations between MDS, a mediator, and an outcome may be confounded by an unobserved variable. It should be noted, however, that not all reviewed studies were subject to each of these limitations.

Lack of knowledge on the associations between MDS and paternal characteristics, and the latter's impact on children's cognitive development represents a substantive limitation of these studies. Paternal depressive symptoms has been associated with more withdrawn behavior in father-child interactions (Paulson and Bazemore 2010; Sethna et al. 2015) and poorer cognitive and language development in young children (Malin et al. 2012; Paulson and Bazemore 2010; Wanless et al. 2008). Additional research is needed on the combined and independent effects of maternal and paternal depressive symptoms on child outcomes to better understand the pathways through which they influence child development (see (Goodman 2004; Paulson and Bazemore 2010) for a review on the associations between maternal and paternal depressive symptoms).

Finally, none of the reviewed studies investigated the role of gene-environment correlations in the association between MDS and children's cognitive development. Common genetic factors may contribute both to MDS and children's cognitive development (van der Waerden et al. 2016), and exposure to a risk environment could exacerbate or hinder gene expression in the child (Scarr and McCartney 1983). If a mother is depressed and the child is susceptible to cognitive or emotional problems, exposure to MDS in the home context can exacerbate the child's susceptibility. Thus, targeting aspects of the home context which explain the association between MDS and child development may be a promising avenue for prevention. Such preventive interventions can be combined with treatment of MDS—which may not be the best solution in and of itself due to its mixed effects on maternal and child outcomes (Cooper et al. 2003; Forman et al. 2007; Murray et al. 2003b; O'Hara et al. 2000)—to prevent poor outcomes in both mothers and their offspring.

Conclusion

The most significant mediators through which MDS are associated with children's cognitive development in early childhood are maternal responsiveness and the quality of maternal caregiving. But these effects, similar to the direct association between MDS and children's cognitive development, are mixed. To improve our understanding of the pathways through which MDS are associated with child development, future research should identify sources of variation in the mediating factors. These include variation as a function of the family context, age of the child, type of cognitive outcome, and nature of depressive symptoms. This information is needed to design preventative programs which target the family processes affected by maternal depressive symptoms within a comprehensive approach fostering family health and well-being.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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