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The impact of paternal mental illness on child development: an umbrella review of systematic reviews and meta-analyses

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Abstract

Background: Whilst there is growing evidence highlighting the importance of paternal mental illness (PMI) on child development, this relationship still remains under-studied, and often over-looked. Considering the increasingly active role of fathers in their children's upbringing, a comprehensive overview on the impact of PMI on child development is overdue.

Aims: To combine and synthesise current available evidence on the relationship between PMI and multiple domains of child development.

Method: Narrative synthesis of systematic reviews and meta-analyses on the relationship between PMI and child development (mental health and social, emotional, language, cognitive or adaptive behaviour), published between 1980 to December 2021, was conducted in line with PRISMA 2020 guidelines. Review quality was assessed based on AMSTAR-2 criteria and respective study confidence interpreted in line with GRADE scoring. All relevant meta-analytic effect sizes were converted to odds ratios (OR) and grouped using a random effects model.

Results: Grouped meta-analyses saw PMI to have a significant, detrimental effect on all studied domains of child development (OR: 1.54; 95% CI: [1.36-1.74]). Subgroup analyses saw PMI affecting both internalising (OR: 1.62; 95% CI: [1.27-2.08]) and externalising (OR: 1.63; 95% CI: [1.28-2.08]) child behaviours to a similar extent. However, included reviews were of poor methodological quality, demonstrating either low or critically low confidence.

Conclusion: The results show a consistent and influential effect of PMI on child development. The relationship between fathers' mental illness and child development warrants further investigation, as current research is limited in scope, particularly regarding cognitive domains of child development and non-affective PMI diagnoses.

Introduction

The transition to parenthood can be an especially challenging period, as reflected by the prevalence of mental illness in new parents. While paternal mental illness (PMI) appears to develop more gradually than that of mothers following parturition [1], meta-analytic data suggests roughly 10% of fathers experience perinatal depression [2], with the risk of depression amongst resident fathers increasing 68% during the five years following the birth of their child [3]. Men also show higher rates of anxiety [4,5] and psychological distress [6] following the transition to parenthood, with symptoms of depression and anxiety strongly confounding each other [7].

These prevalence rates are particularly important when considering child development. PMI has been shown to influence child development (CD) from infancy [8,9] to late adolescence [10,11]. Moreover, accumulating evidence indicates that PMI impacts CD to an equal extent as maternal mental illness [12], potentially even moderating the effects of maternal mental health on CD [13]. Despite this, fathers are still underrepresented in psychiatric research [14], particularly so in relation to developmental psychopathology [15]. A more focused perspective on fathers is necessary, as it appears likely that the mechanisms by which PMI could influence offspring development are different to that of mothers [16], thereby suggesting a lack of translatability from research on maternal to paternal findings.

When compared to unexposed children, the rate of emotional and behavioural developmental problems is about twice as high in children whose fathers suffer from depression [17]. However, whilst the effect of PMI on CD appears to depend on both paternal [18,19] and child [20] diagnoses, the exact domains of CD which are most impacted have not yet been elucidated. This is particularly important as different indicators of CD, such as socio-emotional, linguistic, or other cognitive outcomes, can present different problems long-term [21]. Child internalising or externalising behaviours, for example, have both been linked to children's exposure to PMI [22,23], yet would predicate different long-term problems to that of impaired cognitive development [24]. Furthermore, greater cognitive impairment has been found amongst children exposed to parental psychoses, when compared to other serious mental illnesses, suggesting a transgenerational risk specific to parental diagnosis [25]. Potential moderators such as child gender [12,26], age [27] and the chronicity of PMI [28,29], render the relationship between PMI and CD even more complex. The systematic reviews currently available, however, frequently contradict each other when interpreting these factors.

In general, it is not uncommon for systematic reviews or meta-analyses on the same research question to reach different conclusions, even when published within the same year [30]. This is particularly true when risk factors are unestablished and most likely somewhat interdependent, as is the case for studies focusing on the relationship between PMI and CD. A more comprehensive approach is then needed. In using an umbrella review, the quality and credibility of systematic reviews themselves can be taken into account. Through this, contradictions within the literature may be better understood. Another important benefit of conducting an umbrella review is the possibility to compare a wider range of empirical study methods. Often reviews place limitations on the set of methodical approaches they include to better facilitate comparisons and meta-analyses. However, the choice between self-report or diagnostic interviews for psychological research has already been shown to generate differential findings [31,32]. This is particularly pertinent when assessing the impact of PMI on CD, as both the paternal exposure and child outcome risk being susceptible to this bias.

Thus, this umbrella review aims to systematically investigate the relationship between paternal mental illness and child development, across all paternal diagnoses, measures of CD, and developmental periods. Through this approach, we aim to provide a single, comprehensive overview of recent evidence on this topic capable of spanning multiple domains of child development.

Methods

Search strategy

The protocol for this review was preregistered on PROSPERO (CRD42022298048) and conducted in accordance with the PRISMA 2020 item checklist. The only noteworthy amendment since preregistration was the expansion of inclusion criteria to all chronicities of paternal mental illness (PMI), as opposed to exclusively perinatal (0-2 years postpartum) PMI. This was on the basis of both the paucity of perinatal PMI data, and unclear time-ranges for PMI incidence within reviews.

We searched PubMed, Web of Science, PsycINFO, MEDLINE and EMBASE databases for all systematic reviews and meta-analyses of observational studies reviewing the effect of PMI on child development. Searches were conducted for studies published between 1980 and December 2021 using a predefined search strategy (**Supplementary Table 1**).

Inclusion and exclusion criteria

We included systematic reviews and meta-analyses of observational studies performed on humans that assessed the impact of common PMI diagnoses, excluding addiction due to potential pharmacological interference [33], on any measure of CD, up till the age of 19 years. Reviews fulfilling the following criteria were included: (1) Published in any language; (2) Containing a systematic review and/or meta-analysis of empirical quantitative data (including qualitative and mixed methods studies, if quantitative data on both PMI and CD were available); (3) Reporting PMI measured using a validated screening or diagnostic tool; (4) Reporting outcomes of at least one measure of child mental health, neurodevelopment and/or social, emotional, cognitive, language and regulatory behaviour. For both PMI and CD, no restrictions were made based on the type of measure (e.g. clinical interviews, self-report questionnaires), mode of administration (e.g.

telephone, face-to-face) or the individual administering the measure (e.g. clinician, parent, self-administered) and (5) If meta-analyses were conducted; the methodology, the model, publication bias, and heterogeneity issues were addressed and/or clearly reported.

Reviews were excluded when: (1) Based exclusively on non-human data; (2) Including mothers only, or parents as a group where no defined gender split was used; (3) Describing only the protocol for a review (no results reported); (4) Targeting specific risk groups (e.g. teenage fathers, im/migrants or refugees); (5) Focusing on children with a specific diagnosis of physical disability, disease or prematurity; (6) It was not possible to retrieve the full article.

All reviews meeting the inclusion criteria were screened independently by two reviewers (HS, SM) first on titles/abstracts and then full-text articles, using Rayyan software [34]. Any discrepancies in the inclusion process were resolved through discussion with a third reviewer (JW), where required. As necessary, additional information was sought from study authors to resolve questions about eligibility. The bibliographies of all eligible full texts were also searched manually for additional relevant reviews.

Data extraction

Studies that remained included after full text screen had relevant data coded and extracted by two reviewers (HS, SM), independently, with subsequent consensus achieved via discussion and collaboration with the third reviewer (JW). General review characteristics were extracted from each full-text article: Title/authors; year of publication; number of relevant included primary studies; inclusion/exclusion criteria; variables considered; number of exposed/with outcome per variable; populations; measures of PMI assessment; timing of paternal diagnosis; measure(s) of CD; timing of measure(s) of CD; literature sources; number of reviewers involved in each review process (study screening, selection, inclusion and data extraction); methods for risk of bias appraisal and quality of evidence assessment; assessment of heterogeneity; and, if meta-analyses/syntheses were performed, the (pooled) number of participants; pooled estimations of associations; and methods for pooled estimations.

Quality assessment and GRADE

In order to assess the quality of studies included in our review, the Assessment of Multiple Systematic Reviews 2 (AMSTAR-2) checklist was used [35]. Quality assessment was completed by two reviewers (HS, SM), independently and blinded, based on this proforma and the results tabulated. Any conflict between reviewers was resolved through discussion. For descriptive purposes, in line with advice from the developers, AMSTAR-2 assessments were not divided into categories based on their overall scores but rather considered based on the respective impact of each individual item [35]. Risk of bias and certainty of evidence was further examined using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria [36], again performed in parallel, blind and independently by two reviewers. The GRADE system assigns a degree of confidence to a given study's evidence, based on the study's: risk of bias; inconsistency of results; indirectness of evidence; and imprecision. Criteria were adapted to suit our review, and each article's quality of evidence ranked either "high", "moderate", "low" or "very low". "High" rankings indicated effect estimates for which further research is unlikely to change the confidence rating, whereas for "very low" the estimate of the effect is very uncertain [6].

Data synthesis and effect measures

To summarise and present the main findings for the relationship between PMI and CD, results were first analysed using a narrative synthesis conducted in accordance with the Cochrane guidance for narrative syntheses [37] and Joanna Briggs' guidelines [38]. To address any potential over-lap between reviews, the corrected covered area (CCA) was calculated and ranked [39]. To visualise relevant exposure–outcome relationships, meta-analyses were tabulated. All reported effect sizes were converted to odds ratios, and within study heterogeneity converted to the I^2 statistic [40]. Significance was determined based on 95% confidence intervals [37]. For unreported sample sizes, estimates were calculated by hand-searching the included original studies and their reported sample size. Meta-analytic results were then grouped using random effects models, based on the heterogeneity of respective study effects. Model heterogeneity was assessed using I^2 , and subgroup analyses were conducted based on CD

domain (internalising vs externalising behaviours), and each review's GRADE quality score. A funnel plot was used to examine the potential role of small study and publication bias. Data were analysed using R version 4.0.3 and RevMan 5.4.1 [41].

Results

Study selection and description

The PRISMA diagram (**Figure 1**) outlines the results of the screening process. The search yielded 4791 articles. Upon removing duplicates, 2577 titles and abstracts were eligible for screening, resulting in 154 articles valid for full-text review. Amongst these, 148 reviews were excluded (detailed in **Supplementary Table 2**). With the addition of four articles sourced from hand-searches and bibliographies, 10 reviews were thus included in the final review. Full description of the included reviews is available in **Supplementary Table 3**. Regarding the studies within the reviews themselves, the total number of included original papers was 113. Between review over-lap (CCA) was slight (3.6%). Six articles contained relevant meta-analyses, comprising 266 effect sizes in total. Year of publication for the reviews included in the umbrella review spanned 2002-2020, of which 80% were conducted in the last 10 years. Reviews were conducted in the UK (n = 3), Australia (2), USA (2), Canada (2), and China (1). Seven reviews' aims contained specific mention of fathers, with the remaining three targeting parents generally.

Study population

The total number of fathers included in all reviews was 420,526, ranging from 1235 – 273,299. Included child age ranges were unspecified in two reviews [42,43], and amongst all others ranged from 0 – 21 years, although the chosen boundaries were often unclear. Only two reviews [12,44] specified the distribution of child gender, with both averaging a 49% female population. However, one review [26] specified that the percentage of females ranged from 0-100% and another [20] stratified their results by gender.

Predictors

The timing and chronicity of PMI diagnosis were often unclear, with five reviews providing no

information at all. Amongst those that specified, relevant studies (within reviews) included time-points ranging from “before pregnancy to 1 year postpartum”, “18 weeks gestation to 21 years”, “Diagnosis at any time” and “perinatal”. The paternal diagnoses targeted by each review were: Depression (n = 4); General psychopathology (3); Mood disorders (1); Internalising symptoms (subsequently categorised as depression or anxiety) (1); and psychopathology and/or suicide related thoughts and behaviour (1). The methods of paternal assessment are shown in **Supplementary Table 3**, most commonly the Edinburgh Post-natal Depression Scale (EPDS) (5/10 reviews), with reviews including assessments based on father self-reports (8), diagnostic interviews (4), National registries (3), spousal reports (1) and medical records (1).

Outcome

Included measures of CD were as follows: Internalising (3/10 reviews) and externalising (4) behaviours; Anxiety and depression (1); Autism (1); Socioemotional and behavioural development (1); Suicide-related thoughts (1); Negative affectivity (1); and “emotional, behavioural and internalising/externalising problems, impaired social functioning, depression, “low development and wellbeing”, and behavioural or oppositional defiant disorder” (1). Reviews primarily included assessments based on parent (n = 7) and self-reports (7), followed by medical records (4), teacher reports (3), observer reports (3), clinical assessment (4) and National registries (1). A complete list of all specific methods used to measure CD is shown in **Supplementary Table 3**, most commonly the Child Behaviour Checklist (6), ICD codes (4) and the Strength and Difficulties Questionnaire (4).

Subgroups/confounders

Regarding subgroup analyses, five reviews stratified results based on specific child outcomes, and two for the assessment mode of child symptoms. For PMI, four reviews grouped results based on the type of psychopathology, two on the timing of psychopathology and two on the mode of assessment. Only two reviews stratified by child gender, and one by child age. Several also grouped analyses based on study design (cohort study or case-control study) or type of publication (2), recruitment method (2) and study country (1). The most common confounders reviews accounted for were child

gender (4), fathers' age (4), socioeconomic status (4) and mothers' substance use (4). Four reviews were unable to adjust for confounders due to data unavailability.

Main findings

Amongst the 10 included reviews, eight concluded that there is a significant association between PMI and CD, whilst two found no apparent association [43,44]. The child outcomes for those with non-significant findings were autism spectrum disorder and suicide-related thoughts or attempts. Amongst those with significant findings, associations were seen between PMI and offspring internalising and externalising behaviours, negative affect, emotional and behavioural problems, mental health (depression) and language development. Regarding differences between domains, three reviews [20,23,42] found that PMI associated more strongly to children's internalising problems than externalising.

Wickersham et al. [12] saw only fathers' depression to have a significant effect on CD (mental health), with the influence of other PMI diagnoses inconclusive. Spry et al. [45] found no difference in effect size based on paternal diagnosis (anxiety vs depression), however associations to CD (negative affectivity) were larger for postnatal PMI when compared to antenatal. In support of this, Stein et al. [46] found that antenatal depression did not affect CD (depression) at 18 years, whereas postnatal depression did. The persistence of PMI was also seen to increase the risk of child adverse outcomes.

Two studies [23,45] saw the associations between PMI (depression, internalising symptoms) and CD (emotional and behavioural problems, negative affectivity) were already evident in infancy, as early as 2 months. The effects of PMI were seen to extend as late as 17-21 years [12,23,46]. Amongst those that stratified for child age, only one study [26] found age to be a non-significant factor. Sweeney [23], Cui [47] and Stein et al. [46] found the association between PMI (depression) and CD (emotional and behavioural problems) to be stronger with younger aged children. However, for Stein et al. this depended on the period PMI emerged (postnatal vs antenatal). Contrary to this, Connell and Goodman [20] saw larger effect sizes for

internalising and externalising problems in older children (mean age ≥ 13).

Whilst Kane and Garber [42] found the gender composition of study samples to have no significant influence on the association between PMI and CD, Cheung and Theule [26] observed that samples with a higher percentage of boys yielded larger effect sizes for child externalising problems. However, Connell and Goodman [20] found PMI more strongly associated with externalising problems in girls than boys. Wickersham et al. [12] found the effect of gender to be inconclusive, depending on PMI diagnosis and trajectory.

Confounders

Stein et al. [46] saw both low socioeconomic status (SES) and an absence of social support (including partner support) significantly increased adverse child outcomes in response to PMI. Moreover, children experiencing social disadvantage, particularly in lower-income countries, were more likely to be exposed to PMI. Cui et al. [47] also noted that several studies found the association between PMI and CD was affected by "socioeconomic circumstances", in the narrative sense, whilst Kane and Garber [42] found SES had no significant influence on findings. However, amongst these reviews, the measures of SES were unclear and there was no description of how SES was categorised.

Sweeney and MacBeth [23] found that the association between PMI and CD (internalising and externalising behaviours) was strongly reliant on marital conflict, whereas Cheung and Theule [26] found fathers' relationship status to exert no effect. Both Cheung and Theule [26] and Kane and Garber [42] found the ethnic composition of samples to have no significant influence on findings.

Study design

Study location [26], and the informant of CD [42] did not predict the strength of the found associations, however the measure used for child symptoms was a significant factor. Larger effect sizes were seen amongst studies using continuous measures of child internalising symptoms. Whilst Kane and Garber [42] found the measure of PMI (depression) to also be insignificant, Connell and Goodman [20] saw effect size varied from largest to smallest in the following order: direct interviews from fathers;

indirect reports from mothers; and indirect reports from non-spousal multiple informants. For children's externalising problems, Connell and Goodman found that studies published more recently had smaller effect sizes, however all included studies were published prior to 2001. Two reviews [26, 45] found study publication status had no impact on effect size.

Quality assessment and GRADE

Amongst those that specified ($n = 5$), four reviews used multiple reviewers for both title/abstract and full-text screening, and amongst those that specified ($n = 9$), all used multiple reviewers for data extraction. Seven reviews stated that disagreements between reviewers during screening were resolved by consensus, amongst which four provided a statistical measure of inter-rater reliability. Only seven reviews specified an approved, validated quality assessment tool, most commonly measuring publication bias via Egger's regression ($n = 4$). Three reviews failed to mention quality assessment altogether [20,42,46].

The quality rating of included reviews is shown in **Table 1**, with all reviews demonstrating low or critically low methodological confidence. No studies fulfilled all possible critical domains for meta-analyses (including 'partial yes'), scoring 3.8 (out of 7) on average. The same was true for non-meta-analytic reviews, scoring 3.3 (out of 5) on average. The most common weakness was a failure to report the individual funding sources of included studies (100% of reviews) and information on excluded articles (100%). Reviews also often lacked an explanation of their choice of included study designs (80%); statements declaring the preregistration or establishment of their protocol prior to conducting the review (70%); and, amongst meta-analyses, sufficient assessment of the impact of risk of bias on their results (67%). The best-performing categories were inclusion of PICO criteria (90% of reviews); the use of at least two reviewers for data-extraction (90%); and, amongst meta-analyses, the use of appropriate methodology (83%) and assessment of publication bias (83%). GRADE scores ranged from low ($n = 3$) to very low ($n = 7$), with the confidence in each reviews' results being downgraded based on their inconsistency (100%); risk of bias (60%); imprecision (60%); and indirectness (50%).

Meta-analyses

The results of all six relevant meta-analyses within this review are shown in **Figure 2**, comprising 10 effect sizes. The funnel plot (**Supplementary Figure 1**) was symmetrical, indicating low risk of publication bias. The total number of included fathers was 358,546, ranging 1157-104,387. All analyses applied random-effect modelling, with pooled heterogeneity (I^2) ranging from 5.3% - 88.5%. Included indicators of PMI were as follows: Depression (4); Perinatal depression (3); Affective disorders (1); Internalising symptoms (1), and general mental health (2). CD outcomes were as follows: Internalising (2) and externalising (3) behaviours; General behavioural problems (1); Emotional problems (1); Social development (1); Negative affectivity (1); and autism-spectrum disorders (ASD) (1). All showed a significant relationship between predictor and outcome, except three: Depression and ASD [43], affective disorders and ASD [43], and depression and social development [47].

Our results for the grouped meta-analyses found the overall effect of PMI on CD to be significant (OR: 1.54; 95% CI: [1.36-1.74]). Total heterogeneity was high ($I^2 = 93\%$). Grouped meta-analyses were also recalculated without Ayano et al. [43], being the only study to measure neurodevelopmental disorders. The effect of PMI on CD remained significant (OR: 1.58; 95% CI: [1.39-1.80]).

Sub-group analyses

Grouped meta-analyses were recalculated based on those describing specific child developmental output (internalising/externalising behaviours) (**Figure 2**). The effect of PMI was highly similar for both internalising (OR: 1.62; 95% CI: [1.27-2.08]) and externalising (OR: 1.63; 95% CI: [1.28-2.08]) behaviours. Total heterogeneity (I^2) across all study effect sizes was 97% for externalising, and 96% for internalising behaviours. Sensitivity analyses were also conducted based on each review's quality, based on GRADE scores ("Low" vs "Very low") (**Supplementary Figure 2**). Better quality reviews found a stronger relationship between PMI and CD (OR: 1.91; 95% CI: [1.58-2.32]) than lower quality reviews (OR: 1.41; 95% CI: [1.22-1.64]).

Discussion

We conducted an umbrella review of all systematic literature currently available on the relationship between paternal mental health problems and child developmental outcomes. Including narrative findings, the relationship between PMI and CD remained consistently significant except for studies on offspring autism or suicidal thoughts. PMI was seen to associate with CD from infancy through to late adolescence. Whilst results were highly heterogeneous, there appeared no clear significant differences in impact based on child gender, age and methods of PMI or CD assessment. Grouped meta-analyses saw the pooled effect of PMI on child development to be significant, with subgroup analyses showing effect sizes for both internalising and externalising behaviours to be of equal size.

Child developmental output

The risk for adverse child developmental outcomes was about 50% higher in children whose father experienced symptoms of mental illness, with both internalising and externalising behaviours found to be impacted to an equal extent (62-63% increased risk). This is somewhat surprising, as the literature suggests children are more likely to exhibit the same psychopathology as their parents [25,50], seen also amongst the narrative reviews within this study [20,23,42]. Considering the majority (5/7) of the included meta-analyses used were based on paternal depression, one would then expect the association with internalising behaviours to appear stronger. However, in an investigation on the taxonomies of child psychopathology, Lahey et al. [51] found a strong correlation between child (4-17 years) internalising and externalising symptoms, arguing that this intercorrelation is inherent to child and adolescent psychopathology. An alternative explanation is, paradoxically, that the higher proportion of depression studies included in our analyses could have driven this finding. Research on mothers and fathers (grouped) found that, after accounting for genetic transmission, parental depression associated with both offspring internalising and externalising problems from toddlerhood to adolescence [52]. However, anxiety was linked to only internalising symptoms. Thus, the lack of

inclusion of anxiety-based diagnoses may have prevented the opportunity to see specific relationships to either internal or external behaviours.

Although based on only one review [43], there does not appear to be a significant relationship between PMI and neurodevelopmental disorders, in this instance autism spectrum disorder (ASD). Current knowledge on the pathogenesis of autism indicates a lack of association between the development of ASD and post-natal exposures [53,54]. Whilst an epigenetic link between prenatal factors and ASD has been hypothesised [55,56], only one study relevant to paternal analyses (included by Ayano et al.) used prenatal exposures [57].

Aside from this, investigations on other domains of CD, such as language and cognition, were sparse, with 80% of reviews focusing exclusively on socioemotional development. The lack of discussion on child language is noteworthy, as maternal mental illness has been seen to associate with child language impairment [58], alongside distinct neuroanatomical changes in children's language-related regions [59,60]. Within our study, the only review to have included investigation on this [46] saw that postnatal PMI increased the risk of language problems amongst exposed children. Considering early language impairment can influence both socioeconomic and psychological progress in later life [61, 62, 63], the relationship between PMI and language development warrants investigation.

Timing and long-term impact of PMI

No clear sensitive period of child development was seen in relation to PMI. Due to the complex inter-dependence of different stages of development, determining meaningful, distinctive age-brackets at which child outcomes can be studied is challenging [64]. Both the heterogeneity of age categories used, and data paucity, meant we were unable to perform subgroup analyses based on this moderator. Nevertheless, several included reviews did provide either moderator or stratified analyses based on child age. Amongst these, results were contradictory. Whilst Cheung and Theule [26] did not see child age to be significant moderator, two reviews [20,46] saw that for both externalising and internalising symptoms, larger effects of PMI were seen amongst older children. However,

Sweeney and Macbeth [23] found the opposite; in reviewing studies on children from infancy to 21 years old, associations between PMI and externalising and internalising behaviours were stronger and more common in early childhood [65]. This is supported by Cui et al. [47], who saw the same pattern for children's emotional and behavioural development.

For perinatal assessments, the effect size between PMI and CD (from infancy to late adolescence) appeared larger in studies where paternal symptoms were assessed postnatally as opposed to antenatally [23,45,46]. This suggests children's postnatal exposure to PMI is more influential than potential epigenetic pathways, or indirect prenatal responses to PMI via the mother (e.g. maternal stress). In support of this, some reviews have shown father-child interactions to moderate the impact of PMI on CD [23,42], as well as the degree of paternal involvement [23,28]. Paternal involvement has even been seen to reduce the severity of internalising behaviours in children with depressed mothers [66]. It is likely that the impact of PMI also depends on children's frequency of exposure to PMI during their lifetime, although empirical data supporting this is currently inconclusive [67,68].

Whilst the majority of reviews (70%) included measures of CD spanning infancy to adolescence, the longitudinal relationship between PMI and CD was rarely discussed. In general, research on the longitudinal trajectory of PMI is incredibly limited, rarely exceeding the first five years post-partum. This was reflected in our included reviews, where even after expanding our criteria to include any occurrence of PMI, three out of the five reviews that specified timing focused on exclusively on perinatal PMI. Included reviews frequently failed to provide the timeframe paternal symptoms occurred when giving context to their results. Moreover, the original research studies included within the reviews themselves also often unspecified their chosen range of PMI temporalities, thereby limiting the reviewers. For instance, Goodday et al. [44] highlighted that, despite investigating CD from 0-25 years, 69% of studies failed to report the timepoint PMI was measured. However, arguably the most frequently addressed weakness by reviewers themselves was the limitation in being able to assess bidirectionality between PMI and CD. Children's behavioural traits can influence paternal responses towards them, in turn exacerbating negative outcomes for the child

[69]. An increase in longitudinal assessments is necessary to better understand the trajectories of the relationship between PMI and child development.

Role of child gender

For child gender, our findings challenge the frequently made assumption that PMI has a greater effect on male offspring than female. Most commonly, reviews reported no clear distinction in effect size based on gender. It has been posited that whilst externalising problems are generally more frequent amongst male children, mothers engage in more positive behaviours towards their sons when the father is depressed, compared to daughters [70]. This maternal engagement could then counteract the expected increase in externalising problems amongst boys. Alternately, it has been argued that an increased empathy among young girls towards others renders them more vulnerable to the effects of PMI, thereby offsetting the increased amount of time boys are thought to spend with their fathers [23]. In support of this, research has shown that when exposed to secondary trauma, e.g. adverse events or the fictional suffering of others, female children report greater distress than their male counterparts [71,72]. Several reviews addressed their limitations towards assessing gender discretely, with data being too heterogenous, or limited to specific CD outputs based on gender (e.g. behavioural problems investigated exclusively amongst boys) [20,44,47]. For this reason, it remains unclear how much of the inconsistency surrounding gender-based findings is due to non-significance or simply heterogeneity in data collection and analyses.

Paternal diagnosis

The homogeneity of included PMI diagnoses amongst meta-analyses (60% of which comprised depression or affective disorders, and the remaining 40% more general psychopathology) limited meaningful subgroup analyses. This assumed focus on depression may be unwarranted, considering research shows paternal anxiety might actually be more prevalent than paternal depression [48,49]. The only meta-analysis to compare the two [45] saw no difference in the effect on CD between both diagnoses. Nevertheless, amongst narrative reviews, results were mixed. Wickersham [12] found an association to adolescent depression and anxiety was present only for paternal

depression, with all other PMI diagnoses inconclusive (anxiety, ASPD, ADHD, PTSD and non-specific psychopathology). However, investigation of each of these alternative diagnoses was greatly restricted by the number of empirical studies available, with each being based on less than three. In line with this, Connell and Goodman [20] decided against subgroup analyses based on PMI diagnoses (ASPD, schizophrenia, bipolar disorder) due to each having under five studies. These reviews highlight the need for empirical investigation on a wider range of paternal disorders.

Mode of PMI/CD assessment

Two reviews [26, 42] found neither the informant for PMI (depression) nor CD (internalising/externalising behaviours) significantly impacted meta-analyses. However, Connell and Goodman [20] found that the choice of informant for both PMI and CD exerted a significant effect on the association between the two. Studies relying on direct interviews with fathers generated larger effect sizes than those based on medical records or multiple informants. This is particularly interesting, considering men are known to underestimate depressive symptomology [31,32], which would in turn minimise any given association between PMI and CD. Connell and Goodman's result may be explained by the far greater frequency of data based on self-reports ($n = 40$) than other means (Spousal report = 4; Chart review = 3), in turn over-inflating the effect size driven by self-reports. Regarding the measure of CD, they saw children's reports for both internalising and externalising behaviours yield the largest effect size. However, this conclusion ignored the potential confounding influence of age, which is likely, seeing as younger children would be unable to 'self-report'. This is particularly pertinent considering they included children aged 1.7 to 17.5 years, alongside finding larger effect sizes amongst older children. When combining this with the non-significant findings of the only other reviews to investigate this [26, 42], it appears that neither the informant for CD nor PMI assessment exert a significant effect on the relationship between the two, suggesting a reliable association between CD and PMI independent of research methods.

Reviews' methodology

Pooled results from higher quality reviews found a stronger association between PMI and CD than

lower quality reviews. However, overall, the average quality of the reviews relevant to our study question was very low. Whilst AMSTAR-2 scores typically include more than one non-critical weakness (i.e. fall below "moderate") [73], several methodological elements of the included reviews are causes for concern. The lack of a clear, explicit quality assessment amongst reviews was unexpected, especially considering 80% were published in the last 10 years. This greatly limits the validity of each review's respective findings, particularly when inclusion criteria were often extremely broad, including unpublished literature [26,42,45] and not excluding studies based on the quality of methodology [42]. The failure to report sample sizes was also concerning, particularly for meta-analyses. This once again limits the confidence in each reviews' findings, especially considering the range in sample sizes seen.

Another issue seen consistently across the articles included in this umbrella review is the insufficient description of study sample demographics. The socioeconomic status (SES) of samples was both underreported and rarely discussed. SES has been shown to influence both the prevalence of PMI [74,75] and child mental illness [76,77]. Moreover, amongst one of the only reviews to account for this [46], low SES was seen to accentuate the association between paternal psychopathology and adverse outcomes. Considering the known difficulties accessing proper care and mental health support amongst populations experiencing social adversity [78], these findings warrant greater inclusion in future research.

Strengths and limitations

This synthesis of systematic reviews and meta-analyses provides a multi-faceted analysis previously unavailable in the current literature, encompassing all available data unrestricted by PMI diagnosis and CD measure. This broader outlook is indispensable, considering the complex and interdependent nature of different domains of child development [79]. We employed a rigorous approach to both screening and data extraction, conducted in parallel by three researchers from multiple disciplines. Assessments of respective study quality, risk of bias and certainty of evidence were all performed using approved and validated tools. This review is therefore able to provide a higher-level analysis of the relationship between PMI and CD

in the context of a reliable measure of study quality and methodology.

Nevertheless, this study has limitations to address. Firstly, through conducting an umbrella review, we were only able to report the findings described by the reviews themselves. This is a potential source of bias, as authors would have selectively chosen which elements to report. Moreover, the thresholds for significance were reliant on reviews' own methodology. Fortunately, performing grouped meta-analyses based on each review's raw data, as opposed to their self-generated statistics, allowed us to reduce the potential bias created through reviews' respective interpretations. In the subsequent synthesis and discussion of results, these grouped meta-analytic findings were also given greater priority than results based on solely narrative review. Another limitation is that, whilst originally aiming to assess the effect of solely perinatal (0-2 years post-partum) PMI on CD, the underreporting of PMI temporality amongst included reviews made this unfeasible. However, broadening the inclusion criteria allowed us to assess a far greater range of literature, especially considering the breadth of child ages we wished to consider. As research on perinatal PMI becomes increasingly prevalent, an updated review looking exclusively at this developmental window may be possible.

Wider implications

The publication dates of studies included in this review, 80% of which were in the last 10 years, are indicative of the shift towards fathers' increased relevance to mental health research. However, they still remain hugely under-represented in research on the intergenerational transmission of mental illness [14,15]. Amongst the reviews included in this study, results were often only given for fathers in the context of the mother's mental health (e.g. [20]). This once again reinforces the notion of fathers' taking second place in the family-unit, which qualitative research has shown depressed fathers feel to be a key cause of their symptoms [81,82]. Recent developments on legislative procedures, such as global increases to fathers' rights to paternity leave [83], and physical custody [84], reveal a growing shift from a sole focus on mothers to a more holistic family unit. Moreover, the number of single-parent households is also rapidly increasing [85], with single fathers showing over double the risk of a common mental disorder

compared to those in dual-parent households [74]. Future research on PMI and CD would benefit from greater inclusivity of alternative family dynamics, alongside increased consideration of the father and mother as equal, collaborative, forces rather than two discrete influences [13].

Conclusion

Across reviews, symptoms of paternal mental illness appeared to exert a significant, negative effect on child development. The association between PMI and CD was seen to span infancy to adolescence, across all studied domains of child development except autism. However, CD outcomes investigated were primarily limited to socio-emotional behaviours, most notably lacking cognitive domains. The relationship between PMI and CD was not seen to depend on child gender. Regarding child age, results were highly heterogeneous, indicating that differential effects based on child age-bracket may be in fact related more so to the chronicity and severity of PMI. Notably, across reviews, study quality was poor, and sub-group analyses were limited by the paucity of data and reported sample demographics. Increased inclusion of fathers in mental health research is necessary to better understand the factors moderating this relationship, particularly in relation to longitudinal trajectories.

Author contributions HS and JvdW conceived and designed the study. HS, JvdW and SM contributed to the database preparation and interpretation of the data. HS and SM conducted data analyses and assessed review quality using AMSTAR-2 and GRADE. HS drafted the manuscript. All authors critically reviewed and revised the manuscript and approved the final manuscript for publication.

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Statements and declarations

Competing interests The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. For the purpose of Open Access, a CC-BY public copyright licence has been applied by the authors to the present document and will be applied to all subsequent versions up to the Author Accepted Manuscript arising from this submission.

Ethics statement ICMJE forms are in the supplementary material, available online.

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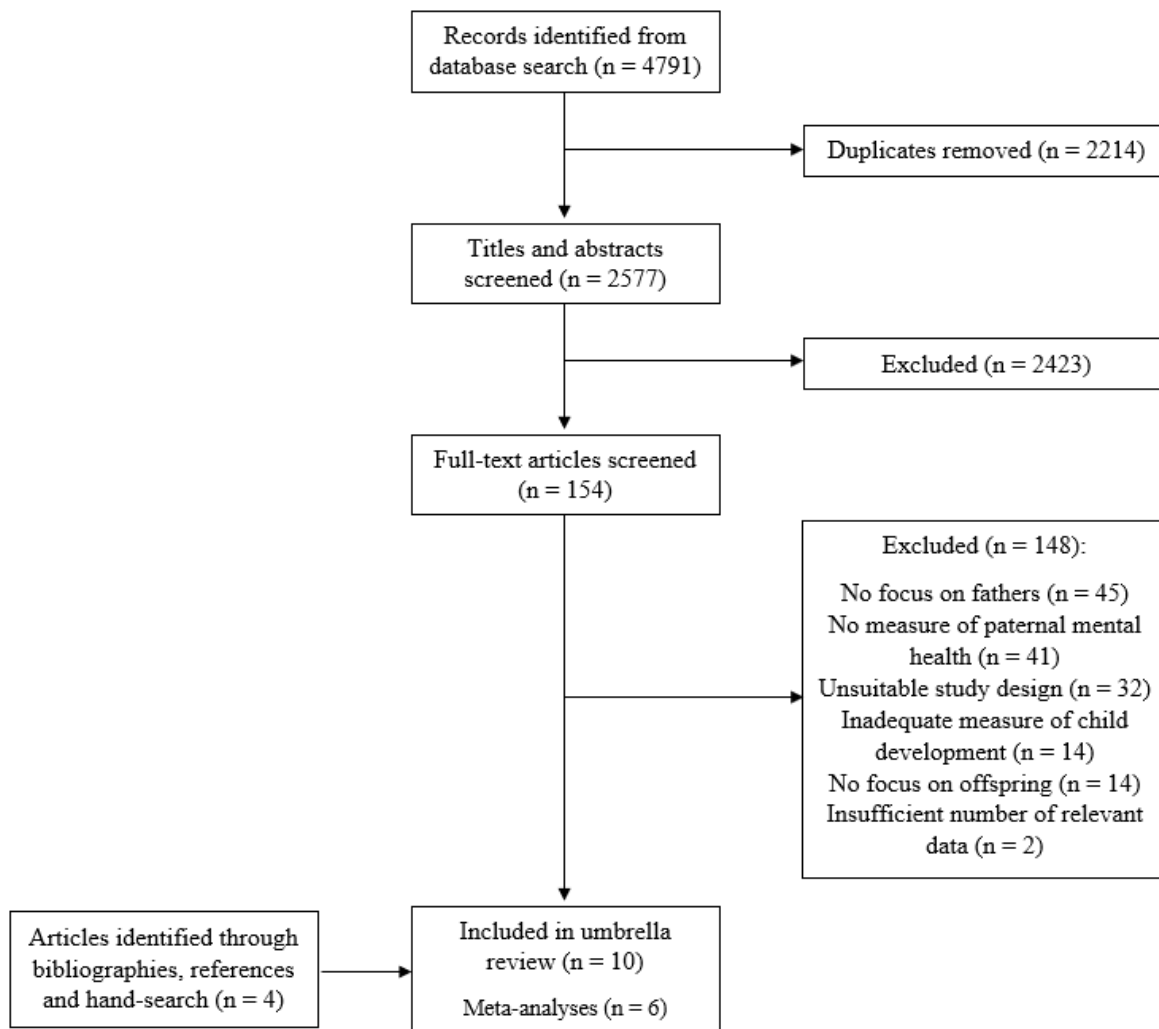


Figure 1 – PRISMA diagram of the study selection process

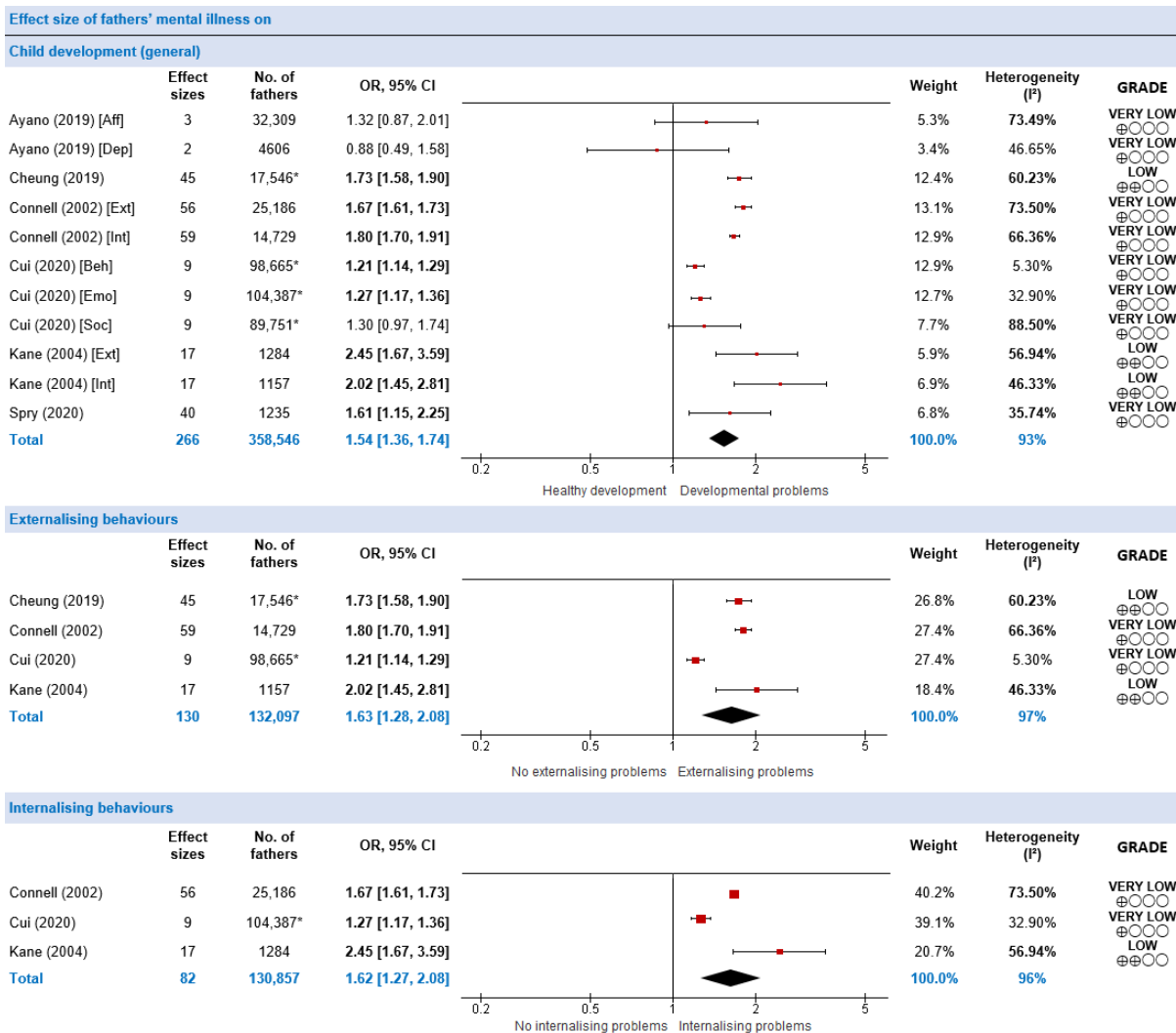


Figure 2 – Individual and grouped meta-analyses on the effect of paternal mental illness on child development (Randomised Effect, 95% Confidence Interval). *Calculated estimate, actual value unspecified by authors

Table 1 Critical appraisal of the systematic reviews and meta-analyses using the AMSTAR-2

	Ayano (2019)	Cheung (2019)	Connell (2002)	Cui (2020)	Goodday (2019)	Kane (2004)	Spry (2020)	Stein (2014)	Sweeney (2016)	Wickersham (2020)
PICO components	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
A priori protocol	No	No	No	No	Partial yes	No	Yes	No	No	Partial yes
Explanation of study design	No	No	No	No	No	Yes	Yes	No	No	No
Comprehensive literature search strategy	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes	Partial yes
Study selection in duplicate	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes
Data extraction in duplicate	No	No	No	No	No	No	No	No	No	Yes
Excluded studies justified	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No
Description of included studies	Partial yes	Partial yes	No	No	Partial yes	No	Partial yes	Partial yes	Partial yes	Partial yes
Risk of bias (RoB) assessment	Partial yes	Partial yes	No	No	Partial yes	No	Yes	No	Partial yes	Partial yes
Reported sources of funding	No	No	No	No	No	No	No	No	No	No
Appropriate meta-analyses (MA) methods	Yes	No	Yes	Yes	No MA	Yes	Yes	No MA	No MA	No MA
Assessed impact RoB on results (MA)	No	No	Yes	No	No MA	No	Yes	No MA	No MA	No MA
Accounted for RoB in interpretation of results	Yes	Yes	No	No	Yes	No	Yes	No	Yes	Yes
Explanation of heterogeneity	Yes	No	No	Yes	No	Yes	Yes	No	No	No
Assessed and discussed publication bias	Yes	Yes	No	Yes	No MA	Yes	Yes	No MA	No MA	No MA
Conflict of interest declared	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes
<i>Total number of critical weaknesses</i>	2	3	5	4	1	4	1	5	1	1
<i>Total number of non-critical weaknesses</i>	3	6	7	5	3	5	2	4	4	3