



La santé mentale du père et le développement des enfants

Honor Scarlett

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La santé mentale du père et le développement des enfants

[Father's mental health and child development]

par

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Thèse de doctorat de Epidémiologie Sociale et Santé Publique

dirigée par

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Cette thèse a été réalisée au sein de l'équipe de recherche en épidémiologie sociale ERES (Équipe de Recherche en Épidémiologie Sociale) dirigée par Maria Melchior à l'Institut Pierre Louis d'Épidémiologie et de Santé Publique (IPLESP) IPLESP UMR-S 1136.

This thesis was carried out in the Social Epidemiology research team ERES (Équipe de Recherche en Épidémiologie Sociale) led by Maria Melchior at the Pierre Louis Institute of Epidemiology and Public Health (IPLESP; Institut Pierre Louis d'Épidémiologie et de Santé Publique) UMR-S 1136.

Short abstract

The transition to parenthood can be a challenging time, often exacerbating factors known to associate with mental illness, such as increased stress, lifestyle changes, reduced social support and sleep deprivation. Whilst maternal mental health during this period is well researched, that of fathers remains understudied and often overlooked. Accumulating evidence suggests that paternal mental health may impact their child's subsequent development. However, results are inconsistent and the influence of contextual moderators remains largely unexplored.

This thesis presents empirical findings based on two cohorts: CONSTANCES, a large-scale, prospective observational cohort conducted across France, and SEPAGES, a smaller parent-child cohort based in the Grenoble region. Both cohorts assessed fathers' mental health, pre and postnatally, through validated self-report measures, and both anxiety and depression were included in all investigations. Within SEPAGES, child socioemotional, behavioural and cognitive development was evaluated at ages two and three using multiple assessment tools administered by parents as well as trained neuropsychologists. Additionally, an umbrella review was also conducted, providing a systematic overview of the current evidence on the relationship between paternal mental illness and child development. In all investigations, social, economic and maternal factors were also included where available, and examined as either confounding or moderating factors.

In our first investigation, amongst first-time fathers in France ($n = 6299$), mental health declined from two-years prior to their child's arrival and improved from two-years after. Levels of self-declared anxiety (averaging 6.5%) exceeded that of depression ($\sim 2.7\%$) or other disorders. However, rates of clinically significant symptom scores ($\sim 22.1\%$) were consistently higher. Risk factors associated with worsening mental health over time included unemployment, not living with one's partner, adverse childhood experiences and foregoing healthcare due to financial reasons.

In the second part of this thesis, grouped meta-analyses saw paternal mental illness to have a significant, negative effect on all studied domains of child development [OR: 1.54; 95% CI (1.36–1.74)]. Higher quality reviews found a stronger relationship between paternal mental illness and child outcomes. However, research focused primarily on paternal mood disorders and child socioemotional development, with limited studies on other paternal diagnoses or child outcomes.

Finally, the third study saw no significant association between paternal mental illness and child development at neither two nor three years of age. This was seen for both paternal anxiety and depression, at three discrete timepoints (pregnancy, and 0-12 and 12-24 months postpartum). This non-significance may be explained by the high socioeconomic status of SEPAGES, with 94-98% of fathers in employment and 98% with a baccalaureate degree or higher. Mothers' professional class was found to moderate the association between paternal anxiety and multiple domains of child development.

The findings presented in this thesis highlight an increased vulnerability to mental illness amongst fathers in the years surrounding their first child's arrival, with a tendency towards symptoms of anxiety. No difference was seen in relation to child outcomes; however, findings were limited to certain developmental domains. Considering the majority of risk factors associating with paternal mental illness are also known to associate with adverse child development, certain families, such as single-parent or those of low socioeconomic status, are at heightened risk for intergenerational patterns of adversity. Future research should make a concerted effort to better include these populations. The high rate of undiagnosed mental illness seen amongst fathers also emphasises the need for increased education and reduced stigma surrounding paternal mental health.

Keywords: Mental health, child, father, anxiety, depression, development

Résumé succinct

La transition vers la parentalité peut être une période difficile, accentuant de nombreux facteurs connus pour être associés aux troubles de santé mentale, tels que l'augmentation du stress, la réduction du soutien social et le manque de sommeil. Si la santé mentale des mères pendant cette période fait l'objet de nombreuses recherches, celle des pères reste peu étudiée et souvent négligée. En outre, les preuves selon lesquelles la santé mentale du père peut avoir un impact sur le développement ultérieur de l'enfant s'accumulent. Toutefois, les données ne sont pas cohérentes et l'influence des modérateurs contextuels reste indéterminée.

Les résultats empiriques de cette thèse s'appuient sur deux cohortes : CONSTANCES, une cohorte nationale d'observation prospective à grande échelle, et SEPAGES, une cohorte plus petite de parents et d'enfants basée dans la région de Grenoble. Dans les deux cohortes, la santé mentale des pères a été évaluée à l'aide de questionnaires validés, avant et après la naissance, et ont inclus des mesures de l'anxiété et de la dépression. Dans SEPAGES, le développement socio-émotionnel et comportemental de l'enfant a été mesuré à deux et trois ans, à l'aide de divers outils d'évaluation et par des neuropsychologues qualifiés. Parallèlement à ces études, une revue systématique a également été réalisée, offrant une vue d'ensemble de la relation entre la santé mentale du père et le développement de l'enfant. Dans toutes les études, les facteurs sociaux, économiques et maternels ont été inclus lorsqu'ils étaient disponibles, et testés en tant que facteurs de confusion ou de modération.

Dans la première étude, nous avons constaté que, parmi les pères primipares en France ($n=6299$), la santé mentale semblait se détériorer deux ans avant l'arrivée de l'enfant et s'améliorer deux ans après. Les niveaux d'anxiété déclarée ($\sim 6,5\%$) dépassent ceux de la dépression ($\sim 2,7\%$) ou d'autres troubles. Cependant, les taux de symptômes cliniquement significatifs ($\sim 22,1\%$) étaient systématiquement plus élevés. Les facteurs de risque associés à l'aggravation de la santé mentale au fil du temps comprenaient le chômage, le fait de ne pas vivre avec son partenaire, les expériences négatives de l'enfance et les difficultés financières.

Dans la deuxième partie de notre thèse, des méta-analyses groupées ont montré que la maladie mentale paternelle avait un effet négatif significatif sur tous les domaines étudiés du développement de l'enfant [OR: 1,54; IC à 95 % (1,36-1,74)]. Cependant, la recherche se limitait principalement à la dépression paternelle au développement socio-émotionnel de l'enfant.

Enfin, notre troisième étude n'a révélé aucune association significative entre l'anxiété et la dépression paternelles et le développement de l'enfant, que ce soit à deux ou à trois ans. Cette non-significativité peut s'expliquer par le statut socio-économique élevé de SEPAGES, 94 à 98 % des pères ayant un emploi et 98 % étant titulaires d'au moins un baccalauréat. La classe professionnelle des mères s'est avérée modérer l'association entre l'anxiété paternelle et de multiples domaines du développement de l'enfant.

Les résultats présentés dans cette thèse mettent en évidence une vulnérabilité accrue aux troubles de santé mentale chez les pères dans les années entourant l'arrivée de leur premier enfant, avec une tendance aux symptômes d'anxiété. Étant donné que la majorité des facteurs de risque associés à la maladie mentale paternelle sont également connus pour être associés à un développement défavorable de l'enfant, certaines familles sont clairement exposées à des schémas intergénérationnels de difficultés. Les recherches futures devraient donc faire un effort concerté pour mieux inclure les familles à faible niveau socio-économique ou monoparentales. Le taux élevé de maladies mentales non diagnostiquées chez les pères souligne également la nécessité de renforcer l'éducation et de réduire la stigmatisation entourant la santé mentale paternelle.

Mots clés : Santé mentale, enfant, père, anxiété, dépression, développement

Abstract for the general public

Parenthood can be mentally challenging, yet father's mental health and its relation to child development is often overlooked. This thesis found that men are at an increased risk of mental illness, most commonly anxiety, during the transition to fatherhood, with a high rate of underdiagnosis. In reviewing the literature, we found a significant association between fathers' mental illness and child development from infancy to late adolescence. However, our study on a cohort of French families found no significant relationship between paternal depression nor anxiety and child development at two and three years of age. This may be due to our sample's unusually high levels of employment and education among fathers. This thesis highlights the vulnerability of father's mental health during the transition to fatherhood. Whilst paternal mental health may influence child development, further research is needed to explore this relationship in less privileged families often excluded from research.

Résumé de thèse vulgarisé pour le grand public

La parentalité peut présenter des défis psychologiques, mais la santé mentale des pères et sa relation avec le développement de l'enfant a souvent été négligé. Cette thèse démontre qu'au cours de la transition vers la paternité, les hommes étaient exposés à un risque accru de dépression et surtout d'anxiété, avec un taux élevé de sous-diagnostic. Notre revue de la littérature a établi une association significative entre les troubles psychiques des pères et le développement de l'enfant, de la naissance à l'adolescence. Cependant, notre étude finale a démontré l'absence de relation significative entre la dépression ou l'anxiété paternelle et le développement de l'enfant à deux et trois ans, peut-être due aux taux élevés d'emploi et d'éducation de notre échantillon. Ainsi, la santé mentale du père pendant la transition vers la paternité semble avoir un impact sur le développement de l'enfant. Des recherches sont nécessaires pour explorer cette relation dans les familles moins privilégiées.

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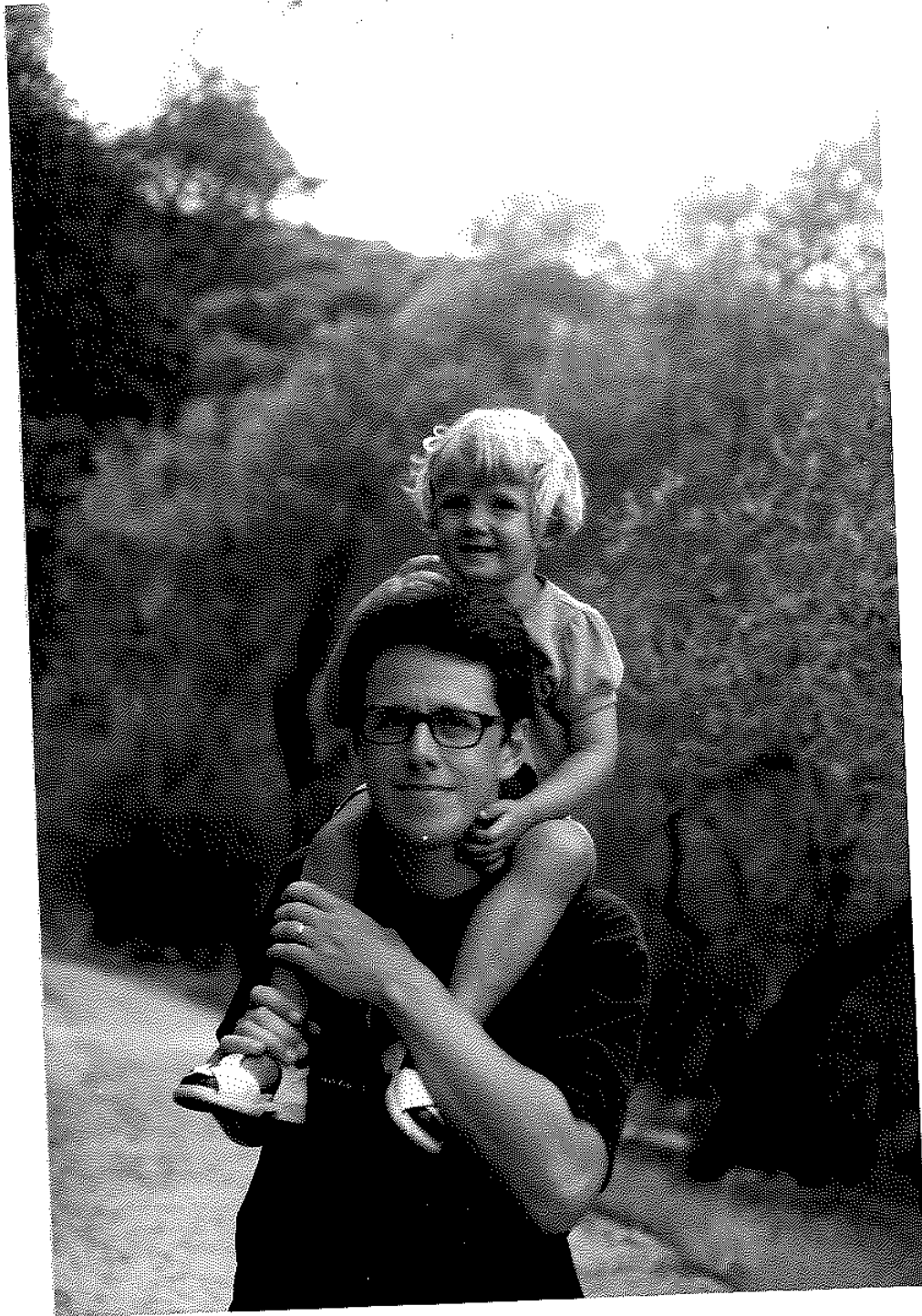


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Long résumé de thèse

Contexte

Alors que la recherche sur l'influence des parents sur le développement de l'enfant a historiquement privilégié l'étude des mères (1), l'intérêt académique pour la paternité s'est progressivement développé au cours du 20^{ème} siècle (2,3). Cependant, les pères sont encore souvent exclus des recherches sur la santé mentale des parents et le développement de l'enfant. Non seulement les pères jouent un rôle plus actif que ce que la recherche aurait pu suggérer, mais l'évolution de la dynamique familiale permet aux pères d'avoir un effet plus important sur le développement de leurs enfants que ce que l'on pensait auparavant. Les changements sociaux progressifs, tels que l'augmentation du nombre de femmes en emploi (4), des lois plus équitables sur la garde des enfants (5,6) et l'augmentation du nombre de congés de paternité (7,8), sont autant de facteurs qui permettent aux pères de jouer un rôle plus important dans l'éducation de leurs enfants. La participation des pères à la garde des enfants a presque triplé entre 1965 et 2011 (9), ce qui a suscité des appels en faveur d'une plus grande inclusion et reconnaissance de ces derniers dans la recherche sur la santé mentale des parents et le développement de l'enfant.

Risque de maladie mentale chez les pères

La paternité est une expérience objectivement difficile. Plusieurs déterminants importants de la santé mentale, notamment la satisfaction relationnelle, le soutien social et la qualité et la durée du sommeil (10), tendent à changer de manière significative après la naissance. Des études qualitatives ont également montré que les exigences extérieures imposées aux pères pendant cette période, en particulier le travail, l'accès au congé de paternité rémunéré et les difficultés financières qui s'ensuivent, sont des facteurs importants de stress et de dépression (11,12). Les niveaux de responsabilité, les obligations et les changements de mode de vie sont particulièrement élevés pendant la période périnatale et peuvent nuire à la santé générale et au bien-être des hommes. De nombreux pères semblent ressentir un stress et une responsabilité considérables par rapport à la situation financière de leur famille, supportant des charges indépendantes de leur volonté, telles que l'évolution de la situation économique (12). Les engagements professionnels des pères, parallèlement à leurs responsabilités parentales, leur laissent souvent peu de temps pour eux-mêmes (13), et sont susceptibles de réduire les possibilités de recherche d'aide ou de soutien extérieur (11,14).

Lorsque l'on aborde les éléments qui sous-tendent la maladie mentale paternelle (MMP), il est nécessaire de reconnaître la santé mentale de la partenaire ou de la mère de l'enfant. La maladie mentale de la mère est l'un des prédicteurs les plus constants de celle du père, l'une étant susceptible d'accentuer l'autre (15,16). Des études font état d'une concordance entre les symptômes dépressifs maternels et paternels pouvant atteindre 70 % (15,17). Dans les couples hétérosexuels, cette association semble dépendre fortement de la qualité de la relation mère-père (75), les facteurs de risque de dépression et d'anxiété paternelles étant notamment les conflits entre partenaires, la séparation, la diminution de l'intimité et le manque de soutien (15,18–21). Un autre facteur qui semble pertinent pour la santé mentale paternelle est l'influence de la classe et du statut socio-économique (SSE). Des taux plus élevés de dépression ont été observés chez les pères socialement défavorisés (22), de même que le stress parental (23) et l'anxiété (24). En outre, la majorité des études qualitatives sur la santé mentale des pères indiquent que les pères sont influencés par des facteurs liés à leur SSE ou à leur milieu culturel, les difficultés financières et l'accès au travail étant souvent considérés comme des facteurs importants de stress et de dépression chez les nouveaux pères (11,12).

Prévalence globale de la maladie mentale des pères

Les deux pathologies les plus courantes chez les hommes pendant cette période sont les troubles anxieux et dépressifs, avec environ 1 père sur 10 présentant des symptômes de dépression (15). Alors que la recherche suggère que les pères sont les plus susceptibles de souffrir de dépression dans la période post-partum de 3 à 6 mois (15), une étude a montré que les symptômes dépressifs des pères résidents augmentaient de 68 % entre la naissance de leur enfant et l'âge de 5 ans (25). Les taux d'anxiété paternelle sont beaucoup moins clairs et varient considérablement d'une méta-analyse à l'autre. Philpott et al. (26) ont observé un taux global de 2,4 % à 51 %, tandis que Leach et al. (27) ont trouvé un taux plus restreint de 2,4 % à 18 %. Néanmoins, de plus en plus de données suggèrent que l'anxiété est plus fréquente que la dépression chez les pères (28–30). Il est important de noter qu'il ne s'agit pas seulement d'un problème postnatal. Les résultats qualitatifs suggèrent également que la transition vers la parentalité est souvent particulièrement soudaine pour les pères, les nouveaux pères se sentant souvent anxieux à l'approche de la date d'accouchement de leur partenaire, exprimant leur peur et leur impuissance en raison de leur manque de préparation (11,13). Pendant la période prénatale, on estime que des symptômes de stress apparaissent chez environ 6 à 9 % des futurs pères (31). De plus, une étude a montré que parmi les pères stressés pendant

la période prénatale (7,8 %), 37 % souffraient d'anxiété concomitante et 31 % à la fois de dépression et d'anxiété (32). La prévalence de l'anxiété prénatale semble se situer entre 3,4 % et 25 % (26).

Si l'on compare ces chiffres à ceux de la France, rien n'indique qu'il y ait une différence significative dans la prévalence : Nakamura et al. (33) ont constaté que les taux de dépression post-partum (2 mois) étaient en moyenne de 7 %, de même que Séjourné et al. (34) ont constaté que les niveaux de symptômes indiquant une dépression paternelle étaient de 21 % à une semaine du post-partum et de 8 % à deux mois. Cela n'est pas surprenant, étant donné que les taux de prévalence « globaux » proviennent principalement de populations de pays à revenus moyens et élevés (15,26). Cependant, aucune étude n'a encore été menée sur les diagnostics paternels autres que la dépression en France.

Santé mentale des pères et développement de l'enfant

L'hypothèse de la modélisation, fondée sur les théories de la socialisation et de l'apprentissage social, suggère que les attitudes et les comportements individuels sont modelés sur les comportements des personnes qui ont été importantes et influentes pour lui (35). Les éléments clés qui sous-tendent la majorité du développement socio-émotionnel, comportemental et cognitif, tels que l'attachement, sont d'abord construits en fonction des personnes qui s'occupent du nourrisson (36). La présence, ou l'absence, de figures paternelles exerce donc une influence vitale sur le développement des compétences sociales et émotionnelles fondamentales des enfants. Des études ont montré que la MMP avait un impact négatif sur le développement de l'enfant, de la petite enfance à la fin de l'adolescence, entraînant des conséquences socio-émotionnelles et comportementales négatives (37-39), notamment des problèmes de comportement (39), des problèmes d'attention (39) et un trouble oppositionnel avec provocation (30), ainsi que des risques accrus de problèmes cognitifs, tels qu'un moins bon développement du langage et de la lecture (40) à tous les âges (41,42). Dès l'âge de deux mois, les enfants de pères présentant des symptômes de maladie mentale présentent des taux plus élevés de problèmes émotionnels et comportementaux et de l'affect négatif (43,44). Plus tard dans l'enfance, les enfants exposés à la MMP présentent également un risque plus élevé de troubles psychiatriques ultérieurs (38,45,46) et de problèmes psychologiques associés tels que des comportements addictifs (12, 13) et le comportement suicidaire (5, 8, 9), que les enfants non-exposés. Les enfants de pères dépressifs sont presque trois fois plus susceptibles de connaître un épisode dépressif au cours de leur vie que ceux de parents non-dépressifs (47,48).

Toutefois, la littérature n'est pas encore concluante. Les domaines cognitifs semblent moins influencés par la santé mentale des parents que les domaines socio-émotionnels ou comportementaux. En outre, l'ampleur de l'effet est souvent faible (49,50) et dépend souvent de plusieurs médiateurs contextuels (51). Alors que les effets de la santé mentale du père sur l'enfant ont été considérés comme indépendants de la psychopathologie de la mère, des études ont montré que la relation entre la dépression paternelle et les résultats de l'enfant était médiée par la dépression maternelle (45,52) ainsi que par les conflits entre la mère et le père (51). Des données suggèrent également que le risque de problèmes de développement liés à la MMP peut être plus élevé chez les fils que chez les filles (39,53), mais de nombreuses études n'ont pas constaté de différence dans l'impact des problèmes de santé mentale paternels sur le développement de l'enfant en fonction du sexe ou du genre (54). Il est également important de tenir compte de la temporalité de la santé mentale des pères, lorsqu'elle est aiguë, et des résultats liés au développement de l'enfant quand l'on discute de la relation entre les deux. Alors que les 1 000 premiers jours ont été mis en évidence comme l'une des fenêtres développementales les plus importantes de la vie d'un enfant (55), les études sur la relation entre la santé mentale paternelle et les résultats de l'enfant pendant la petite enfance montrent des tailles d'effet particulièrement faibles (44,49). Le moment où les enfants sont exposés aux symptômes paternels peut impliquer différents mécanismes de transmission, ainsi que des périodes sensibles distinctes pour des aspects spécifiques du développement (44).

Objectifs

- 1) Évaluer au sein de la population des hommes en France
 - a) La prévalence actuelle de la maladie mentale paternelle (MMP) et son évolution longitudinale au cours de la transition vers la paternité.
 - b) Les facteurs de risque associés à ces schémas de MMP au fil du temps.
 - c) La façon dont ces résultats peuvent varier en fonction de la méthode utilisée pour évaluer la MMP.
- 2) Fournir une vue d'ensemble de la littérature actuellement disponible sur la relation entre la santé mentale paternelle et le développement de l'enfant, en tenant compte de la qualité et de la rigueur de la recherche elle-même afin d'essayer de résoudre les incohérences.
- 3) Étudier la relation entre la santé mentale paternelle et le développement socio-émotionnel et comportemental du jeune enfant, ainsi que les facteurs modérateurs.

Pour atteindre ces objectifs, j'ai mené trois études indépendantes.

Populations

Cohorte CONSTANCES

CONSTANCES est une cohorte nationale à grande échelle ciblant les adultes âgés de 18 à 69 ans à l'inclusion et affiliés à la Sécurité sociale française (plus de 85 % de la population française) (56). Cohorte généraliste, elle vise à couvrir un large éventail de problèmes de santé et de leurs déterminants. Les sujets ont été sélectionnés sur la base d'un échantillonnage aléatoire, stratifié avec des probabilités inégales en fonction de l'âge, du sexe et du statut socio-économique afin de surreprésenter les catégories habituellement sous-représentées dans les enquêtes. Le recrutement a été réparti sur l'ensemble du territoire français métropolitain. Les personnes invitées à participer ont été invitées par courrier à remplir des questionnaires à domicile et à bénéficier d'un examen de santé complet dans un centre d'examen de santé. Le recrutement des participants s'est déroulé principalement entre 2012 et 2019, et s'est terminé en 2021, ce qui a permis d'obtenir une population finale d'environ 220 000 volontaires.

Le suivi était à la fois actif et passif. Le suivi actif comprenait un questionnaire annuel, proposé sur papier ou en ligne, ainsi qu'un examen dans un centre de dépistage proposé tous les quatre ans. Les données comprennent le mode de vie et les caractéristiques socio-économiques, les antécédents médicaux personnels et familiaux, ainsi que les examens cliniques et paracliniques. Le suivi passif s'appuie sur des informations provenant de diverses bases de données nationales relatives aux données socio-économiques, professionnelles, résidentielles, environnementales et médico-administratives des personnes. Par rapport aux moyennes nationales, les participants à CONSTANCES étaient moins éduqués (27,4 % sans diplôme ou avec un niveau d'études inférieur au lycée contre 16,4 % en France) et moins susceptibles d'être célibataires (27,4 % contre 40,2 %) et âgés de 18 à 29 ans (12,9 % contre 20,2 %) (56). Avec un taux de réponse annuel compris entre 60 et 70 %, et moins de 0,5 % de participants se retirant activement, la cohorte bénéficie d'un fort engagement volontaire.

Cohorte SEPAGES

SEPAGES (Suivi de l'Exposition à la Pollution Atmosphérique durant la Grossesse et Effet sur la Santé) est une cohorte couple-enfant visant à caractériser l'exposition et les effets sanitaires ultérieurs des contaminants environnementaux sur les femmes enceintes et leurs enfants. La cohorte a été conçue et réalisée dans la région de Grenoble, dans le sud-ouest de la France. La région de Grenoble compte environ

450 000 habitants et comprend des zones urbaines, périurbaines et rurales (57). Les critères d'éligibilité des mères étaient les suivants : être enceinte de moins de 19 semaines au moment de l'inclusion, être âgée de plus de 18 ans, avoir une grossesse unique, prévoir d'accoucher dans l'une des quatre maternités de l'agglomération grenobloise et habiter dans la zone d'étude. Les pères de l'enfant attendu ont également été invités à participer, sans critère d'exclusion. La participation du père n'était pas obligatoire, ce qui a permis de constituer une population finale de 484 mères et 410 pères.

Les volontaires ont rempli des questionnaires en ligne à chaque trimestre de la grossesse ainsi que de nombreuses mesures postnatales jusqu'à 3 ans (au moment de notre étude) (58). Les questionnaires destinés aux parents portaient sur un large éventail de sujets, en particulier sur la nutrition, l'exposition aux polluants et les événements de santé. Le développement neurologique de l'enfant a été évalué longitudinalement à l'aide d'évaluations cliniques réalisées par des travailleurs de terrain de SEPAGES, y compris des neuropsychologues qualifiés, et de questionnaires validés remplis par les parents. La réputation scientifique et universitaire de Grenoble attire des étudiants et des travailleurs hautement qualifiés, ce qui se reflète dans les caractéristiques démographiques de la population étudiée. Par rapport aux femmes enceintes en France, les mères de SEPAGES avaient tendance à être plus âgées et à avoir un niveau d'éducation plus élevé, et elles étaient beaucoup plus susceptibles d'être en couple (99,8 % contre 81,9 % en France) (58).

Article 1 : Trajectoires longitudinales et facteurs de risque associés à la maladie mentale paternelle dans les neuf années entourant la transition vers la paternité

L'arrivée d'un premier enfant est un facteur de risque connu de maladie mentale, mais les études longitudinales sur la santé mentale des pères sont limitées. Alors qu'environ 10 % des pères souffrent de dépression pendant la période périnatale (15,28), les taux d'anxiété paternelle sont très hétérogènes (27), potentiellement en raison des variations entre les méthodes de diagnostic (26). En outre, les méta-analyses montrent que les taux de maladies mentales paternelles (MMP) varient de manière significative avec le temps (15), mais les études longitudinales sont limitées et s'étendent rarement au-delà de la période périnatale. Nous avons réalisé une étude de la prévalence actuelle de la MMP en France, ainsi que de ses trajectoires longitudinales en relation avec l'arrivée de l'enfant, et des facteurs de risque associés à ces tendances. Cette étude s'est concentrée sur tous les participants masculins au sein de la cohorte

CONSTANCES qui ont accueilli leur premier enfant au cours de la période d'étude (2013-2020) (n = 6 299) (56). Deux mesures ont été utilisées pour évaluer la MMP :

1) La maladie mentale auto-déclarée, qui repose sur les déclarations des participants concernant la présence d'une maladie mentale (oui/non), parallèlement à leur pathologie spécifique.

2) Les scores des symptômes cliniquement significatifs, où la maladie mentale a été mesurée directement à l'aide du Center for Epidemiologic Studies Depression scale (CES-D) (59) ou du General Health Questionnaire (GHQ-12) en 12 points (60). Pour mesurer la prévalence de la MMP, une notation binaire a été utilisée, avec un score seuil de ≥ 6 pour le GHQ-12 (61) et de ≥ 16 pour le CES-D (62,63). Pour toutes les autres analyses, les deux échelles ont été standardisées et traitées comme des échelles continues.

« Group-Based Trajectory Modelling » (GBTM) a été utilisée pour identifier les groupes de trajectoires latentes pour les deux mesures, en prenant l'arrivée du premier enfant de chaque participant comme année 0 (64–66). Les variables ont été sélectionnées comme facteurs de risque potentiels sur la base de la littérature, et confirmées par une analyse chi-deux et des régressions logistiques multivariées à l'année 0. Les variables significatives à $p < 0,05$ ont ensuite été testées par rapport aux groupes de trajectoires via des modèles de régression multinomiale. Toutes les analyses ont été effectuées indépendamment pour les maladies mentales déclarées et les scores de symptômes cliniquement significatifs.

Les niveaux d'anxiété déclarée (en moyenne 4,9 % avant la paternité, 7,8 % après) dépassaient ceux de la dépression (1,9 % avant la paternité, 3,3 % après) ou d'autres troubles. Cependant, les taux de symptômes cliniquement significatifs (17-27 %) étaient systématiquement plus élevés. En ce qui concerne les trajectoires longitudinales, alors que la majorité des pères présentaient un risque faible et constant de maladie mentale déclarée, environ 10 % d'entre eux présentaient un risque élevé temporaire ou constant. La santé mentale des participants semble s'être dégradée deux ans avant l'arrivée de leur enfant et s'être améliorée deux ans après. En ce qui concerne les scores des symptômes cliniquement significatifs, tous les participants ont montré une augmentation au cours de la période précédant la paternité, à partir de deux ans avant l'arrivée de l'enfant. Les facteurs de risque associés à des trajectoires d'aggravation de la santé mentale sont le chômage, le fait de ne pas vivre avec son partenaire, l'âge avancé, le renoncement aux soins de santé pour des raisons financières et le fait d'avoir vécu des expériences négatives pendant l'enfance.

Nos résultats indiquent un sous-diagnostic potentiel des maladies mentales chez les hommes, ce qui a été mis en évidence par de nombreuses études (12,67,68). L'anxiété paternelle était systématiquement plus

répandue que la dépression, ce qui plaide en faveur d'une attention accrue aux symptômes liés à l'anxiété et aux troubles associés chez les pères. Cependant, toutes les mesures de la maladie mentale reposaient sur les déclarations des participants et sont donc sujettes à des biais. Il est nécessaire de sensibiliser davantage à la pertinence des soins de santé mentale, tant formels qu'informels, avant la transition vers la paternité. Nous apportons ici la preuve d'une période claire de vulnérabilité qui pourrait aider les prestataires de soins de santé mentale à mieux cibler les pères qui ont besoin de soutien.

Article 2 : L'impact de la maladie mentale du père sur le développement de l'enfant : une revue générale des revues systématiques et des méta-analyses

Compte tenu du rôle de plus en plus actif des pères dans l'éducation de leurs enfants, une vue d'ensemble de l'impact de la MMP sur le développement de l'enfant s'impose. Cette étude visait à combiner et à synthétiser les revues actuellement disponibles sur la relation entre la MMP et de multiples domaines du développement de l'enfant, et à confronter les résultats contradictoires actuels, dans le cadre d'une revue générale. Nous avons réalisé une synthèse narrative des revues systématiques et des méta-analyses sur la relation entre la MMP et le développement de l'enfant (santé mentale et comportement social, émotionnel, linguistique, cognitif ou adaptatif), publiées entre 1980 et décembre 2021, conformément aux lignes directrices PRISMA 2020. L'outil d'évaluation AMSTAR-2 (Assessment of Multiple Systematic Reviews 2) a été utilisée pour évaluer la qualité des revues incluses (69). Le risque de biais et la certitude des preuves ont également été examinés à l'aide des critères GRADE (Grading of Recommendations, Assessment, Development and Evaluation) (70). Toutes les tailles d'effet méta-analytiques pertinentes ont été converties en odds ratios (OR) et regroupées à l'aide d'un modèle à effets aléatoires.

Dix revues ont été incluses dans les analyses finales (44,51,54,71-77), dont huit ont trouvé que la PPM exerçait un effet négatif significatif sur le développement de l'enfant, avec des résultats incluant des problèmes émotionnels et comportementaux, la santé mentale et le développement du langage. Les deux études ne montrant aucune association apparente étaient toutes deux uniques en ce qui concerne la variable dépendante choisie pour l'enfant : L'une portait sur les pensées suicidaires ou les tentatives de suicide des enfants (74) et l'autre (75) sur les troubles du spectre autistique. Les méta-analyses groupées ont révélé que l'effet global de la MMP sur le développement de l'enfant (OR : 1,54 ; IC à 95 % : [1,36-1,74]). Les analyses de sous-groupes ont montré que l'effet de la MMP était très similaire pour les comportements

internalisants (OR : 1,62 ; 95% CI : [1,27-2,08]) et externalisants (OR : 1,63 ; 95% CI : [1,28-2,08]). Le plus souvent, les associations sont plus fortes chez les enfants plus jeunes (51,73,76), mais les résultats varient. Deux études ont montré que la MMP prénatale avait un effet plus faible sur le développement que la MMP postnatale (44,73), la MMP chronique ou persistante augmentant également la probabilité de résultats défavorables pour l'enfant. Les revues de meilleure qualité ont montré une relation plus forte entre la MMP et le développement de l'enfant (OR : 1,91 ; IC 95% : [1,58-2,32]) que les revues de moindre qualité (OR : 1,41 ; IC 95% : [1,22-1,64]).

Ces résultats montrent un effet cohérent et influent de la MMP sur le développement de l'enfant. L'association entre la MMP et le développement de l'enfant s'étend de la petite enfance à l'adolescence, dans tous les domaines étudiés du développement de l'enfant, à l'exception de l'autisme. Toutefois, les résultats étudiés se limitaient principalement aux comportements socio-émotionnels. En ce qui concerne l'âge de l'enfant, les résultats étaient hétérogènes, ce qui indique que les effets différentiels en fonction de la tranche d'âge de l'enfant peuvent en fait être davantage liés à la chronicité et à la gravité de la MMP. Les analyses de sous-groupes ont été limitées par le manque de données et les caractéristiques démographiques de l'échantillon. Il est nécessaire d'inclure davantage les pères dans la recherche sur la santé mentale afin de mieux comprendre les facteurs modérant cette relation, en particulier en ce qui concerne les domaines cognitifs du développement de l'enfant et les diagnostics non affectifs de la MMP.

Article 3 : Santé mentale périnatale du père et développement du jeune enfant : une approche « outcome wide »

Il a été démontré que la santé mentale du père est associée à de nombreux éléments du développement de l'enfant, dès la petite enfance. Cependant, l'influence modératrice potentielle de facteurs tels que la santé mentale de la mère, le sexe de l'enfant et le SSE reste incertaine. Cette relation n'a pas encore été étudiée en France. Dans une approche « outcome wide » (78), des modèles de régression linéaire ont été utilisés pour tester la relation entre l'anxiété ou la dépression paternelle et les résultats de l'enfant à deux et trois ans. Cette étude s'est appuyée sur la cohorte SEPAGES (58). Tous les pères âgés de plus de 18 ans ont été invités à participer à la cohorte, et cette enquête s'est concentrée sur les 301 dyades père-enfant pour lesquelles des données sur la santé mentale du père étaient disponibles. La MMP a été regroupée en trois périodes : la grossesse de leur partenaire (n = 166), le post-partum de 0 à 12 mois (n = 117) et le post-partum de 12 à

24 mois (n = 207). À tous les moments, la santé mentale a été mesurée à l'aide de l'échelle HADS (Hospital Anxiety and Depression Scale) (79). Les résultats pour les enfants étaient les suivants : The Child Behaviour Checklist (CBCL/1.5-5) à l'âge de deux ans, et the Behavior Rating Inventory of Executive Function – version préscolaire (BRIEF-P) ; the Social Responsiveness Scale (SRS) ; et les échelles d'intelligence de Wechsler pour le primaire et le préscolaire (WPPSI) à l'âge de trois ans (80–83). Des analyses de modération ont été effectuées en prenant comme modérateurs potentiels la santé mentale des mères (scores HADS), le sexe de l'enfant assigné à la naissance et la classe professionnelle des parents (scores ISCO ; (84)).

Après correction des tests multiples, aucune association apparente entre la dépression ou l'anxiété des pères et les mesures étudiées du développement de l'enfant n'a été observée, avant et après ajustement des facteurs de confusion. Aucune différence de taille d'effet n'a été observée entre la santé mentale prénatale et postnatale, ni en fonction du sexe de l'enfant et de la classe professionnelle des pères. Cependant, la classe professionnelle de la mère a modéré de manière significative l'association entre l'anxiété paternelle et plusieurs résultats chez l'enfant. Des scores d'anxiété paternelle plus élevés sont associés à des scores de problèmes d'attention plus élevés, à une mémoire de travail plus faible et à des scores visuospatiaux plus faibles, mais à une meilleure cognition sociale chez les enfants dont les mères appartiennent à une classe professionnelle inférieure. On a également constaté que la santé mentale de la mère modérait une relation, les enfants exposés à une anxiété paternelle prénatale plus élevée présentant de moins bons résultats en matière de mémoire de travail (scores plus élevés) lorsqu'ils étaient exposés à des scores HADS maternels prénataux plus élevés.

Ces analyses vont à l'encontre de la majorité des recherches sur ce sujet, qui ont le plus souvent trouvé une association entre la santé mentale du père et le développement de l'enfant, et sont probablement dues au SSE particulièrement élevé de cet échantillon, avec 94 à 98 % des pères ayant un emploi et 98 % étant titulaires d'au moins un baccalauréat. L'importance de la classe professionnelle de la mère, mais pas de celle du père, suggère un déséquilibre potentiel entre les sexes en ce qui concerne les responsabilités et l'implication parentales. Cette étude élucide l'importance de la classe sociale des familles dans l'étude de la relation entre la MMP et le développement de l'enfant, ce qui peut expliquer certaines variations dans la littérature. Ces résultats sont particulièrement pertinents si l'on considère l'écart grandissant en matière d'éducation et de développement entre les enfants des ménages à faible revenu et ceux des ménages à revenu élevé (85).

Discussion

Principales conclusions

Parmi les nouveaux pères en France, bien que la prévalence de la maladie mentale paternelle (MMP) auto-déclarée semble légèrement inférieure aux moyennes périnatales globales, les scores de symptômes (CES-D/GHQ-12) indiquent un taux élevé de détresse psychologique cliniquement significative après l'arrivée de l'enfant (~25%). Nous avons fourni l'une des rares études à avoir examiné la MMP au-delà de la période périnatale, avec une inclusion particulièrement unique de données pré-conceptionnelles. Les symptômes de MMP semblent augmenter deux ans avant l'arrivée du premier enfant du père, et s'améliorer deux à trois ans après.

Dans l'ensemble, la littérature montre une relation significative entre la MMP et le développement de l'enfant [OR : 1,54 ; 95% CI (1,36-1,74)], les méta-analyses groupées ne voyant pas de différence entre les comportements d'internalisation et d'externalisation. Toutefois, dans un échantillon de familles françaises de statut socio-économique élevé, aucune association significative n'a été observée entre la MMP et la développement de l'enfant, comportementaux ou cognitifs de l'enfant, bien que la classe professionnelle de la mère ait été considérée comme modérant partiellement cette relation. Les conclusions de cette thèse suggèrent que la relation entre la MMP et le développement de l'enfant n'est pas spécifique à un aspect particulier du développement socio-émotionnel, comportemental ou cognitif, et que l'ampleur de l'effet varie peu d'un domaine à l'autre. Nos résultats contestent également la pertinence du sexe de l'enfant ou du genre dans cette relation, mais, conformément à la littérature, les enfants des familles à faible position socio-économique semblent être plus exposés à des résultats défavorables.

Santé mentale des pères : cherchons-nous au bon endroit ?

Un résultat important est que l'anxiété paternelle est systématiquement plus fréquente que la dépression paternelle. Cette constatation est confirmée par la littérature (26,86,87). Pourtant, l'anxiété paternelle reste très peu étudiée, les résultats actuels se limitant presque exclusivement à la période périnatale et présentant des résultats très hétérogènes (88). Qu'il s'agisse de conditions distinctes ou non, la tendance actuelle à étudier la dépression paternelle plutôt que l'anxiété pourrait donc sous-estimer les niveaux de détresse psychologique chez les pères. Notre premier article a également révélé une disparité considérable entre les taux de maladies mentales auto-déclarées par les hommes (8 % en moyenne) et les symptômes

réellement présents (22 % en moyenne). Cette différence est apparue à tous les moments, de 4 ans avant à 4 ans après l'arrivée du premier enfant, ce qui suggère un taux important de sous-diagnostic chez les hommes. Il a été constaté que les hommes, comparés aux femmes (68), ainsi que les pères, comparés aux mères (12), sont moins susceptibles de présenter une symptomatologie dépressive comme une mauvaise santé mentale. Les hommes et les pères sont également moins susceptibles d'avoir un médecin traitant (89,90) ou de déclarer leur diagnostic à des professionnels de la santé (12,68,91). La recherche qualitative montre que les pères estiment souvent qu'il est socialement inacceptable de reconnaître leurs difficultés mentales ou d'en parler, car cela les rend inadéquats ou impuissants (11,13). Plusieurs études indiquent également des nombreuses différences genrées en ce qui concerne les symptômes des troubles de santé mentales courants, notamment une tendance plus marquée chez les hommes à adopter des comportements externalisants et des méthodes d'adaptation telles que la colère, la consommation de substances et les comportements à risque (92). Il est nécessaire de remettre en question la stigmatisation de la maladie mentale chez les hommes et de développer des outils de dépistage plus inclusifs pour mieux représenter la véritable prévalence de la MMP.

Les résultats de cette thèse mettent en évidence plusieurs populations clés de pères que la recherche et la prévention devraient cibler à l'avenir. Le premier article a révélé que le fait de ne pas vivre avec son partenaire augmentait la probabilité de trajectoires négatives de santé mentale au fil du temps. En outre, les pères célibataires présentent un risque deux fois plus élevé (33,6 %) de souffrir d'un trouble mental courant que les pères vivant dans un foyer biparental (13,3 %) (93). Ce constat est d'autant plus pertinent que les taux de foyers monoparentaux augmentent rapidement (94–96). Notre premier article a également mis en évidence des trajectoires d'augmentation des symptômes de la MMP associées à la fois au chômage paternel et au renoncement aux soins de santé pour des raisons financières. Le chômage est également systématiquement associé à la MMP (97,98). On voit aussi des taux plus élevés de MMP chez les pères socialement défavorisés (22), avec des facteurs tels que les faibles revenus et le fait de vivre dans un logement loué associés à des symptômes accrus (99,100). Les pères à faible SSE sont constamment sous-représentés dans la recherche, certaines études reconnaissant que leurs résultats peuvent sous-estimer les taux de MMP en raison de leur manque de représentation des pères défavorisés sur le plan socio-économique (101). En outre, comme le soulignent notre deuxième et troisième article, un faible niveau socioéconomique, et donc les contraintes financières qui y sont liées, est associé à des résultats plus défavorables pour l'enfant en ce qui concerne la MMP.

Le développement de l'enfant selon la maladie mentale paternelle

En analysant systématiquement toutes les revues disponibles au moment de l'enquête (jusqu'en décembre 2021), le deuxième article a révélé un lien évident entre la santé mentale du père et le développement de l'enfant, des symptômes plus importants de MMP correspondant à un développement plus défavorable de l'enfant. La comparaison entre les résultats, bien que limitée aux comportements internalisants et externalisants n'a révélé aucune différence dans l'ampleur de l'effet. Au troisième article, nous avons également inclus un large éventail de résultats, couvrant les domaines socio-émotionnel, comportemental et cognitif. Là encore, aucune différence nette n'a été observée au niveau de l'ampleur de l'effet entre les résultats. Alors que le développement se produit à travers de multiples voies intégrées et niveaux comportementaux, la catégorisation du développement de l'enfant en domaines isolés a été critiquée parce qu'elle obscurcit la vision holistique d'un individu (101). Notre constat selon lequel la relation entre la MMP et le développement de l'enfant semblait principalement indépendante du domaine développemental va dans ce sens, dans la mesure où l'interdépendance des domaines de développement peut empêcher un impact isolé sur un seul domaine. Cependant, au deuxième article, nous avons vu que les résultats étudiés dans la littérature se limitaient presque exclusivement aux comportements socio-émotionnels, 80 % des études se concentrant exclusivement sur le développement socio-émotionnel. Il est nécessaire d'étendre les recherches aux domaines cognitifs et à d'autres aspects du développement neurologique.

Un résultat inattendu de cette thèse est la relation non significative entre la MMP et le développement de l'enfant observée au troisième article. Non seulement la MMP était liée de façon constante et non significative au développement de l'enfant du père, mais cela a été constaté pour la dépression et l'anxiété paternelles, ainsi que pour toutes les temporalités de la MMP (grossesse, 0-12 mois et 12-24 mois) et les résultats de l'enfant (deux et trois ans). Ce constat est en désaccord partiel avec la littérature, telle qu'elle a été analysée dans le deuxième article. Cependant, plusieurs études ont également trouvé des associations entièrement non significatives entre la dépression paternelle et le tempérament de l'enfant de 9 mois à 7 ans (102) et les problèmes de comportement de l'enfant à 48 mois (103). Il est également possible que certains de ces résultats non significatifs résultent en partie d'un sous-diagnostic ou d'imprécisions dans la détection de la MMP. On a constaté que les hommes sous-déclarent davantage leurs niveaux de dépression par rapport aux femmes (104,105), ce qui peut rendre les scores MMP moins précis, contribuant ainsi à

des tailles d'effet plus faibles que prévu. À l'appui de cette hypothèse, le premier article a révélé un niveau considérable de sous-diagnostic chez les hommes.

Une autre hypothèse potentielle pour expliquer nos résultats non significatifs, ainsi que les disparités susmentionnées dans la littérature, pourrait également être que l'impact de la MMP dépend de celle du co-parent. Un nombre considérable d'études ont montré que l'association entre la MMP et le développement de l'enfant n'était statistiquement significative que lorsqu'elle coexistait avec la maladie mentale de la mère (106–109). Cependant, lors de l'étude de l'influence modératrice de la santé mentale de la mère au troisième article, son influence sur la relation entre la MMP et le développement de l'enfant s'est avérée beaucoup plus faible que prévu, avec seulement une association significative sur 126. On pourrait avancer que cela est dû au SSE de notre échantillon, dans la mesure où les familles plus aisées ou privilégiées peuvent disposer d'un plus grand nombre de facteurs de protection pour les enfants ou leurs parents, ce qui atténue les effets observés dans d'autres populations. À l'appui de cette hypothèse, dans un échantillon de même niveau SSE, la santé mentale de la mère n'a pas non plus modéré l'effet de la dépression ou de l'anxiété du père sur les résultats comportementaux et cognitifs de l'enfant (52). Il est nécessaire de poursuivre les recherches sur les facteurs qui influencent l'impact de la maladie mentale concomitante des parents sur les enfants, étant donné que les personnes souffrant de maladie mentale sont plus susceptibles d'avoir un partenaire souffrant du même diagnostic (110,111), une tendance également confirmée chez les parents (15).

Le statut socio-économique

En accord avec la littérature actuelle, cette thèse souligne l'importance du SSE pour la santé mentale du père et sa relation avec le développement de l'enfant. Dans le deuxième et troisième article, un SSE faible augmente de manière significative le risque de résultats défavorables pour l'enfant en ce qui concerne la MMP. Le SSE élevé et relativement homogène de l'échantillon de troisième article pourrait donc également expliquer la non-significativité de nos résultats. Il est intéressant de noter que la modulation par la classe professionnelle des parents de la relation entre la MMP et le développement de l'enfant n'était présente que pour la classe professionnelle de la mère, contrairement à celle des pères. En accord avec ce constat, Badini et al. (112), en étudiant l'association entre le SSE et la psychopathologie de l'enfant, ont constaté que les symptômes comportementaux de l'enfant étaient modérés par le SSE de la mère, alors que celui du père

n'avait pas d'effet. Cela pourrait refléter le niveau accru de la présence, les responsabilités parentales (113) et l'engagement en temps (114) des mères encore présentes dans la société.

L'association tout au long de la vie

Le deuxième article a montré que les maladies mentales paternelles ont souvent des effets plus importants lorsqu'elles surviennent après la naissance que pendant la période prénatale (3, 28, 39-41). Néanmoins, des associations ont été observées dès la petite enfance. En outre, dans le troisième article, nous n'avons pas constaté de différence dans l'ampleur de l'effet en fonction du moment des mesures MMP (prénatal et 0-12 ou 12-24 mois postnatal), ce qui est en accord avec certaines autres analyses (44,51). Une étude a montré que, bien que la comparaison des effets de la dépression uniquement prénatale ou postnatale sur les résultats de l'enfant n'ait pas non plus révélé de différence significative dans la taille de l'effet sur les résultats de l'enfant à l'un ou l'autre moment, les enfants exposés à la dépression paternelle aux deux périodes (prénatale et postnatale) présentaient les risques les plus élevés de psychopathologie subséquente (115). La période prénatale reste encore peu étudiée chez les pères (34-36), ce qui entraîne une incertitude quant aux mécanismes par lesquels la MMP prénatale peut influencer le développement de l'enfant. L'effet cumulatif de la maladie mentale paternelle prénatale et postnatale sur le développement de la progéniture mérite d'être exploré, car il est possible de mettre au point des mesures préventives efficaces.

Forces et limites méthodologiques

Populations

Dans le premier article, nous nous sommes appuyés sur les données de la cohorte CONSTANCES. CONSTANCES est actuellement la plus grande cohorte de population générale en France, ce qui nous a permis d'étudier un grand nombre de participants (56). Nous avons également réussi à inclure des pères qui n'étaient pas nécessairement en couple avec la mère de l'enfant et/ou qui vivaient avec leur enfant. Ceci est particulièrement précieux, car les pères non-résidents ou célibataires sont généralement exclus des recherches. En incluant cette population, nous avons pu identifier l'importance de ces facteurs. Cependant, dans le troisième article, notre choix de cohorte (SEPAGES) s'est traduit par une taille d'échantillon relativement petite qui n'était pas représentative de la population nationale française, ce qui a limité la validité externe de nos résultats. Par rapport à la population générale, le statut socio-économique des participants à SEPAGES est particulièrement élevé, avec des niveaux d'éducation et d'emploi plus élevés,

ainsi que des parents nettement plus susceptibles d'être en couple (99,8 % contre 81,9 % en France). Le recrutement pour SEPAGES s'est fait par l'intermédiaire de la mère, la participation des pères étant facultative. Nous risquons donc un biais de sélection en faveur des pères les plus engagés, ce qui a été associé à de meilleurs résultats pour les enfants (2,116). Pour CONSTANCES et SEPAGES, nous nous sommes appuyés sur des questionnaires auto-administrés, risquant ainsi également un biais de sélection dû à la participation volontaire des membres de la cohorte et à la sous-représentation des sujets difficiles à atteindre, par exemple les personnes sans-papiers. Enfin, alors que les populations incluses dans le premier article étaient basées sur des recherches mondiales, la plupart des recherches sur les relations père-enfant se sont principalement concentrées sur les pays à revenu élevé (31,117) et pourraient donc ne pas être généralisables à d'autres contextes. Ce point est important car environ 95 % des enfants de moins de cinq ans atteints de troubles du développement vivent dans des pays à faible revenu ou à revenu intermédiaire (118). Compte tenu des niveaux inférieurs de soins de santé mentale et de soutien disponibles dans la plupart des pays à revenu faible ou moyen (119), l'extension de la recherche à d'autres pays pourrait bénéficier à un plus grand nombre d'enfants et de familles.

Mesures

Au troisième article, en utilisant quatre mesures validées du développement de l'enfant, nous avons étudié un large éventail d'aspects liés au développement de l'enfant, y compris des indicateurs potentiels d'autisme, de trouble déficitaire de l'attention et de comportements internalisants et externalisants. Les résultats des enfants ont été mesurés à deux et trois ans, âges entre lesquels des changements significatifs se produisent dans le tempérament de l'enfant, l'autonomie, la relation enfant-parent, les rôles de genre et les relations avec les pairs (120). Le développement a également été évalué par les parents eux-mêmes et par des psychologues cliniciens, ce qui est particulièrement important, car les rapports sur le développement de l'enfant peuvent varier en fonction de l'objectivité de l'observateur (121). Le fait de s'appuyer uniquement sur les rapports des parents aurait donc pu introduire un biais. Cependant, l'une des principales limites de nos résultats empiriques et de bon nombre des articles inclus dans cette thèse est la dépendance à l'égard des déclarations des parents pour évaluer la santé mentale des pères. Le premier et troisième article, ainsi que de nombreux articles de la revue générale du deuxième article, ont utilisé des questionnaires remplis par les pères eux-mêmes. Dans les études épidémiologiques, les auto-évaluations des pères sont systématiquement la mesure la plus courante d'évaluation de la santé mentale (51), et une

revue de 2010 des études sur la dépression paternelle a révélé que 93 % des études (n = 40) s'appuyaient sur des mesures d'auto-évaluation (15). L'objectivité réduite par rapport aux entretiens de diagnostic ou aux dossiers médicaux peut avoir augmenté la probabilité de résultats inexacts dans nos enquêtes.

Les revues « umbrella »

Les décisions en matière de recherche clinique et de soins de santé doivent être fondées sur l'ensemble des données disponibles afin de tirer des conclusions fiables et de soutenir l'élaboration des politiques publiques (122). En procédant à une revue « umbrella », nous avons pu résumer un vaste corpus de données probantes dont les recoupements entre les analyses étaient limités. En utilisant cette méthode, nous avons pu partiellement contrecarrer certaines incohérences dans la littérature. Par exemple, d'un point de vue narratif, nous avons constaté des résultats contradictoires quant à l'impact de la MMP sur les comportements internalisants ou externalisants des enfants. Cependant, en synthétisant toutes les méta-analyses et en stratifiant sur la base de ces résultats, nous avons constaté des tailles d'effet presque identiques pour les comportements internalisants et d'externalisants. Les revues systématiques et les méta-analyses sont de plus en plus nombreuses, peut-être en raison d'une probabilité accrue de publication et de citation (123), avec environ 80 revues systématiques publiées par jour en 2019 (124). L'utilisation d'une revue umbrella permet de prendre en compte la qualité et la crédibilité des revues systématiques elles-mêmes. Pour procéder à l'examen critique des études incluses, nous nous sommes appuyés sur deux outils, l'AMSTAR-2 et la notation GRADE. AMSTAR a été conçu comme un outil d'évaluation critique utilisable par des personnes n'ayant pas de formation avancée en épidémiologie, ce qui permet de minimiser le risque de biais lié à la formation préalable des utilisateurs (69). Cependant, AMSTAR-2 repose sur une notation stricte « oui », « oui partiel » et « non », ce qui se traduit par une tendance accrue aux réponses « non » en cas de non-application ou d'indétermination (125). Cela a pu expliquer en partie la tendance à des scores faibles ou très faibles dans tous les domaines. En utilisant également la notation GRADE, la robustesse de nos évaluations s'est probablement accrue. L'approche GRADE, développée par un groupe international et largement représentatif de chercheurs et de développeurs, fournit des critères explicites, transparents et complets pour classer la qualité des évaluations des preuves (126). Approuvée par plus de 120 organisations dans 19 pays, l'approche GRADE bénéficie d'un soutien continu dans le domaine de la recherche en santé (127).

Perspectives

Le manque de pères dans la recherche pédiatrique ne reflète pas la contribution croissante des pères au développement de l'enfant, tout en entravant le développement d'interventions familiales efficaces. La rareté des données sur les sujets abordés dans cette thèse a été particulièrement perceptible lors des analyses de sous-groupes, limitant les recherches sur des éléments tels que le diagnostic spécifique des pères, le sexe de l'enfant et le champ du développement. Néanmoins, 80% des études incluses dans le premier article ont été publiées au cours des 10 dernières années, ce qui indique une augmentation de l'attention portée à l'association entre la santé mentale des pères et le développement de l'enfant. Il est également important d'élargir les recherches pour inclure les pères non biologiques (128). Comme notre premier article le montre, les pères non-biologiques sont sous-représentés dans la recherche, ce qui fait que les couples homosexuels et/ou composés uniquement de pères ont très peu de chances d'être inclus dans la recherche (87). L'élargissement de la perspective de recherche à d'autres dynamiques familiales, telles que les familles élargies ou les environnements parentaux non-monogames, peut également apporter un éclairage nouveau et précieux sur la relation entre la maladie mentale des parents et le développement de l'enfant. Compte tenu de l'association entre la dynamique familiale non nucléaire et les indicateurs socio-économiques dans les pays occidentaux, en ce sens que des niveaux plus élevés de pauvreté, le statut d'immigrant et l'appartenance à une ethnie non-blanche augmentent la probabilité d'être élevé par une autre personne (129,130), l'exclusion de ces types de famille risque de perpétuer l'exclusion de certains groupes démographiques dans la littérature académique.

La prévalence et le sous-diagnostic des maladies mentales observés au cours de la période entourant la transition vers la paternité (Article 2) confirment la nécessité d'améliorer les soins et le soutien apportés aux hommes au cours de la période périnatale. Une approche potentielle pour contrer la prévalence de la MMP serait d'augmenter les efforts d'éducation paternelle. Le deuxième article a montré que les symptômes de maladie mentale chez les nouveaux pères commençaient à augmenter deux ans avant l'arrivée de leur enfant. En effet, de nombreuses études montrent que les pères souhaitent bénéficier de programmes d'éducation prénatale centrés sur eux (11,13,131). Les programmes soutenant le rôle des pères au sein du foyer peuvent également être utiles pour égaliser les chances entre la santé mentale de la mère et celle du père (11). Les hypothèses culturelles relatives à la division du travail et à la garde des enfants doivent également être remises en question, afin de créer un espace pour les pères - et, en fin de compte, une plus

grande liberté pour les mères. L'exclusion historique des pères dans les soins de santé périnatale a entraîné un manque de politiques publiques concernant la MMP (132). De nombreuses propositions politiques ont été suggérées pour améliorer l'équité dans l'éducation des enfants et à la maison, telles que les approches travail-famille qui augmentent le travail à temps partiel, le partage des tâches et le télétravail qui permettent aux parents d'équilibrer leurs engagements professionnels et familiaux (133,134).

Conclusion

L'objectif de cette thèse était de mettre en lumière l'importance de la santé mentale des pères pendant et au-delà de la période périnatale, ainsi que d'étudier sa pertinence pour le développement de l'enfant. Les maladies mentales paternelles (MMP) ont été considérées comme ayant un effet significatif sur le développement de l'enfant dans l'ensemble de la littérature, bien que limité au développement socio-émotionnel et comportemental. Cette relation a été observée de la petite enfance à la fin de l'adolescence et n'a pas semblé varier en fonction du domaine spécifique de développement. Cependant, les facteurs modérateurs restent peu clairs et peu étudiés, en particulier en ce qui concerne les diagnostics paternels autres que la dépression, les résultats cognitifs de l'enfant et les trajectoires longitudinales. Les résultats longitudinaux sur la santé mentale des pères primipares ont montré que les symptômes de maladie mentale augmentaient deux ans avant l'arrivée du premier enfant et diminuaient de deux à trois ans après. L'anxiété paternelle était systématiquement plus répandue que la dépression, avec un taux évident de sous-diagnostic, ce qui plaide en faveur d'une plus grande attention portée aux symptômes liés à l'anxiété et aux troubles associés chez les pères. Cette thèse met également en évidence plusieurs sous-populations de pères pour lesquelles une attention accrue et des efforts de recrutement devraient être déployés. Non seulement nous avons constaté que le fait de ne pas vivre avec son partenaire, ainsi que les déterminants du SSE tels que le chômage, étaient des facteurs de risque pertinents pour les pères, mais ces facteurs sont également associés à de plus mauvais résultats pour les enfants en ce qui concerne la MMP. Une plus grande inclusion des pères de faible statut socio-économique et des pères non-résidents est vitale, car ils restent constamment sous-représentés dans la recherche. Un changement culturel en faveur de l'inclusion des pères en tant que parties indépendantes dans la recherche sur la santé mentale serait bénéfique à la fois pour le père, l'enfant et la famille environnante.

List of publications and presentations

Publications in peer-reviewed journals

First author

Scarlett, H., Moirangthem, S. & van der Waerden, J. The impact of paternal mental illness on child development: an umbrella review of systematic reviews and meta-analyses. *European Child and Adolescent Psychiatry* (2023). 10.1007/s00787-023-02261-1

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Scarlett, H., Benarous, X., Consoli, A., Montreuil, T. Lyon-Caen, S. Philippat, C., van der Waerden, J. Paternal perinatal mental health and early child development: an outcome-wide analysis.

Co-authored during the thesis

Marr K., Maguet C., Scarlett H., et al. Social determinants in prenatal antidepressant use and continuation: Systematic review and meta-analysis. *Acta Psychiatr Scand.* 2023; 1-21. doi:10.1111/acps.13647X

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Hecker I., Wallez, S., Scarlett, H., Ayuso-Mateos, J. L., Bryant, R., Caggiu, G., Conflitti, C., Gémes, K., Haro, J. M., Lorant, V., Mediavilla, R., Mittendorfer-Rutz, E., Monistrol-Mula, A., Compagnoni, M., Petri-Romão, P., Pinucci I. Stoffers-Winterling, J. Walter, H. Mary-Krause M., Melchior M. Psychological distress and compliance with sanitary measures during the Covid-19 pandemic: IPD meta-analysis of gender and socioeconomic characteristics.

Vincent C., Girault C., Hecker I., Scarlett H., El Hage W., Mediavilla R., Melchior M. & Vuillermoz C. Social support and financial status are associated with depression symptoms among healthcare workers one year after the onset of the COVID-19 pandemic in France.

Poster and oral presentations at international conferences

20th EPA Section in Epidemiology & Social Psychiatry Conference, Cambridge, England, 2023. "The impact of paternal mental illness on child development: An umbrella review". (Oral Presentation)

Life History Research Society Conference, Montreal, Canada, 2024. "Longitudinal Trajectories and Associated Risk Factors of Paternal Mental Illness Amongst First-time Fathers in France". (Oral presentation)

21st EPA Section in Epidemiology & Social Psychiatry Conference, Lausanne, Switzerland, 2024. "Paternal mental health in France". (Oral presentation)

Poster and oral presentations at national conferences and seminars

Seminaire de l'école doctorale 393. November 2021, St. Malo, France. (Presentation)

Seminaire de l'école doctorale 393. February 2023, St. Malo, France. (Poster) Awarded: Best poster/presentation.

ERES Seminar. "Santé mentale paternelle en France" January 2024, Paris, France. (Presentation)

École des Hautes Etudes en Santé Publique (EHESP). "Paternal depression and child social, emotional and cognitive development", February 2023, Saint-Denis, France. (Presentation)

Seminaire de l'école doctorale 393. February 2024, St. Malo, France. (Poster)

Journée CONSTANCES cohorte. "La santé mentale de père", June 2024, Paris, France. (Poster)

Journée scientifique de SEPAGES. October, 2024, Grenoble, France. (Presentation)

Other scientific contributions

Peer reviewing

Peck, A., Hutchinson, M., Provost, S., Childhood adversity, emergent psychopathology, and adolescent-to-parent violence: process mining trajectories from police and health service administrative data. *Child and Adolescent Psychiatry*.

Clinical psychologists' perceptions of telephone consultation for low-income French patients during lockdown: a qualitative study. *Primary Health Care Research & Development*.

Mathole, R., & Ross, E. (2024). How do you stay at home if you don't have a home? Experiences of homeless persons at homeless shelters in Tshwane, South Africa during the COVID-19 pandemic. *Journal of Social Distress and Homelessness*, 33(1), 122–131. 10.1080/10530789.2022.2107329

Commitments

2021-2024: École des hautes études en santé publique (EHESP), Paris, Teaching M2 students qualitative analysis using nVivo and Atlas.ti software as part of their qualitative research methods module.

2022-2024: Representative of doctoral students at the Pierre Louis Public Health and Epidemiology Doctoral School (Représentante des doctorant.e.s de l'École Doctorale Pierre Louis de Santé publique).

June 2023: Assisted in the organisation of the INRICH 14th Annual workshop: From Familial to Structural, Using a Global-Equity and Child-Rights Lens. Paris, France.

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List of abbreviations

AMSTAR Assessment of Multiple Systematic Reviews checklist

CD Child development

CESD Center for Epidemiological Studies Depression Scale

CI Confidence Interval

GAD Generalised Anxiety Disorder

GHQ-12 12-item General Health Questionnaire

GRADE Grading of Recommendations Assessment, Development and Evaluation

MA Meta-analysis

MDD Major Depressive Disorder

MMH Maternal Mental Health

MMI Maternal Mental Illness

OECD The Organisation for Economic Co-Operation and Development

PMH Paternal Mental Health

PMI Paternal Mental Illness

SEP Socioeconomic Position / Status

SUD Substance Use Disorder

SR Systematic Review

WHO World Health Organization

Preface: Essential definitions and context

First and foremost, several key terms will be repeated throughout this thesis and require context in relation to their applied use. The intended meaning of these terms is outlined below. Whilst not all authors of articles referenced in within this thesis may have applied the exact same definition, these terms remain politically active it is important to acknowledge their intention.

Father.

There are several potential different manifestations of what it means to be a father. The definition of fathers in the majority of the literature included in this thesis falls into a binary, heteronormative categorisation. However, globally, father figures are a diverse group, and increased normalisation and acknowledgement of alternative family dynamics should be encouraged. In this thesis, father is defined as any male parental figure. As much as possible, I have aimed to include discussion on non-biological fathers, sexual minorities and those of alternative family dynamics throughout this thesis. However, there remains a dearth of research on same-sex male couples and fatherhood. Whilst this is understandably reflective in part of the relatively low prevalence of openly gay father couples (135), research on child development is likely to benefit considerably from increased inclusion of persons outside of heterosexual two-parent (“nuclear”) families. Whilst underrepresented in the empirical studies used, the term “father” in this thesis applies to all father figures, LGBTQIA+ or heterosexual, biological or otherwise.

Mental health and illness.

Mental health is dynamic state in continuous fluctuation, determined by balance with and adaptation to one’s environment. Mental illness may be considered a disruption to this dynamic equilibrium. Although historically hard to define and heavily influenced by social, economic and political context (136). Krahn et al. (137) define disability as

“Experienced limitations in body function, activities, or participation in major life activities due to a health condition that occur in the context of one’s environment and are influenced by personal factors”

Mental illness can be defined correspondingly. However, mental health must be contextualised by systemic and planetary factors such as war, natural disasters, government policies, as well as an individual’s socioeconomic position. The baseline resilience required is not shared universally between individuals

(138). Within the lens of this thesis, whilst larger geopolitical factors such as war and global crises were not the focus, where possible, we took into account the socioeconomic context of individuals and study locations.

The transition to parenthood is also a naturally stress-inducing period, within which adaptation is required, whether successful or maladaptive. Thus, the associated symptoms of mental illness could be defined as a healthy adaptation to a challenging situation (139). Whilst we may be labelling certain responses as mental illness, in the perinatal context, as in many other contexts, they are not solely a product of the isolated individual, but a dynamic response to the environment. Regardless, this does not undermine the need to study paternal mental illness at the individual level, as the personal difficulty fathers experience, as well as the potential influence on the child and surrounding family, remain real and resolvable.

'Healthy' child development.

Child development is a messy, complex, multidimensional pathway within which the diversity of individuals is necessary. There is no one 'ideal' or 'perfect' developmental pathway, and often the definition of healthy is strongly dependent on societal and cultural norms. Within the literature included in this thesis, often due to the statistical approaches used, child development is frequently dichotomised as "healthy" or otherwise ("unhealthy", "sub-optimal", etc.). However, child development is a spectrum, and where possible child outcomes were taken as continuous measures to avoid oversimplified cut-off points grouping children as normal or otherwise (140). In many contexts, childhood diagnoses can indeed be beneficial, enabling greater support, tailored resources and more appropriate approaches to learning and play (141,142). However, they can also entail negative consequences, such as increased social isolation, stigma, feelings of inadequacy and adverse responses from parents (143–145). Whilst recognising that categorising certain patterns of child behaviour is often necessary in the context of a study, acceptance of the natural diversity of human behaviour and cognition is vital to reduce stigma. Atypical developmental trajectories are not necessarily associated with poorer outcomes and are often defined by cultural perceptions of success or capital (140). Reducing stigma does not mean exclusion from research, but rather progressively shifting the discourse towards one of increased compassion and acceptance of natural human heterogeneity.

"If you are always trying to be normal, you will never know how amazing you can be." Maya Angelou.

Chapter 1. Introduction

1.1. Father

1.1.1. The relevance of fathers

Progressive social changes such as more women in the workplace (4), more equitable custody laws (5,6), and increases to paternity leave (7,8) are all factors continuously enabling an increasing presence of fathers in their children's upbringing. Fathers' involvement in childcare almost tripled from 1965 to 2011 (9). Following the first legalisation in 2001 by the Netherlands, joint adoption by same-sex couples is now legal in 39 countries (146). And in opposite-sex relationships, men are now expected to play a more equal role in raising their children than previous generations (147). As of 2024, 35 (92%) of the 38 high- and middle-income nations comprising the Organisation for Economic Co-operation and Development (OECD) countries offer a nationwide form of paid paternity leave, compared to just three (Belgium, Luxembourg and Spain) in 1970 (148). However, progress has been slow and thus relatively recent. In France, although maternity leave was created in 1909, it took over 90 years for paternity leave to be established in 2001 (149,150).

Whilst research on the influence of parents on child development has historically favoured mothers (1), academic interest on fatherhood has progressively grown during the 20th century (3), with a trend of the number of articles on father specific factors like paternal involvement increasing considerably from the 1960's onwards (151). One review of research on father involvement and child cognition highlighted a growing and sustained interest in the relevance of fathers in recent years (2). Nevertheless, despite this increased focus, fathers are still often excluded from research on parental mental health and child development. Accordingly, there remains a limited understanding of psychopathology in fathers, especially in the context of contemporary fatherhood. The need for research on this topic can be illustrated by the following quote, taken from Kim and Swain (152):

However, an increasing number of recent studies suggest that fathers exhibit capabilities to interact with their infants almost as well as mothers.

Although published in 2007, this shows how the historical representation of fathers as a secondary parent is still present in modern research. Findings on fathers are often almost exclusively seen in studies focused

on both parents (71), with response rates frequently much lower for fathers than mothers. This disparity creates an inherent inequality in the representation of both parents, as well as a response bias amongst fathers potentially stemming from factors such as their degree of involvement, which can influence a father's impact on their child's development. Even when fathers are included in research, men's direct voices are often absent, relying on maternal reports instead of direct input from fathers. In 2005, Phares et al. (153) saw that whilst 48% of studies on parenting and child psychopathology included exclusively mothers, only 1% of studies included only fathers as research participants. Furthermore, in the remaining studies that did include fathers, only half differentiated them as a distinct group. To align with the growing recognition of the relevance of fathers in children's upbringing, an increased, active inclusion of fathers in research is necessary. And indeed, the exclusion of fathers is not only unwarranted but also overlooks key findings. Several studies have shown that the effects of paternal mental illness on children are similar in magnitude to those of maternal psychiatric disorders (53,71,154). A more equal focus on fathers is likely to not just benefit men, but also the extended family unit.

1.1.2. The risk of paternal mental illness

The recent political and cultural changes surrounding paternity suggest a significant intergenerational divide has occurred during current fathers' lifetimes, encompassing parenting styles, attitudes, and behaviour (147). This considerable gap between generations may be negatively impacting men's psychological adjustment to fatherhood; It is often hypothesised that men model the experience of their own fathers. Clear, positive role models adapted to modern standards may be lacking for many men (155–157). Even for those growing up in single-parent households, external representations of fatherhood in media and general society risk generating insecurities in fathers' identities (158,159). And indeed, qualitative research has shown that fathers often feel they do not meet the required expectations of being a father, commonly centred on the idea of needing to provide for their family (11). Fathers also express that unachievable ideals are frequently placed on them by their parents, or older generations, which leads them to stress about their fulfilment of various societal roles (e.g. father, provider and husband) (160,161). Shorey (160) explains this through self-discrepancy theory (162). In this context, the discrepancy results from fathers' 'ideal self' misaligning with their actual behaviour, as their notion of an ideal father is based on unrealistic time and knowledge requirements.

Whilst some of these feelings of insecurity, uncertainty or inadequacy in relation to one's role as a father can be an expected part of a healthy experience of fatherhood, when existing in isolation and/or to a particularly relentless or severe degree, they may develop into acute or chronic mental illness. The two most common manifestations of psychological distress amongst fathers, if following classical ICD-11 (163) categorisation, are mood (affective) disorders, most commonly depression, and anxiety disorders aside from phobias (26,27,44,164). Many of the symptoms experienced by fathers are the same as those experienced by men in the general population who are not fathers. These include low mood, fatigue, changes in appetite or weight, loss of interest in work, hobbies, and sex, intense worrying, negative thoughts, irritability and anger (165,166). However, some symptoms are specific and unique to fathers, such as confusion in one's fathering role or ability, intrusive thoughts in relation to one's child and decreased engagement in infant caregiving activities (167–169).

The most studied period of father's mental health by far is the postnatal period, spanning birth until one- or two-years following father's child's arrival. Qualitative findings suggest the transition to parenthood is often particularly sudden for fathers, with some stating they do not feel like a parent until the moment of birth (13). Although much less studied, beyond this period, the aforementioned manifestations of paternal mental illness, such as insecurities in one's ability to parent, and balancing work and family, remain pertinent. Even following the departure of their adult children, just as their maternal counterparts, fathers are also vulnerable to "Empty Nest Syndrome", the phenomenon where psychological difficulties occur when the last or only child leaves home (170,171). However, father's mental health is not an exclusively postpartum issue. Qualitative research also highlights pregnancy as a particularly challenging period for fathers in relation to their self-perceived role, feeling excluded and unprepared, as well as anxious for their baby and partner's wellbeing (128,172,173). First-time fathers often appear anxious towards their partners due date, and express fear and helplessness as a result of being unprepared (11). Even prior to conception, men's psychological state appears to have a strong bearing on their likelihood to develop postnatal mental illness, with those having a history of depression having an up to 3.5 times higher risk of developing depression postnatally (174).

1.1.3. Overall prevalence of fathers' mental illness

These psychological challenges seen highlighted by the literature are partially reflected in the prevalence of paternal mental illness. Globally, around 1 in 10 fathers experience paternal depression in the perinatal period, with a 2010 meta-analysis of 43 studies finding a prevalence of 10.4% (95% CI: 8.5–12.7%) (175) and another approximately 8.4% (95% CI: 7.2–9.6%) (165). However, it is important to note that these 'global' prevalence rates primarily draw from similarly high-middle income country populations (15,26). Rates of paternal perinatal anxiety are a lot less clear, ranging drastically within meta-analyses. Philpott et al. (26) saw 2.4–51.0% globally, with Leach et al. (27) finding a narrower 2.4–18.0%. Nevertheless, a growing body of evidence suggests that perinatal anxiety may be more common than depression amongst fathers (28–30). Although less studied, evidence also indicates fathers are also vulnerable to psychological distress during the prenatal period. Stress symptoms are estimated to occur in roughly 6% to 9% of expectant fathers (87). Moreover, one study saw that amongst fathers who were prenatally stressed, 37% had concurrent anxiety and 31% both depression and anxiety (32). The prevalence of anxiety in the prenatal period appears to range between 3.4% and 25.0% (26,27), and roughly 10% for prenatal depression (176), with rates dependent on study area.

When comparing these figures to France, we see no indication of a significant difference in prevalence: Nakamura et al. (33) found rates of postpartum (2 months) depression averaged 7%, with a second study finding rates of symptoms indicative of paternal depression to be 21% at 1-week postpartum and 8% at two-months (34). However, research on French data has not yet extended beyond the immediate perinatal period, with both the aforementioned studies limited to just 2-months postpartum. No investigation has yet been done on paternal diagnoses other than depression in France.

Research on paternal depression or anxiety extending beyond this point, both in France and globally, is sparse. However, data on fathers from the United States saw paternal depressive symptoms in 6.2% of fathers to children aged 5–17 years (177). And whilst perinatal studies suggest that fathers are the most susceptible to depression in the 3–6-month postpartum period (15), Garfield and colleagues (25) 23-year long analysis found that resident fathers' depressive symptoms increased by 68% from their child's birth through until 5 years of age. This was, however, based on data collected only at birth and 5 years, meaning that any potential fluctuations in depressive symptoms between these two points is unknown. Long-term rates in France may differ from other countries; Global statistics on episodes of major depression in the

general population in 2011 show that the average lifetime prevalence in France was in fact higher ($21.0\% \pm 1.1$) than other high-income countries ($14.6\% \pm 0.2$), with rates in France strongly linked to respondents income (178).

1.1.4. Inaccuracies in diagnosis

It is important to note that these figures are likely only a partial reflection of the reality and may be underestimating the true prevalence of paternal mental illness for several reasons. Firstly, the screening methods used to identify mental illness in the perinatal period have historically been tailored to women. The tools used for screening are thus often ill-equipped to accurately measure paternal symptoms (179), with the validation of scales like the Edinburgh Postnatal Depression Scale (EPDS; (180)) conducted primarily on mothers (181). However, now that research is progressively extending its inclusion to fathers and co-parents, these scales are often simply applied to fathers, following the deletion of questions based on child-bearing anatomy where necessary, as opposed to a more in-depth reflection on father-specific patterns of symptomology. Men are known to manifest depression differently to women, more commonly presenting externalising symptoms such as anger, violence, substance use and risk-taking behaviours (92,182). And regarding fathers, there still remains a lack of consensus regarding the definitions of paternal perinatal or male postpartum depression, with several studies relying on the definition of maternal postpartum depression to form the basis (152). Even when being assessed by a health professional, father's perinatal mental illness may not be diagnosed with the same efficiency as that of mothers, due to lack of an expected model or training relevant to paternal mental health (18,183). It is therefore possible that a proportion of fathers have been overlooked, due to their specificities of their psychopathology being unaccounted for.

Alongside potentially ill-equipped screening methods, the prevalence of fathers' mental illness is also likely to be underestimated due to reduced opportunities for detection itself. In many countries, women are actively screened for postnatal depression; however, the possibility that men might also be depressed during this time has, until recently, been almost entirely ignored (73). This exclusion is more broadly mirrored in healthcare systems, with qualitative studies highlighting father's difficulties in accessing both information and treatment for their mental health (13,184). Maternity wards frequently lack adequate facilities for fathers, with some fathers saying it was difficult being asked to leave following the birth of their child. These factors are likely to perpetuate the idea that perinatal healthcare prioritises the mother. Even

prenatally, several barriers are already present for fathers. Prenatal classes are often tailored for, and dominated by, mothers, despite men saying this was often their only source of information during pregnancy (13). Studies show fathers are often unaware that support exists for paternal mental health, rendering them much less likely to reach out to perinatal organisations, instead preferring to contact their general practice (GP) (13). Considering GPs are not tailored specifically to perinatal care, this may hinder fathers' access to a more appropriate mental health service.

Currently, both in France and abroad, perinatal programs and care services are predominantly centered on responding to the needs of mothers (185,186). For example, in Denmark, only 6% of municipalities were seen to offer psychological support for fathers in 2017 (11). In the context of single-parent households, even when the father remains active in the child's life, they are unlikely to be present for home visits where mental health screening often occurs. There are therefore reduced opportunities for non-resident fathers to come into contact with health services. Moreover, fathers' mental health may well be a reason for which they are no longer present. Turning to households where the father is present, the average duration of paternity leave in OECD countries, countries typically more progressive and of higher income than the global average, has only just risen to 3.1 weeks (148). In France, the current rate is 25+/-3 days, increasing from 11+/-3 days in 2021 (178). Nurse visits and at-home check-ups are thus overwhelmingly likely to exclude fathers due to their work obligations. In Denmark, fathers are screened for postpartum depression by the Health Authorities during home visits (187). However, recent statistics show that for the second postpartum visit, when this screening is normally conducted, only one third of all fathers were available to participate (11). Thus, the exclusion of these fathers could be skewing current prevalence data.

This problem does not exist exclusively on a structural level. The culture surrounding men's mental health and help-seeking behaviours is likely to have contributed to a potential underdiagnosis of paternal mental illness. Fathers have expressed that the stigmatisation of mental illness amongst men prevented them from seeking help, instead turning to avoidant behaviours or denial (160). Self-stigma has been shown to partially mediate the link between socialised gender roles amongst men and their willingness to seek counselling (188), rendering men less likely to self-disclose. Qualitative research shows that fathers also often feel it is socially unacceptable to either acknowledge or discuss their mental hardships (11,13). Difficult experiences during the perinatal period, such as complications during pregnancy, are also primarily centred on the mother, which may contribute to many fathers' prioritisation of mothers' mental

wellbeing over their own. New fathers express reluctance to share their mental hardship with their partners, often viewing their own opinions as unimportant (13).

Studies show one of the main reasons fathers are hesitant towards addressing their mental health is feeling shame or inadequacy, frequently associated with unattainable expectations of masculinity (13). However, fathers have also linked this hesitancy to the presence of intrusive thoughts about hurting their own child (11). This coincided with fears that sharing these intrusive thoughts could result in losing custody or being unable to see their child. This is particularly important, as research has shown not only high rates of intrusive thoughts amongst both new mothers and fathers, ranging 44% (168) to 65% (189), but that they occurred independent of parents' gender. Whilst the gap is slowly minimising, fathers are still less likely than mothers to be warranted custody of their child (190,191). It is therefore understandable for men to be more concerned about the fragility of their position.

Thus, we have three main parameters by which fathers' mental illness may be going underdiagnosed.

- 1) Inappropriate screening tools.
- 2) Reduced opportunities for diagnosis: structural (*no access to leave, exclusion from visits, perinatal education*)
- 3) Reduced opportunities for diagnosis: personal (*internal barriers, hegemonic masculinity, stigma*)

Taken together, these factors suggest the present rates of paternal mental illness may be understated.

1.1.5. Associated factors

i. External demands and reduced support

Independent of internalised expectations or pressures, fatherhood is objectively challenging. Several important determinants of mental health, including relationship satisfaction, social support and the quality and duration of sleep, are expected to change significantly following birth. For example, one study found just 5% of fathers fell within the normal range of sleep onset latency in the early postpartum period, with no difference seen between mothers and fathers on sleep quality, sleepiness, or fatigue (10). Postpartum sleep problems amongst fathers' have been seen to associate with poorer mental health and intimate partner relationships (192). Other aspects of father's physical health have also been seen to influence with their well-being during this time, with exercise interventions showing a positive effect on perinatal

depressive and anxiety symptoms in fathers (193). Obstetric and infant factors have also been found to influence paternal mental health. The birth order of the child, for example, has been seen to associate with paternal anxiety and depression, with experienced fathers showing a 70% higher risk of both conditions when compared to first-time fathers (194). Complications during pregnancy or delivery have also been found to be a key source of anxiety for expectant fathers, once again accompanied by feelings of helplessness (11). Unplanned caesarean sections, for example, can be intense and traumatic for fathers, leading to negative well-being, anxiety and depression postpartum (12,195).

Qualitative studies have further shown that external requirements for fathers during the perinatal period, most notably work, access to paid paternity leave and subsequent financial struggles, are significant triggers for stress and depression (11,12). Levels of responsibility, obligations and lifestyle changes are particularly high during this period and can harm men's general health and well-being. Many fathers appear to feel considerable stress and responsibility for their families financial situation, carrying burdens outside of their control, such as the changing economy (12). When interviewed, fathers express that the choice to continue working is often accompanied by feelings of guilt at not being there to help care for the baby. Fathers' work commitments, alongside parental responsibilities, also often leave them with little time for themselves (13), and are likely to reduce the opportunities for help-seeking behaviours or external support (11,14).

Looking beyond the perinatal period, many of these factors are likely to remain relevant. For example, father's mental health appears strongly reliant on the quality of the relationship with their partner and/or co-parent. On average, depressed fathers perceive the quality of their marital relationship as significantly lower than those non-depressed (75). Identified risk factors for paternal depression and anxiety include partner conflict, separation, decreased intimacy and a lack of support (15,18–21). Interestingly, similar problems can also be a product of paternal mental illness; For example, research has shown some fathers believe their postpartum depression led to decreased sexual intimacy and increased conflict with their partners (13), often resulting in separation (160). Whilst these conflicts could be accentuated in the period immediately following birth, there is no evidence to support why they would cease to be relevant after the postpartum period. The relationship difficulties resulting from paternal mental illness have also been found to aggravate external predictors of fathers' mental health, such as financial difficulties and subsequent job dissatisfaction (196–198), which are also likely to remain pertinent beyond the perinatal period.

ii. Broader family and social context

When discussing the risk factors contributing to fathers' mental illness, acknowledgement of their partner or child's mother's mental health is also necessary. Whilst this thesis focuses primarily on fathers' mental health and its relationship to child development, it must be remembered that emotional demands of the father during this period are not independent of that of their child's mother or surrounding family, where present. Maternal mental illness is one of the most consistent predictors of that in fathers, with the occurrence of one likely to accentuate the other (15,16). Amongst North American parents of children aged 5-17 years, maternal depressive symptoms independently associated with an almost six-fold increase in the risk of paternal depressive symptoms (177). This is consistent with findings of other studies that report a concordance between maternal and paternal depressive symptoms as high as 70% (15,199).

The association between mother's and father's mental health is also highly likely to be bidirectional. In opposite-sex couples, mothers often turn to their partner for emotional support, and fathers experiencing mental illness may have greater difficulty providing this. Indeed, women with depressive symptoms report feeling less supported by their partners and higher levels of partner conflict (200,201). This dynamic is also pertinent amongst single mothers, with involvement from non-resident fathers linked to improved psychological wellbeing and lower levels of depression amongst low-income mothers (202). Moreover, contextual factors associated with paternal depression, such as financial insecurity and social disadvantage, have been shown to mutually predispose mothers to depression (203,204).

This bidirectional relationship in partner's mental health aligns with family systems theory, the notion that the family is a complex, deeply-connected emotional unit (205). Whilst this theory has been accused of reflecting, in part, primarily Occidental thinking (206), expanding the family 'triad' to a more encompassing family unit (e.g., **Figure 1**) may present a more realistic representation of the interpersonal, dynamic context underlying parental mental health. For example, the presence of the maternal grandmother has been seen to negatively influence the degree of paternal involvement, in turn reducing fathers' positive effect on mothers' level of stress (207).

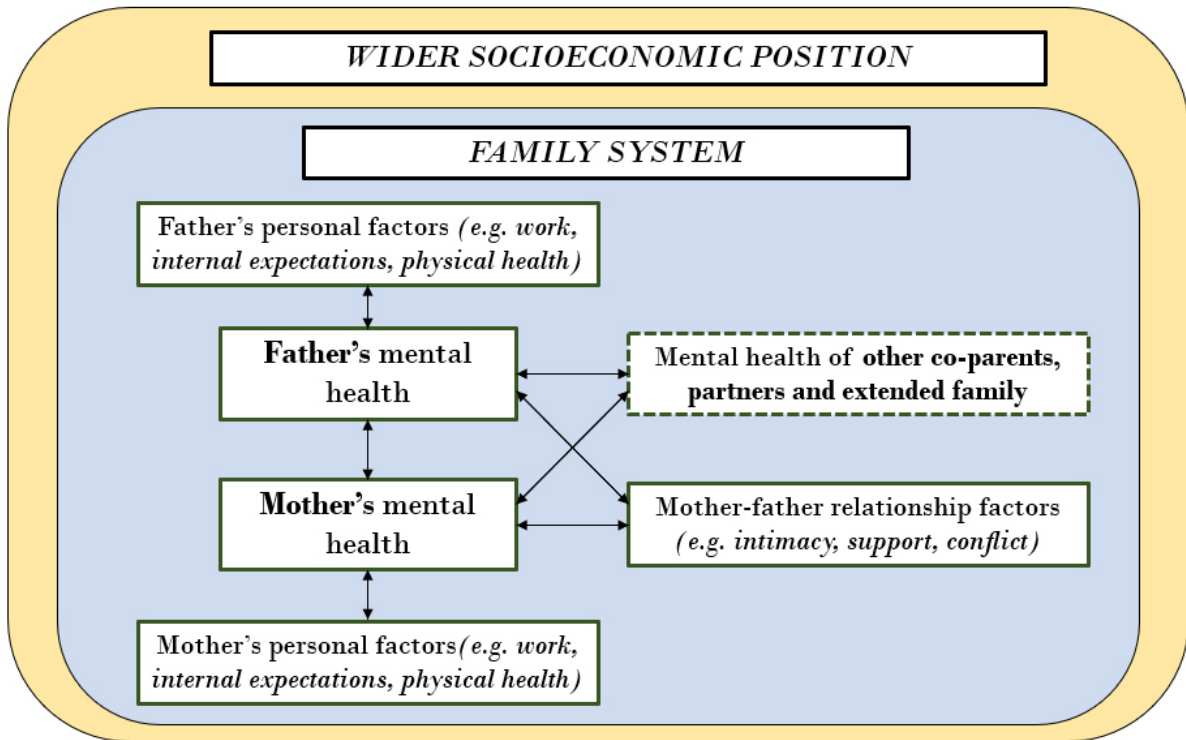


Figure 1 – Simplified example of the interacting within-family dynamics relating to psychological risk.

Finally, an important factor that appears relevant to paternal mental health is the influence of one's socioeconomic position (SEP), a construct defined by an individual's education, income, and professional class, as well as structural, historical and cultural influences (208,209). SEP is an all-encompassing influence thought to have a pertinent and lasting effect on almost all aspects of health (210,211). SEP has been added to **Figure 1** to demonstrate the underlying importance of the social determinants of health to this psychological risk model (212). The majority of qualitative studies on paternal mental health report fathers being influenced by factors relating to their SEP; Financial difficulties and access to work are commonly given as significant triggers for stress and depression amongst fathers (11,12). And indeed, unemployment is consistently associated with mental health disorders amongst adult men (213) as well as factors like low income (214) and neighbourhood characteristics (215). These patterns remain relevant to paternal mental health (98), with higher rates of depression seen amongst more socially deprived fathers (177), as well as parenting stress (23) and anxiety (24). And in France, Nakamura and colleagues (33) found that depressed mother-father couples were more likely to be migrant, less educated, and have had financial difficulties, indicating the relevance of SEP to fathers mental health in the French context.

1.2. Child

1.2.1. Domains of child development

To understand and research child development, it has been historically categorised into developmental domains. Although often encompassing shared or overlapping elements, the main groupings used within this thesis are the following:

1) Social and emotional (socioemotional)

Social and emotional development, commonly grouped into socioemotional development, encompasses emotional expression, regulation, and recognition. It underlies the basis of learning to understand one's own emotions, as well as those of others, and maintain sustained meaningful relationships with others. Whilst in early infancy, socioemotional regulation is based on responding directly to the senses, e.g., feeling cold, hot or hungry, as children grow, socioemotional development hinges much more on the interpretation of interpersonal interactions (216,217), and thus regulation is deeply embedded in early relationships (218).

2) Cognitive

Cognitive development is a broad concept that involves the maturing of skills involved in tasks associated with memory, perception, spatial reasoning, literacy, awareness, reasoning, intuition and problem-solving (219). Cognitive performance often aligns with classical academic achievement, with cognitive measures, such as the Woodcock-Johnson Psycho-Educational Battery (WJ), often also used to examine academic achievement.

3) Behavioural

The definition of behavioural development varies more than that of socioemotional and cognitive development, and is often used to represent the complex and dynamic expression of skills included in both socioemotional and cognitive development. In other instances, it may refer to the ability to self-regulate one's behaviour, such as attentional reactivity, approach-withdrawal behaviour and control (220) or an individual's functioning within the sociohistorical context of their environment (221).

Whilst other domains, such as physical development, comprising elements such as the development of fine and gross motor skills, were not the focus of this thesis, it is important to note that all domains continuously interact with each other (**Figure 2**).

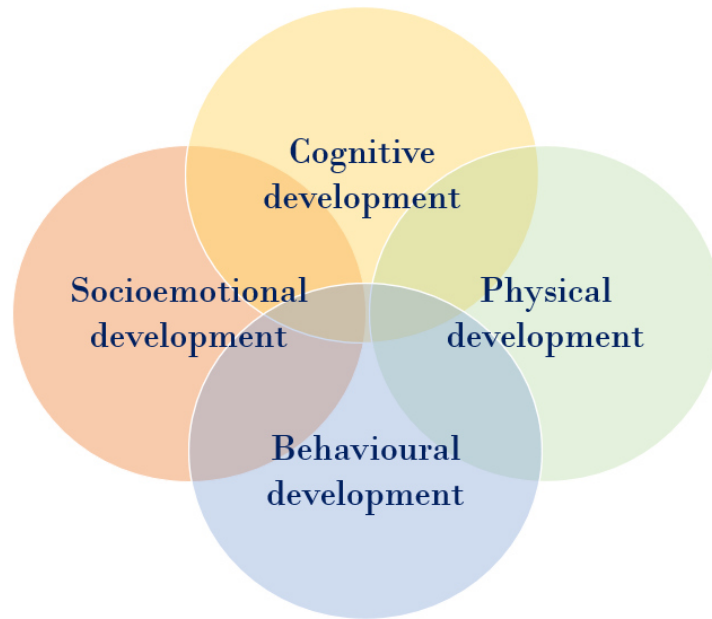


Figure 2 – *Demonstration of the overlapping nature of several child developmental domains*

Moreover, the historical interpretation that child development follows multiple, parallel linear progressions has also been accused of oversimplifying the reality (101). Whilst development does appear to occur across multiple integrated pathways, to quote Ayoub and Fischer, isolating developmental domains can lead to “the erroneous belief that the child, for example, has a cognitive delay rather than an adaptive response to an adverse environment or condition” – a response that may be advantageous at a given time. Alternative approaches, such as dynamic systems theory, take development as a dynamic process allowing for developmental synchrony across skills, thus viewing an individual more holistically (222). However, methodologically, the holistic individual is hard to study. The categorisation of child development into specific domains has enabled researchers to make significant advances in the study of child socioemotional, behavioural and cognitive development (223). Whilst each comprises strands in an intersecting web, the isolation of separate domains can show nuances in the effects of exposures on child development, thus better tailoring preventative measures, healthcare and support.

1.2.2. Complications in child development: Prevalence and rates

Globally, United Nations Children's Fund (UNICEF) 2021 report estimated that 4.3% of children aged 0–4 years and 12.5% of children aged 5–17 years have moderate-to-severe disabilities, in any aspect of development, resulting in a total of 236.4 million children aged 0–17 years (224). In expanding the

parameters to include mild disabilities, the global burden of disease (GBD) 2019 report shows this figure rise to 291.3 million (11.3%) amongst children younger than 20 years (225). And whilst global rates of disease and injury amongst children have been decreasing over time (226), one report comprising 195 countries and territories found no significant improvement in developmental disorders from 1990 to 2016 in children younger than five (118).

Taking just socioemotional and cognitive development, a 2010 UNICEF report estimated that 80.8 million children aged 3-4 years in low to middle income countries had low socioemotional or cognitive development scores, based on the Early Child Development Index (ECDI) (227). 14.6% of children scored low in cognitive domains, and 26.2% in socioemotional domains. In France, recent ENABEE (National Study on Child Well-being) findings saw that amongst children aged 6-11, an estimated 13.0% of children aged 6 to 11 years have a probable mental health disorder, 6.6% an oppositional disorder, 5.6% an emotional disorder, and 3.2% attention deficit hyperactivity disorder (ADHD) (228,229).

Looking closer at child mental health, in 2015, the worldwide prevalence of mental disorders amongst children and adolescents globally was 13.4% (230), and depressive disorders were the sixth top cause for disability-adjusted life-years (DALYs) in persons aged 10–24 years (226). And recent findings on adolescents in France shows mental health appears to be deteriorating, with the prevalence of depression increasing from 5.2% to 6.9% in boys and 13.4 to 21.4% in girls from 2018 to 2022, likely due in part to the COVID-19 pandemic (231). Persistent mental illness and/or associated symptomology also associate with both immediate and long-term negative consequences, such as physical comorbidities, family conflict or peer problems, as well as aggravating certain social determinants of health, such as criminal history and level of completed education (232–234). Importantly, 2019 data from the World Health Organization (WHO) revealed suicide to be the fourth leading cause of death for adolescent boys and the third leading cause for girls of the same age (235).

The estimated prevalence of certain neurodevelopmental disorders also appears to be increasing, with the percentage of children diagnosed with ADHD rising from 6% in 1997/98 to 10% in 2015/16 amongst North American children and adolescents (236). These changes may be indicative of increased awareness, testing, and changes to diagnostic criteria as opposed to purely higher rates (237). Nevertheless, they highlight the need for increased awareness, engagement and support for those affected; as discussed above, whilst these developmental adaptations are often beneficial in a given situation or moment in time, the adverse impacts

of these conditions on children and their families can be profound and enduring (232). For example, left untreated, ADHD can lead to an increased risk of an increased risk of lower educational attainment, unemployment, substance use, and other mental health conditions, alongside reduced quality of life and social integration (238).

However, it is important to note that, largely owed to the incredible work from disability movements in the 1990's (239), the emergence of theories surrounding neurodivergence have challenged assumptions made about child developmental disorders and normality. Studies in which autism is included as a child outcome, for example, should not necessarily take it as an indicator of undesired or adverse development. However, identifying an association between such neurodivergence and paternal mental health remains useful for several reasons. Children with autism or ADHD have been shown to benefit from increased support as early as possible (240–242), thus identifying said populations can enable faster referrals and better targeted care. Moreover, associations may be bidirectional, in that fathers of children with autism may require greater emotional support. Parents of neurodivergent children are indeed at greater risk of depression (243) and psychological distress (240,244), and research shows social support interventions can help reduce stress and improve parental wellbeing (245,246).

1.2.3. Critical periods

Sensitive or critical periods are developmental periods with particularly high neuroplasticity or vulnerability to adaptation (247). For example, the period from conception until about two years of age ('the first 1000 days') has been highlighted as particularly important for cognitive development, with functional networks maturing rapidly (55). Parents are vital not just to development during these periods, but also for the timing itself; cues from caregivers have been seen to trigger the termination of sensitive periods in relation to emotional development (248). The European Union has recently placed focus on funding investigations on the first 1000 days of development, starting from conception (249,250). In France, this resulted in a 2020 report commissioned by the government, aiming to improve policy frameworks to support children during this period (251). However, clear periods of specific developmental vulnerabilities are difficult to isolate. Whilst the first 1000 days have been highlighted as one of the most important developmental windows of a child's life, direct causal evidence to support the relationship between this period and adult outcomes remains sparse (252). Complex behaviours such as language, attachment styles

and intelligence quotients (IQ) are likely to rely on multiple underlying neural circuits, and thus overlapping sensitive periods (247,253).

Early life exposures can also result in positive or negative developmental cascades that continue throughout the life course (254). Life course epidemiology is an approach that considers the long term progression and result of exposures on development, not only on an individual's life course but also across generations (255). Even prenatal exposures, such as stress, drugs or malnutrition in utero, have been seen to exert effects far beyond childhood (256–259). Understanding what processes may program these sequential chains of risk can thus provide lifelong benefits. Economically, global cost-benefit analyses provide support for investing in prevention during early development (260,261).

1.2.4. General risk and protective factors

Decades of research support the existence of factors that significantly alter the trajectories of child development. Common models in developmental psychopathology highlight the importance of parental attachment, interactions and support for healthy socioemotional and behavioural development (36,262). Adverse early life experiences, such as experiencing significant and/or repeated trauma in early childhood, are likely to influence these developmental milestones in fundamental ways (263). Whilst these adaptations can be simultaneously adaptive and maladaptive, depending upon the circumstance, they can nevertheless alter the child's associated development in both the short and long-term (264). Recent work in the area of trauma and psychopathology, for example, supports a connection between adverse childhood experiences, such as early child abuse, and a pervasive array of changes in emotional regulation (254,265). Children from abusive or violent homes often show a significant negativity bias in their play and early relationships (264). However, wider structural factors still pertain. Certain children are more vulnerable than others to maladaptive patterns of development, be it from birth due to genetic or prenatal influences (266,267), as a result of environmental exposures, such as malnutrition and disease (268,269), or from wider contextual adversity such as structural inequalities, social exclusion and neighbourhood deprivation (270,271).

There are numerous ways through which family socioeconomic position (SEP) may impact child development. Firstly, economic resources enable parents to provide the food and housing security essential for children's basic needs (272), as well as certain resources, education and experiences known promote positive child development (273). Differences in parental involvement and engagement have also been seen

based on parent's occupational class (85,274,275) and level of education (85,114,276,277), with evidence suggesting variations in parenting practices may be partially rooted in social class (85,278,279). Considering parent-child interactions are pertinent to child socioemotional and behavioural development, SEP may therefore be a particularly influential factor. A review on child mental illness saw 55/52 studies (95%) found an inverse relationship between children's socioeconomic position (SEP) and their mental health, with socioeconomically disadvantaged children and adolescents two to three times more likely to develop mental health problems (280).

For cognitive development, we see that biological, environmental and socioeconomic factors all remain strongly influential. For example, children's birth weight (281), home environment (282) and access to education (283,284) all appear to influence cognitive development. Children from less-advantaged homes are also much more likely to begin school with lower levels of literacy (285), alongside showing decreased subsequent educational success (286), and higher rates of absenteeism or school dropouts (287,288). However, although potentially to a lesser degree than for socioemotional development, parent-child factors also play a role, with parent-child interactions providing invaluable play and intellectual stimulation (289). Moreover, many of the aforementioned socioeconomic and environmental factors thought to influence cognition, such as the home environment and access to material and educational resources, also link fundamentally to children's parents.

1.3. Father and child

1.3.1. General findings on the effect of fathers' mental health on the child

While mental illness does not preclude parents from providing appropriate care for their children (290), it can potentially expose them and their families to a number of risks. Studies have shown paternal mental illness (PMI) to negatively impact child development from infancy to late adolescence, resulting in adverse socioemotional and behavioural outcomes (37–39), including conduct problems (2), attention problems (39), and oppositional defiant disorder (30), as well as increased risks of cognitive problems, such as poorer language and reading development (40) across ages (41,42). As early as 2 months, children of fathers with symptoms of mental illness show higher rates of emotional and behavioural problems, with a meta-analysis of 40 effect sizes showing a correlation coefficient (r) of 0.13 (95% CI: 0.04-0.22) between paternal internalising symptoms and infant generalised negative affect (43,44). Amongst toddlers, postnatal

paternal depression significantly predicts hyperactivity and emotional and conduct problems (39). In later childhood, children exposed to mental illness are also at greater risk for later psychiatric disorders (38,45,46) and associated psychological problems such as substance abuse (12, 13) and suicidal behaviour (5, 8, 9), than non-exposed children. These effects commonly persist even after controlling for maternal psychopathology (39,291).

One study based on the UK Millennium Cohort found that, after adjustment for maternal psychological distress and confounders, paternal psychological distress still predicted all four examined domains of child problem behaviour (hyperactivity, conduct, emotional and peer problems) (23). However, the wider literature remains inconclusive. Cognitive domains appear to be less impacted by father's mental health than socioemotional or behavioural, although the evidence is limited (52,292,293). Moreover, effect sizes are also often small (49). In Sweeney and colleague's (51) review, whilst 10 out of 16 included studies saw externalising problems to be associated with paternal depression, and 17 of 19 studies on internalising difficulties (25), the effect was frequently small or dependent on several contextual mediators, including paternal involvement and marital conflict. Some studies even show no significant effect overall, with Metz et al. (50) finding no correlation between neither mother nor father's anxiety and child temperament from 4 to 30 months. Even more paradoxically, Jones et al. (52), after controlling for maternal mental health and parental education, found that increased prenatal paternal depressive symptoms associated with fewer child behavioural difficulties. Additionally, greater concurrent paternal depression or anxiety predicted higher child IQ. These variations highlight the need for further research to better understand the complex relationship between paternal mental health and child outcomes.

1.3.2. The importance of paternal diagnosis

Regarding the intergenerational transmission of mental health, studies suggest paternal diagnoses appear to align with that of the child. Children of depressed parents are almost three times as likely to experience a lifetime episode of depression as those of non-depressed parents (26, 27); Children of fathers with social anxiety disorder have a higher risk of the same disorder (11); and adolescents whose parents have bipolar disorder are 3–4 times more likely to develop other psychiatric illnesses but up to ten times more likely to develop bipolar disorder (19, 20). However, these patterns might have partially resulted from trends in study design, in that the exposure and outcome are often chosen by authors to align. For example,

longitudinal studies have shown consistent associations between paternal alcoholism to substance abuse and dependence amongst their children (12, 13). However, paternal alcoholism is also associated with an increased risk of mood disorders and depressive symptoms in adolescents (14).

Certain mechanisms through which paternal mental illness influences the child may be shared across multiple distinct psychopathologies, extending beyond the specific diagnosis. These shared mechanisms could impact the child's development similarly, regardless of whether the father is experiencing depression, anxiety, or another mental health condition. For instance, paternal stress, depression and anxiety all lead to low perceptions of parenting efficacy (294–296), thought to be a potential mediator of the relationship between father's mental health and their child's development (section 1.3.5ii). And indeed, many of the outcomes seen to associate with paternal mental illness are also shared across different paternal diagnoses, such as general emotional and behavioural problems, academic underachievement, low self-esteem, and relational difficulties (51,297–301). Finally, the socioeconomic and environmental risk factors for many paternal diagnoses are shared, and thus may exert similar effects on the child indirectly. Taking substance use as an example, families in which parents use illicit drugs are more likely to live in poverty, as well as having reduced access to social support (302). Paternal prenatal depression, stress, and anxiety all also associate with lower social support (303) and higher social deprivation (23,24). With time, these contextual factors may present a greater influence on the child than the father's diagnosis itself ((269,270); section 1.2.3).

1.3.3. Temporality

When discussing the relationship between fathers' mental health and child outcomes, it is important to consider the timing of both, as it may entail different mechanisms of transmission, as well as distinct sensitive periods for specific aspects of development (44).

Regarding the perinatal period, evidence suggests that a father's mental health can affect the child as early as conception (43,52,304). However, when comparing the influence of prenatal and postnatal paternal mental health on the child, patterns appear to emerge. Spry et al. (44), in reviewing the literature, saw that whilst the association between postnatal paternal mental illness and child development was similar to that observed for mothers, the association was much weaker for paternal symptoms occurring during the prenatal period. This may be due to reduced influence from the father prenatally. In support of this, studies

on the relationship between prenatal paternal mental illness and child outcomes during infancy show particularly small effect sizes (44,291) or no significant effect at all (305). Nevertheless, enough studies have shown an association between prenatal paternal mental health and child development to warrant its continued investigation (43,51,52,304,306), with particular attention to be paid on indirect mechanisms of effect. Prenatal paternal anxiety has been seen to influence child subsequent neuroendocrine function at 6-8 years (307). Moreover, Ramchandani and colleagues (38) found fathers with symptoms of both pre and postnatal depression posed the greatest risk to their child's development, suggesting a cumulative effect of both antenatal and postnatal on offspring development. Pre-existing mental illness is one of the most significant risk factors for paternal postnatal depression and anxiety (87,308), thus the cooccurrence of both is not uncommon.

As seen (section 1.2.4), the nature of child development means that effects on certain earlier childhood domains associated with paternal mental illness are likely to lead to subsequent developmental adaptations or mental illness later in life. For example, studies on children aged 4-7 years found that those with persistent language disorders are more likely to have concomitant social-emotional and behavioural difficulties (309). And exposure to paternal mental health problems during childhood has been seen to exert long-term effects extending into late adolescence and throughout adulthood (310,311). However, more longitudinal investigations are needed to follow the relationship between paternal mental health and child development over time, as currently most studies measure father's mental health cross-sectionally, often during the perinatal period. One study with a longitudinal design, albeit only two measures one year apart, saw positive father-adolescent, but not mother-adolescent, relationships had protective effect against depressive symptoms in Chinese male adolescents (312).

1.3.4. Child sex

The literature surrounding the relevance of child sex assigned at birth and gender to the relationship between fathers' mental health and child development varies greatly. It has been theorised that fathers engage in more gender socialisation than mothers (67). One would therefore expect to find more pronounced gender differences in the impact of fathers' mental health on child problem behaviour (23). And indeed, several studies suggest the risk of developmental problems linked to paternal mental illness may be greater in sons compared to daughters (53), with boys appearing more vulnerable than girls to the effects of their fathers' depression, especially during early development (39). Some argue that these

patterns might be a result of fathers spending more time with their sons than with their daughters, which Lamb and Lewis (66) suggest occurs because parents identify better with a child of the same sex, in turn creating an assumption that their knowledge and skills are more suited to raising said child. However, observational studies actually find that fathers are more attentively engaged with their daughters than their sons (313). Moreover, numerous studies have found no difference the impact of paternal mental health problems on their child's development based on their sex or gender (54).

Rather than differences in the relative effect size, supposed gender disparities may be more dependent on the specific developmental outcome of the child. Glover and Hill's (314) investigation on prenatal stress in animal models found that, in response to maternal distress during pregnancy, girls primarily exhibited outcomes related to depression and stress reactivity, whereas boys were more likely to experience learning, memory and cognitive deficits. However, Flouri et al. (315) found that high levels of paternal psychological distress predicted emotional symptoms and hyperactivity more strongly in boys than girls, indicating that the previous findings from animal models may not directly translate to human populations. These disparities may also vary based on the timing of assessments; In response paternal post-traumatic stress disorder (PTSD), daughters of Vietnam war veterans showed more somatic complaints and aggression in early childhood, and depression in adolescence, whilst their sons showed anxiety in early childhood and somatic complaints and hyperactivity in adolescence (316). Finally, gender or sex-specific findings may also be a product of certain biases, such as prioritising investigation on father-son relationships as opposed to father-daughter or other children. For example, studies show sons of alcoholic fathers have a higher risk of conduct disorder, delinquency, substance abuse and alcohol-related mortality (317–319), yet all of these studies were conducted exclusively on male children. Moreover, one study on the long-term impacts of parental alcoholism found the outcomes were actually worse for daughters than for sons (320). Overall, the assumption that fathers impact sons more than daughters appears to be unwarranted, and risks oversimplifying a complex series of biological and social pathways (321).

1.3.5. Socioeconomic position (SEP)

As seen (sections 1.1.5; 1.2.3), socioeconomic disadvantage associates independently with increased rates of paternal mental illness (11,23,24,213), as well as child psychiatric problems (280,322) and developmental disabilities (225,226,235). It is therefore possible that some of the associations between

paternal mental health and child disorders may be explained by confounding socioeconomic factors. Indirect influences, like fathers' ability to undertake aspects of their paid employment for example (323), may also have a knock-on effect on the opportunities available to their child. Moreover, differences in SEP have also been hypothesised to explain the significantly better psychological outcomes seen amongst children of gay fathers when compared to those of heterosexual parents (324). However, in some instances the association between paternal psychological distress and child problem behaviour has persisted after accounting for socioeconomic disadvantage (23). One study also saw that whilst child behavioural symptoms were moderated by maternal SEP, that of fathers had no effect (112). These findings further support the need for research exploring the importance of socioeconomic status in the relationship between paternal mental health and child development, as, currently, low-income and minority fathers are systemically unrepresented in research (273,325).

1.3.6. Model of intergenerational risk

The relationship between children and their parents' mental illness appears to differentially impact the child based on the affected parent (38,71,259,299). Moreover, several of the hypothesised mechanisms by which mothers' mental health may impact their child's development are not directly applicable to fathers (326). For example, direct prenatal exposure through neuroendocrine alterations, psychotropic medications and certain health behaviours – 'the foetal programming' hypothesis (327) – associate primarily with the mother (328). Thus, models of intergenerational transmission cannot be directly transferred from mother to father. In response to this, Ramchandani and Psychogiou (329) propose a variation of Goodman and Gotlib's model (326), adapted to fathers. An adaptation of this model for our context is shown in **Figure 3**, changed to show possible bidirectional effects between effect moderators and paternal mental health.

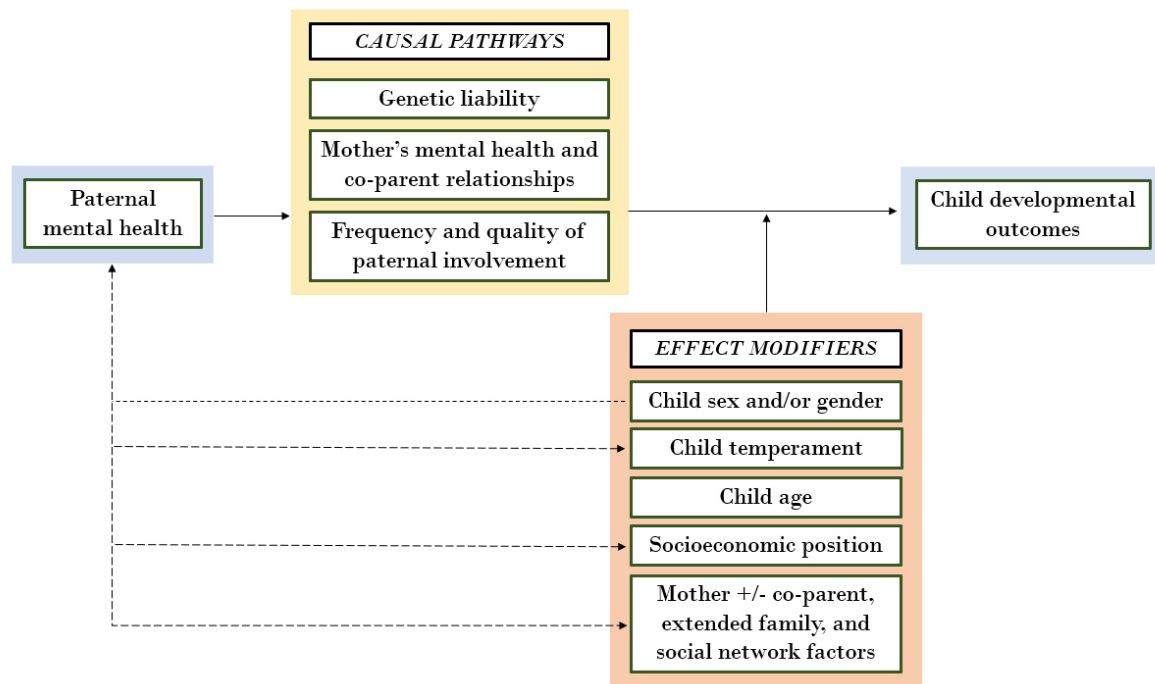


Figure 3 –Proposed model of the transmission of risk between father's mental health and child development, adapted from (218). Dotted lines show possible additional, bidirectional influences on father's mental health.

1.3.7. Mechanisms of risk transmission

i. Genetic liability

Genetic liability is a potential causal pathway in which children inherit genes from their biological father that may increase or decrease the risk of certain developmental outcomes (330). Although the genetic inheritance of mental health issues has been much more extensively studied in relation to mothers, research has shown higher degrees of conduct problems amongst children residing with antisocial fathers when a genetic link was present (331). Another study examining genetic and environmental influences on the transmission of parental depression found an additive effect, where both family environment and genetic factors contributed to the child's overall risk, although direct environmental risk demonstrated the greatest impact (330). One study saw no significant difference in the effect of paternal major depression on psychiatric disorders amongst nonadopted or adopted adolescents, suggesting that the genetic link was not influential in this instance (332). The genetic contribution to psychiatric disorders varies based on

diagnosis, being high in autism and bipolar disorder, and low in anxiety disorders (333–335), indicating that the genetic inheritance of mental illness is also likely to differ based on diagnosis.

ii. Relevance of maternal wellbeing and the coparent relationship

Secondly, Ramchandani and Psychogiou highlight the importance of father's effect on the child's mother's mental wellbeing, where present. As previously discussed (section 1.1.5), paternal mental illness is highly associated with that of their child's mother or their romantic partner. During pregnancy, important neuroregulatory mechanisms begin to develop in the womb often result as a direct effect of prenatal exposures on mother (327,328). The father may thus indirectly influence the child by directly affecting the mother, for instance by increasing her stress levels during pregnancy. This paternal influence could, in turn, reproduce similar effects on the child's development through the mother's altered mental or emotional state. Considering there is often a shared burden of care between parents, this renders the risk of adverse effects even greater amongst children exposed to concurrent mental illness in both parents. In support of this, the presence of paternal depression has been found to aggravate the negative effects of maternal postpartum depression on child development (336,337), with healthier paternal mentality potentially acting as a protective factor for the child when maternal depression is also present (51,323). Nevertheless, evidence on this relationship remains inconclusive, with father's mental health often studied as a moderator for the effects of mother's mental on child outcomes, but rarely the inverse. Whilst the effects of father's mental health on the child have been seen to act independently of mother's psychopathology, with one study also finding no moderation effect of maternal depression or anxiety on the relationship between paternal depression and cognitive outcomes in children aged 6-8 (52), Gutierrez-Galve and colleagues saw maternal depression and mother-father conflict to mediate roughly two-thirds of the association between paternal depression and child outcomes at 3.5 and 7 years of age (37), with maternal depression also mediating the risk of depression in daughters at age 18 years (45).

The strength of the association between paternal depression and negative offspring development has also been found to rely strongly on marital conflict (51), with one study even labelling mother-father conflict as a better predictor of poor child outcomes than maternal depression (65). Considering both maternal and paternal mental illness are strongly linked to intimate relationship conflict or satisfaction (74, 76-80),

mothers' mental health remains a potentially viable mediator of the relationship between fathers' mental health and child development.

iii. Frequency and quality of paternal involvement

Another key environmental mechanism suggested is the impact of psychopathology on father's parenting practices. Paternal involvement is the extent to which fathers interact with, and are responsible for, their children (338,339), which can be grouped into two main elements; the quality and the frequency.

Presence of the father: the frequency of paternal involvement

Taking the frequency of father's involvement, it could be that fathers with mental illness are less available than those without. Studies have shown that fathers with depression spend less time with their children than non-depressed fathers (97,336). Non-resident fathers have also been found to show higher rates of psychological distress, which in turn negatively associates with family responsibilities and commitments (340). Early childhood father absence has been found to strongly associate with offspring depression in adolescence and early adulthood (341). Gutierrez-Galve et al. (37) also saw paternal non-involvement account for 5-8% of the total effect of paternal depression on child development at ages 3.5 and 7. Alterations to the frequency of father involvement as a result of paternal mental illness may then mediate the potential impact of their psychopathology on the child (37). It is also possible that a higher frequency of paternal involvement may increase children's exposure to their fathers' mental health, thus increasing the risk of associated outcomes. However, some findings suggest that fathers' presence has a positive effect on the child regardless of fathers' mental health; Mezulis et al. (337) found the degree of father involvement amongst depressed fathers to beneficially moderate the effect of maternal depression on child development, with high to medium amounts of father involvement associated with less internalising behaviours.

The presence, or non-presence, of father figures is thus also vital for children to develop foundational social and emotional competencies. Even for non-resident fathers, one North American study saw that 72% of children not living with their biological father still had at least yearly contact with him, with 68% meeting their father at least once per month (342). Father's active presence during their child's upbringing has also been shown to lead to significant improvements in their child's cognitive skills (2,343).

The modelling hypothesis, based on theories of socialisation and social learning, suggests that an individual's attitudes and behaviours are modelled upon the behaviours of people who were important and influential to them (35); Children frequently learn patterns of behaviour by observing the adults around them (156). Paternal engagement in activities such as reading and telling stories, painting and drawing, and visiting local community or cultural spaces is important for children's early language and cognitive development, and associates with positive cognitive, socioemotional, behavioural and academic outcomes (116).

Evidence suggests the quality of paternal involvement can be impacted by paternal depression and anxiety. Studies on fathers with depression show that the quality of time spent with their children is frequently less positive, with fewer activities such as reading, singing, and hugging, and higher rates of conflict and neglect (97,336,344). Depressed fathers are more likely to express aggravation and stress in parenting when compared with non-depressed fathers (37). Disengaged and remote parenting behaviours associated with paternal postpartum depression are likely to negatively affect fathers initial attachment to their baby (345), and have been linked to early behavioural problems in children (291,346). One review saw the most common mediator of the relationship of paternal depression on offspring internalising and externalising problems were parenting behaviours, relying strongly on increases to negative expressiveness and hostility (51). Depression amongst fathers also increases the likelihood of corporal punishment (36), known to be associated with increased mental health problems, delinquent behaviour and subsequent criminality amongst children (347). Paternal anxiety also associates with an increase in overly protective and controlling behaviours towards both their infant and their environment (348). Fathers' overinvolvement and overprotection resulting from anxiety has been found to predict increased anxiety (349), as well as negative subsequent treatment outcomes (350), in their children. Other paternal diagnoses, including mood, personality, obsessive-compulsive, and substance use disorders, have all also been seen to independently associate with specific types of maladaptive parenting behaviours (348,351). However, the associated changes to fathers' behaviour are often shared between diagnoses, such as those of paternal anxiety and obsessive-compulsive disorder (352).

An important construct relative to this association is fathers' own perception of their parenting abilities (parenting self-efficacy). On average, depressed fathers have a lower sense of parenting efficacy than those

who are not depressed (353), as well as those experiencing increased stress or anxiety (294,354). Low parenting self-efficacy has been found to associate with behaviours known to increase the risk of child socioemotional and behavioural problems, such as increased hostility (169) and coercive discipline (169,355). Qualitative research has also found fathers' feelings of inadequacy and powerlessness sometimes turn anger and frustrations towards their children (11), likely to impact their child's attachment and subsequent mental health (356,357). And indeed, mother and father parenting efficacy has been seen to mediate the effect of mental illness symptomology on developmental outcomes (294). It is therefore possible that the link between father's mental illness and their child's development may partially stem from father's perceived efficacy as opposed to solely real, perceivable changes in parenting practices. One study showed that paternal depression did not have any effect on the way fathers interacted with their infants (358). Interestingly, two reviews saw that whilst mental illness often led to low parenting self-efficacy, low parenting self-efficacy also increased the risk of mental illness, suggesting a bidirectional relationship between the two (169,294).

v. Effect moderators and bidirectional effects

Effect modifiers are also present, appearing to moderate the relationship between the effect of father's mental health on the child. These elements have been in subsequent detail, and include child sex or gender (section 1.3.4), child age (section 1.3.3) and SEP (section 1.3.5). There also exists the potential for bidirectional effects in the relationship between child development and fathers' mental health. Taking child temperament for example, the child's behaviour is likely to in turn effect that of their parents. Children of depressed or anxious fathers show temperamental difficulties (51,301), such as persistent crying or impulsive behaviours (359,360) which might subsequently accentuate or trigger negative coping methods in the father. Research supports this, showing that fathers with alcohol dependency tend to drink more alcohol after interacting with a difficult child if they think they will interact with the child again soon (361,362). Furthermore, when controlling for confounding factors, perceptions of having a difficult child or dysfunctional interactions with one's child, as well as the degree of parenting distress, all appear significantly higher amongst depressed fathers than those not depressed (75). Brooker et al. (363) saw that increased paternal symptoms of anxiety at 9-months postpartum predicted infant negative affect at 18-months, whilst infant negative affect at 9-months predicted more anxiety symptoms in fathers 18 months later (27-months), supporting this bidirectional association. Evidently, the influence of father's mental

health can extend throughout the family network in a multitude of ways, and is likely to impact the child through multiple indirect and direct pathways.

Altogether, further research is needed on the mechanisms by which fathers' mental health impacts their child's development. As seen, almost every aspect of this relationship raises inconsistencies within the literature. Due to the limited number of studies, reliable patterns are hard to decipher, thus impeding the development of effective prevention methods or targeted interventions. Further research is necessary. Investigation of certain variables thought to moderate the relationship between paternal mental and child development, such as child sex and maternal factors, may also help elucidate the pathways underpinning this relationship.

1.4. Thesis aims

1.4.1 Objectives

The main aim of this thesis is to explore paternal mental illness and its relation to child development. This will be conducted through three articles, with both distinct and overlapping aims:

- 1) Firstly, I aim to examine the current state of paternal mental health amongst new fathers in France. Within the French male population, the longitudinal progression of men's mental health following the transition to fatherhood will be presented, with a particular effort made to include a range of paternal diagnoses and assessment methods.
 - a) Alongside this, correlates of these long-term trajectories will be investigated, in the aim of identifying risk or protective factors for patterns of paternal mental illness over time.
 - b) A parallel investigation will also be conducted to investigate differences in both the prevalence and longitudinal patterns based on the method of paternal mental health assessment.
- 2) Secondly, I will conduct an integrated overview of the systematic review literature available on the relationship between fathers' mental health and child development. In doing this, I aim to summarise the current state of understanding on this relationship, as well as nuances in relation to paternal diagnoses, timing, child developmental domains, sex and age where possible.
 - a) A secondary aim will be to simultaneously assess the quality and scope of the systematic reviews currently available, addressing important weaknesses and implications for future research.
- 3) Thirdly, the final article aims to assess the association between perinatal paternal depression and anxiety and early child socioemotional, behavioural and cognitive development. An outcome-wide approach will be used in the aim of detecting possible differences based on child developmental domain.
 - a) The moderating influence of aforementioned factors, such as child sex, mothers' mental health, and socioeconomic status, on this relationship will also be investigated to respond to inconsistencies within the literature.

Taken together, this thesis aims to provide a multifaceted investigation the relevance of fathers' mental illness and its association to socioemotional, behavioural and cognitive child development.

2. General methodology

2.1. Population cohorts

2.1.1. CONSTANCES

CONSTANCES is a large-scale, nationwide cohort targeting adults aged 18-69 at inclusion and affiliated to the French Social Security system (over 85% of the French population) (56,364). A general-purpose cohort, it aims to cover a wide range of health problems and their determinants, with a focus on chronic diseases, aging and social and occupational factors. Subjects were selected based on random sampling, stratified with unequal probabilities according to age, gender and socioeconomic status (SES), over-representing categories usually underrepresented in surveys. Recruitment was distributed throughout mainland France (**Figure 4**).

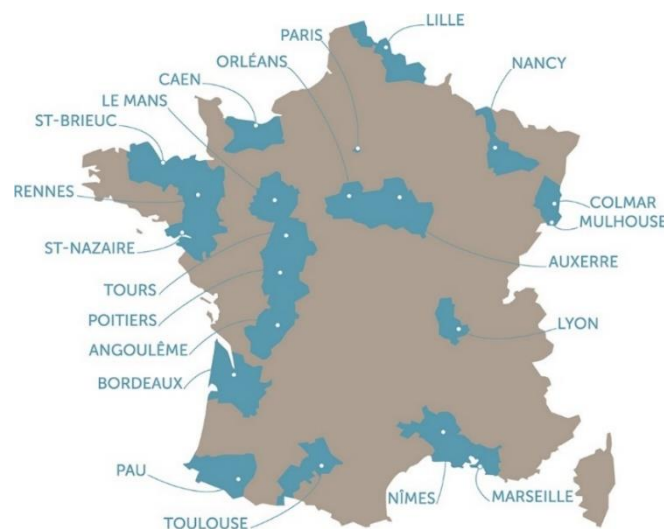


Figure 4 – Distribution of the CONSTANCES recruitment centres across mainland France. Taken from (240)

Upon invitation to participate, individuals were invited by mail to complete questionnaires at home and receive a comprehensive health examination at a health screening centre. Recruitment of participants took place primarily between 2012 to 2019, and ended in 2021, resulting in a final population of around 220,000 volunteers. The follow-up of participants is both active and passive. Active follow-up comprises an annual questionnaire, offered in either paper form or online, as well as an examination at a health screening centre proposed every four years. Data include lifestyle and socioeconomic characteristics, personal and family medical history, and clinical and paraclinical examinations. Passive follow-up draws information on

people's socioeconomic, professional, residential, environmental and medico-administrative data from the French national health database (SNDS) (365), comprising the SNIIRAM database of national health insurance data (366), the database of National Health Insurance and Retirement Funds (CNAV) and the National Death Registry (CépiDc).

Representativeness of the sample

CONSTANCES includes a sample of subjects diverse in terms of age, education and socio-professional category, with a slight majority of women (54%), as a result of a sampling strategy designed to actively over-represent individuals with a higher likelihood of non-participation (56). Compared to national averages, CONSTANCES participants were less educated (27.4% with no diploma or lower than high school versus 16.4% in France) and less likely to be single (27.4 vs 40.2) and aged 18-29 (12.9% vs 20.2%) (**Table 1**).

Table 1 – Comparison between a sample of CONSTANCES participants (2016 data; $n=71,804$) and the French National Institute of Statistics and Economic Studies (INSEE) population estimates. *Unpaired t-tests.*

	CONSTANCES 2016 sample ¹		INSEE population estimates ²	
Age	%	n	%	n
18–29	12.9	9291	20.2	9,243,305
30–39	16.8	12 036	18.2	8,325,655
40–49	22	15 796	19.0	8,695,358
50–59	23.5	16 898	19.2	8,816,803
60+	24.8	17 783	23.5	10,769,587
Gender				
Male	46	33 006	48.4	32,535,913
Female	54	38 798	51.6	34,722,069
Education level*				
No diploma or lower than high school	27.4	19322	16.4	NA
High school	17.5	12329	31.3	NA
College	24.5	17245	17.7	NA
University	29.3	20673	35.5	NA
Other diploma	1.3	892	NA	NA
Marital status*				
Single (never married)	27.4	19230	40.2	NA
Married, civil partnerships	59.0	41452	44.4	NA
Divorced, separated	11.5	8071	8.2	NA
Widower	2.2	1542	7.2	NA

*Percentages recalculated without missing data. ¹Taken from (367) ²Based on the following references: For age and gender (368) 2019 data; For education level (369) 2015 data; For marital status (370) 2016 data, persons aged 15 years or older.

With an annual response rate of between 60 and 70%, and less than 0.5% of participants actively withdrawing, the cohort benefits from strong volunteer engagement. The proportion of subjects lost to follow-up is also low due to the use of national databases, where data continues to be collected from subjects even if they no longer participate in active data collection. However, a key limitation is that, through recruiting via the French Social Security system, agricultural and self-employed workers were excluded due to their affiliation to other health insurance funds.

2.1.2. SEPAGES

SEPAGES (*"Suivi de l'Exposition à la Pollution Atmosphérique durant la Grossesse et Effet sur la Santé"*) is a couple-child cohort aiming to characterise the exposure and subsequent health effects of environmental contaminants on pregnant women and their children (58). The cohort is coordinated by an environmental epidemiology research team from Inserm (the French National Institute for Health and Medical Research) and Grenoble Alpes University, in collaboration with a number of partners, including the Grenoble Alpes University Hospital. Eligibility criteria for mothers were the following: being under 19-weeks pregnant at inclusion, older than 18 years old, having a singleton pregnancy, planning to give birth in one of the four maternities clinics from Grenoble area and living in the study area. Fathers of the expected child were also offered to participate, with no exclusion criteria. The participation of the father was not mandatory, resulting in a final population of 484 mothers and 410 fathers (**Figure 5**). Every year from inclusion, questionnaires, interviews and clinical examinations were used to collect information on children and their parents, both during and after pregnancy (371). Alongside the collection of biological samples, questionnaires were completed online by the volunteers at each trimester of the pregnancy as well as numerous postnatal measures up till 3-years (at the time of our study) (58). Parent's questionnaires included a wide range of topics, with particular focus on nutrition, exposure to pollutants and health events, as well as key contextual factors like socioeconomic status and participants living environment. Child development was assessed longitudinally using both clinical assessments performed by trained SEPAGES fieldworkers, including trained neuropsychologists, and validated questionnaires completed by the parents.

Representativeness of the sample

SEPAGES was designed and carried out in the Grenoble region of South-West France, across the four maternity hospitals and ultrasound practices in the Grenoble area. The Grenoble region comprises roughly 450,000 inhabitants and includes urban, peri-urban and rural zones (57). It's scientific and academic reputation attracts students and highly educated workers, reflected in the demographics of the included study population. Full description of the SEPAGES female participants in comparison with samples of pregnant women in both Grenoble and France is shown in **Table 2**.



Figure 5 – Participation of SEPAGES participants over time. Adapted from (5)

Compared to pregnant women in France, SEPAGES mothers tended to be older and of a higher education level, and considerably more likely to be in a relationship (99.8% versus 81.9% in France) (58). SEPAGES women were also more likely to not smoke before (89% vs. 70%) or during (93% vs. 83%) pregnancy, and have used an infertility treatment to become pregnant (10% vs. 7%).

Nationwide data on the developmental measures used in our analyses is not available in France thus comparison with the general population was not feasible. However, Rescorla et al. (372) conducted an international investigation of the Child Behavior Checklist for Ages 1½–5 (CBCL 1½-5) across 24 nations (n = 19,850). Comparison of these scores with the SEPAGES children shows significant differences in all CBCL subscales except emotional reactivity and attention problems (**Table 3**), with SEPAGES children showing lower scores for anxiety/depression, somatic complaints and withdrawn behaviours, but higher scores for sleep problems and aggressive behaviour. CBCL total scores, however, were not significantly different between groups.

Table 2 - Description of the women included in the SEPAGES cohort and comparison with samples of pregnant women from Grenoble and France. Adapted from (58). Values are n (%) unless stated otherwise.

	Population of Pregnant Women							
	SEPAGES Women n = 484		Approached but not included ¹ n = 1841		Grenoble Area ² n = 17,899		Whole France ³ n = 12,950	
Age (years), mean ± SD	32.7 ± 3.9		31.0 ± 4.7		31.1 ± 5.0		30.3 ± 5.2	
Age (categories)			(<0.001) ⁴		(<0.001) ⁵		(<0.001) ⁶	
<20	-	-	13	(0.7)	113	(0.6)	204	(2.5)
20–24	13	(2.7)	128	(7.0)	1483	(8.3)	1553	(12.0)
25–29	113	(23.3)	589	(32.0)	5116	(28.6)	4052	(31.3)
30–34	230	(47.5)	683	(37.1)	6656	(37.2)	4377	(33.8)
35–39	117	(24.2)	353	(19.2)	3626	(20.3)	2236	(17.3)
≥40	11	(2.3)	74	(4.0)	900	(5.0)	519	(4.0)
Maternal Parity⁷			(0.002) ⁴		(<0.001) ⁵		(<0.001) ⁶	
0	222	(45.9)	816	(44.6)	6036	(39.7)	5464	(42.2)
1 child	214	(44.2)	721	(39.4)	6098	(40.1)	4609	(35.6)
≥2 children	48	(9.9)	294	(16.1)	3071	(20.2)	2872	(22.2)
Marital status			(0.005) ⁴				(<0.001) ⁶	
In a relationship ⁸	483	(99.8)	1808	(98.2)	NA		9593	(81.9)
No relationship	1	(0.2)	33	(1.8)			2123	(18.1)
Education level			(<0.001) ⁴		(<0.001) ⁵		(<0.001) ⁶	
Primary school	-	-	4	(0.2)	106	(1.4)	187	(1.6)
Secondary education	6	(1.2)	226	(12.3)	677	(9.2)	2489	(21.3)
High school education (Bac)	23	(4.8)	316	(17.3)	1404	(19.2)	2521	(21.6)
Undergraduate or graduate	452	(94.0)	1285	(70.2)	5141	(70.2)	6464	(55.4)
Nationality							(<0.001) ⁶	
French	394	(94.7)	NA		NA		10,083	(85.9)
Other European ⁹	18	(4.3)					416	(3.5)
African	0	(0.0)					993	(8.5)
Other nationality	4	(1.0)					243	(2.1)
Working status during pregnancy			(<0.001) ⁴		(<0.001) ⁵		(<0.001) ⁶	
Employed	434	(92.9)	1532	(85.0)	6806	(75.0)	7830	(68.1)
Unemployed	13	(2.8)	79	(4.4)	508	(5.6)	1928	(16.8)
Stay-at-home/parental leave/student	20	(4.3)	191	(10.6)	1757	(19.4)	1630	(14.2)
Other	-	-	-	-	-	-	108	(0.9)
Infertility treatment							(0.02) ⁶	
None	426	(90.1)	NA		NA		10,896	(93.1)
ART ¹⁰ , ovulation induction	47	(9.9)					805	(6.9)
Smoking during pregnancy¹¹							(<0.001) ⁶	
0	402	(93.3)	NA		NA		9798	(83.4)
1–10 cigarette/day	29	(6.7)					1447	(12.3)
>10 cigarette/day	-	-					499	(4.2)

¹Women interviewed by SEPAGES who met inclusion criteria but chose to not participate. ²Database of birth certificates 8 days after birth in the Isère department, where Grenoble is located, restricted to women (1) who gave birth in one of the 4 maternity wards in Grenoble, (2) aged over 18-years at parturition and (3) whose last menstrual period was between March 2014-February 2017. ³Source: (373). ⁴P-value; chi-square or Fisher exact test comparing SEPAGES women and women approached but not included. ⁵Comparing SEPAGES women and pregnant women living in Grenoble. ⁶Comparing SEPAGES women and pregnant women living in France (58). ⁷Before the index pregnancy. ⁸Cohabitation or married. ⁹Including Turkish. ¹⁰Assisted Reproduction Technology. ¹¹For SEPAGES participants: defined as smoking any time during pregnancy. For the pregnant women living in France: defined as smoking during third trimester of pregnancy.

Table 3 - Comparison of Child Behaviour Checklist (CBCL) scores between SEPAGES cohort children and an international average from 24 societies, taken from (372). *Unpaired t-tests, SD: Standard Deviation.*

CBCL Subscale	SEPAGES Children		International comparison		
	<i>n</i>	<i>Mean (SD)</i>	<i>n</i>	<i>Mean (SD)</i>	<i>p value</i>
<i>Emotional reactivity</i>	417	2.9 (2.3)	19,850	2.7 (0.7)	0.077
<i>Anxiety/Depression</i>	417	1.4 (1.6)	19,850	3.1 (1.0)	<0.001
<i>Somatic complaints</i>	415	1.9 (1.8)	19,850	2.3 (0.6)	<0.001
<i>Withdrawn behaviour</i>	417	0.68 (1)	19,850	1.7 (0.6)	<0.001
<i>Sleep problems</i>	417	3.2 (2.7)	19,850	2.7 (0.3)	<0.001
<i>Attention problems</i>	415	2.3 (1.6)	19,850	2.3 (0.6)	1.000
<i>Aggressive behaviour</i>	416	11 (5.6)	19,850	9.7 (1.8)	<0.001
<i>Other problems</i>	416	8.7 (4.4)	-	-	NA
<i>Internalising problems</i>	417	6.9 (4.9)	19,850	9.6 (2.6)	<0.001
<i>Externalising problems</i>	416	13 (6.5)	19,850	12.0 (2.3)	<0.01
<i>Total score</i>	416	32 (15)	19,850	33.3 (7.1)	0.079

2.2. Definitions and Preparation of Variables of Interest

2.2.1 Determination of fatherhood status

As we were primarily interested in fathers, or men becoming fathers, a first step consisted of identifying those participants within the overall population of the CONSTANCES cohort. Specific to our study, we were subject to a strong limitation regarding gender differences in the questionnaire design. At inclusion, both men and women received the same questionnaires, with the exception of a “Women’s health” questionnaire sent only to female participants. This questionnaire contained questions on fertility, contraception, pregnancy, hormones, breast cancer, menstruation, and gynaecology, amongst which participants were asked to give details on any existing children. One of these questions was their children’s date of birth. This question was not asked to male participants. We were therefore only able to identify the presence of fatherhood status at inclusion based on the question:

“Do you have, or have you had children (biological or adopted)?” (yes/no).

This led us to having to exclude the 53,148 participants who were already fathers, but of children/adults of an undeterminable age, as well as only being able to include fathers who then had their children during the follow-up period. For this reason, our analyses concerned only new fathers, reducing our original pool of roughly 92,000 men to just 6299 fathers. Comparison between our study population and a random, age-

matched sample of excluded participants is available in the Supplementary Material of Chapter 3. Noteworthy significant differences were that included participants were more likely to be married (84.3% versus 57.6%) or live with their partner (95.4% vs 74.0%) and have higher education (49.3% with a Baccalaureate +4 years and more of education vs 42.6%).

For the SEPAGES cohort, all participating men were considered as fathers. Comparison between the participating fathers and the 74 mother-child dyads without a participating father is available in Appendix Table 1. In families with participating fathers, mothers were more likely to be higher educated ($p<0.01$) and in a higher ISCO professional skill class ($p<0.01$). No significant difference on any measures of child development were seen except for the CBCL withdrawn ($p<0.05$) and BRIEF-P planning/organisation ($p<0.05$) subscales, both of which had higher scores for children of non-participating fathers. Once participating, however, attrition of fathers during the duration of the study was low. From 2015 and 2020, only 12 of the included fathers (2.9%) dropped out. Comparison of these fathers to those who remained for the duration of the study is also available in Appendix Table 1. No significant difference between fathers who remained in the study versus fathers who left, although statistical comparison was limited due to the low number of fathers.

2.2.2. Measures of Paternal Mental Illness

In Chapter 3, paternal mental illness (PMI) was measured through several measures. Firstly, at every year since inception (2013-2020), fathers were asked to **self-report the presence of mental illness** (yes/no) in each health-screening questionnaire in response to the following question: *“Below is a list of health problems. Indicate those from which you suffer or have suffered over the past 12 months (whether or not accompanied by occupational leave, whether or not accompanied by treatment)”*. If responding yes, they were also asked to give their specific diagnosis, based on the given categories: “Anxiety disorders”; “Depression” (all years except 2013); “Bipolar disorder, manic-depressive syndrome”; “Nervous breakdown, bipolar disease” (2013 only); “Other psychiatric disorder”. Data from 2013 were excluded due to deviations in categorisation. All categories were then subsequently grouped into the categories: “Depression”, “Anxiety”, “Other” and retained for reports of prevalence. However, the “other” category was excluded from subsequent analyses due to the low number of members, with prevalence ranging 0.1-0.8% across time-points within the study sample.

Alongside this, to provide an investigation of PMI without the potential bias of relying on diagnostic history or father's degree of self-awareness, validated symptom scales were used. Symptoms were measured at several time-points, using either the **Center for Epidemiologic Studies Depression scale (CES-D)** (inclusion, 2015, 2018) (59) or the 12-item **General Health Questionnaire (GHQ-12)** (2016, 2019) (60).

Originally designed as a measure of depressive severity for adults in the general population, the **CES-D** is one of the most widely used measures of depression across epidemiological studies (59). Comprised of 20 questions, responses are given on a 4-point Likert scale based on the frequency certain feelings or behaviours (e.g., *"I felt confident for the future"*) occurred over the past week. Responses range from *"Never or very rarely (less than 1 day)"* to *"Frequently, always (5 to 7 days)"*. The CES-D shows good comparison with other highly validated measures, such as the Beck Depression Inventory (BDI) (374,375) and has been validated for use in new fathers (62,63,376).

Also validated for use in new fathers (377,378), as well as screening for depression in adult males (379), the **GHQ-12** is a consistent and reliable instrument when used in general population samples with relatively long intervals between applications (380). Items on the GHQ-12 are rated on a varying 4-point Likert scale, based on the frequency of certain feelings (e.g., *"Have you felt constantly under strain?"*) over the previous two weeks. There are three ways of scoring the GHQ-12: the bimodal GHQ scoring method (0-0-1-1) recommended by the test authors for use in clinical settings; the Likert scoring method (0-1-2-3) which is commonly used in research, and the corrected scoring method (C-GHQ) where positively phrased items are scored (0-0-1-1) and negatively phrased items (0-1-1-1). For the purposes of our study, the C-GHQ was used, as it is found to present a wider range of scores and a more normal distribution than the conventional scoring method (381) and higher specificity than the Likert scoring method (61).

Within our study, both binary and continuous scores of the CES-D and GHQ-12 were used throughout analyses. For binary assessment, a cut off of ≥ 6 was used for GHQ-12 scores, found to produce the highest combination of sensitivity and specificity when compared to semi-structured interviews on DSM-III-R symptoms of minor and major depression and anxiety (61). For CES-D scores, meta-analytic findings suggest that a cut-off of 20 may provide a better trade-off between sensitivity and specificity than that of the commonly used 16 (382,383). However, for greater congruency with the GHQ-12, and previous literature, ≥ 16 was used (62,63). One study also found the CES-D cut-off score of ≥ 16 to show almost identical predictive value for depression and anxiety (based on *MINI* Mini international neuropsychiatric

interviews), further supporting comparison with the more general psychopathology detected by the GHQ-12 (384).

In Chapter 5, paternal mental health was measured at all time-points (pregnancy; 0-12 months postpartum; 12-24 postpartum) using the **Hospital Anxiety and Depression Scale (HADS)**. The HADS is a 14-question, self-report assessment of anxiety and depression. Designed in 1983 (385), it is not intended to diagnose psychiatric disorders, but rather provide a reliable, valid, cost-effective and easy to implement measure for identifying general patients with clinically significant indicators worthy of further evaluation and assistance (386). Widely used in more than 25 countries, it has been seen to perform well in psychiatric and/or primary care settings, as well as within the general population, and antenatal clinics (79,383,387,388). The HADS has also been seen to correlate highly with the sensitivity and specificity of the General Health Questionnaire (383).

Responses can be summed into two sub-scores for the discrete depression and anxiety scales, each based on seven questions with no overlap. Questions are answered based on a 0-4 Likert scale, with the categories varying from question to question, and higher scores indicating higher symptomology. All questions are deemed equal value, and responses summed. Regarding missing observations, if there was more than one missing value for either the anxiety or depression score, respectively, the sub-score was not computed. If one or less missing value for each anxiety and depression score, taken respectively, missing values were replaced by the sample most frequent answer for the corresponding score. For reports of prevalence, cut-off scores of ≥ 8 for depression or anxiety were used (382). For all other analyses, scores were treated as continuous.

2.2.3. Measures of child development

In Chapter 5, we relied on four measures of child development. These were conducted through clinical assessments performed by trained fieldworkers and neuropsychologists, as well as validated questionnaires completed by the child's parents. One measure was taken when children were two years of age, and three the following year. The choice to use multiple measures was not just to include the widest range of outcomes possible, but to also allow investigation spanning two developmental periods. Within socioemotional development, we see that effective attachment relationships begin to develop from 6 to 12 months of age, whilst 18 to 30 months commonly sees the onset of autonomy, individual temperament and

the manipulation of subjective emotions to more socially appropriate responses (120). Regarding cognition, whilst basic inhibitory and working memory abilities emerge during the first year of life, more complex executive functions being to develop around the age of three (389). Disparities between these timepoints may also provide insight into the mechanisms through which paternal mental health may influence their child's development, as well as key sensitive periods.

At two years, the **Child Behaviour Checklist (CBCL/1½-5)** was used (390). The **CBCL/1½-5** is a broad-spectrum assessment that consists of 100 items, divided into seven subscales: 1) *Emotional reactivity* 2) *Anxious/depressed symptoms* 3) *Somatic complaints* 4) *Withdrawn behaviour* 5) *Sleep problems* 6) *Attention problems* and 7) *Aggressive behaviour* subscales, as well as an "other" category grouping all other difficulties (32 items such as "eating inappropriate foods"). Subscales can be further grouped into internalising behaviours (subscales 1, 2, 3 and 4), externalising behaviours (subscales 6 and 7) and an overall total score, however for the purposes of our study the original subscales were used. Intended to assess the emotional and behavioural problems of children from ages 1.5 to 5 years, the CBCL can be used clinically to identify behaviours that may or may not interfere with a child's functioning, as well as track changes in the presence and severity social, emotional or behavioural problems over time (391). Parents or those who interact with the child on a regular basis rate the child's behaviour now or within the previous two months by answering statements such as "argues a lot" on the following Likert scale: 0 = not true; 1 = somewhat or sometimes true; 2 = very true or often true. The 2-month recall rate is specific to this preschool (1½-5 years) version of the CBCL, due to the rapid developmental changes that occur during this period (390). Developed based on decades of research by Achenbach and colleagues, the CBCL forms part of the Achenbach System of Empirically Based Assessment (ASEBA) and receives worldwide support (392). Analyses of CBCL/6-18, a version of the CBCL for children ages 6-18, across 45 societies (n=72,493 children) revealed that only 10% of the variance in children's scores was based on cultural and societal differences, with around 90% variation explained by individual family characteristics, thus supporting the international validity of this scale (393).

At three years, several measures were available. Firstly, the **Social Responsiveness Scale (SRS)**. The SRS is a 65-item, Likert-scale questionnaire completed by parental figures or teachers (80,394). Intended to screen social behaviour and ASD, it is grouped into five scales: 1) *Social Awareness* 2) *Social Cognition* 3) *Social Communication* 4) *Social Motivation* 5) *Restricted Interests and Repetitive Behavior (RRB)*. The SRS

relies on retroactive observations of the child over weeks or months in the child's natural social context, scoring each item on a Likert scale from 0 ('never true') to 3 ('almost always true'). Suitable for use in both clinical settings as well as large epidemiological surveys, the SRS can indicate both the likelihood and severity of ASD (395), as well as more general social impairment or anxiety. Overlap between SRS scores have been seen for ADHD and ASD diagnoses (396), which is logical due to their high rate of comorbidity (397), however methods have been developed to distinguish the two (398). One French study found a gradient in SRS score severity based on diagnosis, with typical development scoring lowest, followed by ADHD, ASD and finally comorbid ASD/ADHD (399). The SRS has been validated in numerous cultures, such as Germany (400), the United States (401), Britain (402), Vietnam (403) and Japan (404), and for use in families affected by autism as well as general population studies (405).

Secondly, the **Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)** (83) was recorded at three years. The BRIEF-P is a 63-item, Likert-scale questionnaire, completed by parental figures or teachers. Intended to evaluate executive function and development, as well as a broad range of associated disorders, it is grouped into five non-overlapping scales:

- 1) *Inhibition*: impulse control, the ability to stop/modulate one's behaviour
- 2) *Shift*: the ability to move freely from one situation or activity to another. Flexibility between aspects of a problem.
- 3) *Emotional control*: the ability to modulate emotional responses.
- 4) *Working memory*: the ability to hold information in one's mind in order to complete a task.
- 5) *Plan/Organise*: the ability to assess problems, plan, organise, and implement appropriate steps for future-oriented problem solving.

Adapted from (406).

These subscales can in turn be grouped into composite indexes, such as "Emergent Metacognition" (*Working memory and Plan/Organise*), but for the purposes of our study the original subscales were used. Executive functions are often harder to assess than other domains of child development (407), historically tested in laboratory-based settings far removed from participants real environment. The BRIEF-P is the only standardised executive functioning scale designed for use on pre-schoolers and assesses children's behaviour observed in real-world settings such as their home or school (where present) (406). Although much less studied than measures like the CBCL, studies on the BRIEF-P show excellent reliability (408) as

well as alignment with ADHD subscales (409,410) and the possibility to detect other disorders such as autism spectrum disorders (ASD), brain injury and Tourette's syndrome (411).

Finally, the fourth edition of the **Wechsler Primary and Preschool Scales of Intelligence (WPPSI-IV)** was also used. The WPPSI-IV is a cognition test performed by a neuropsychologist. It consists of five verbal and five performance (nonverbal) subtests, with scores standardised post-examination based on child age. Three main indexes can be derived from the age-standardised scores: 1) *Verbal comprehension*: 2) *Visual Spatial* 3) *Working memory*. Capable of detecting both giftedness or intellectual talent as well as learning difficulties and disorders, the WPPSI measures the intellectual capability of an individual, aiming to reflect an individual's cognitive ability across a variety of interrelated methods and tasks relative to same-age peers (412). The total score (derived from the sum of all standardised scores), can be then taken and used as an Intelligence Quotient (IQ), one of the most relevant psychological markers to life-course epidemiology (413). However, in line with all other included measures in this thesis, scoring was kept as the original subscales. We used the latest version of the WPPSI, the WPPSI-IV, which has revised subscales and indexes developed to provide a more differentiated description of children's cognitive performance (414). The WPPSI is internationally renowned and, whilst no validation study has yet been conducted in France, the WPPSI-IV has been verified in numerous different cultures, from Germany (414) and Scandinavia (415) to Korea (416).

The WPPSI was the only included child outcome that relied on a neuropsychologist for the assessment. Whilst this adds a certain degree of robustness to our findings, in that they were based on assessment from multiple sources, not all assessments were performed by the same professional. We thus also introduce a risk of bias based on the chosen psychologist, in that evaluations may vary between individuals (417). We therefore additionally tested our WPPSI results for a "psychologist effect" - a shift in the score distributions based on the psychologist conducting the assessment. Within the SEPAGES dataset, this effect was tested by taking each psychologist's identity as a potential confounder, and significance was indeed confirmed for the visuospatial ($p < 0.001$) and the working memory ($p = 0.008$) indexes. For consistency, all three indexes were then standardised based on this factor using a 2-step approach described by Mortamais et al. (418). Full details of the raw distribution of the WPPSI score based on psychologist ($n = 7$) is available in Appendix Table 2.

2.2.4. Confounding factors

Confounders are variables that relate to both the exposure and the outcome but are not necessarily on the causal pathway. Addressing confounding factors is crucial to many epidemiological approaches (419). When ignored, unaddressed confounding may bias results, leading to an over- or under-estimation of an observed association (420). It is thus important to account for potential confounding when testing relationships between two variables. The following variables were tested as potential confounders in our empirical studies, based on the literature and availability within the given dataset:

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The following variables were considered as factors potentially associating with father's mental health trajectories: Fathers' age at first child's arrival; Close relationship satisfaction (combined variable of close friends/family satisfaction and/or relationship satisfaction); Employment status (Employed; Unemployed; Retired; Student/Other); Spouse's employment status (Employed; Unemployed; Retired; Student/Other); Financial difficulties (yes/no); The arrival of subsequent children (yes/no); Having forgone healthcare due to financial difficulties over the past 12 months (yes/no); and Daily alcohol use according to recommended (WHO) guidelines (Moderate consumption; No consumption; Non-recommended consumption) (421).

Where possible, variable data was taken at either the same year of participants' child's arrival (for chi-square and multivariable models), or the same year as each data point in relation to the child's arrival (for trajectory analyses). For several other variables, data taken at inclusion was deemed reliable and thus used. These were as follows: Geographical region of birth (France; Europe; Africa; Other); French nationality status (French by birth; Naturalised French; Foreign national); Level of education (No diploma; Primary, Professional/vocational certificate (9-11 years); Baccalaureate or equivalent diploma; and Baccalaureate +2 or 3 years; +4 years; +5 or more); (Father's) parent's history of serious psychiatric illness (yes/no); and (father's) parent's history of suicide attempt (yes/no).

Chapter 5 / SEPAGES

The following variables were considered as potential confounding factors for the relationship between father's mental health and their child's development. Fathers' and mothers' age at conception, ethnicity (White/Other), weight (kg), and education level (Baccalaureate +5 and more; Baccalaureate +3-4 years; Baccalaureate or equivalent diploma and under), and mothers' employment status at first trimester

(employed/unemployed). Included pregnancy and child specific variables were maternal parity, prenatal tobacco (>1 cigarette per day; yes/no) and/or alcohol consumption (no; one or less drinks per month; over one drink per month), complications during pregnancy (yes/no), gestational duration, delivery mode (vaginal/caesarean), child weight, number of weeks breastfed until week 48, and number of child hospitalisations between birth and 1 year. The main mode of childcare at 6 months was also considered (collective care (nursery, crèche, family day care, or day care centres) vs. other (spouse, partner, family members, childminders, neighbour, unlicensed nanny etc.)) alongside the arrival of subsequent siblings (yes/no).

2.2.5. Missing data

Missing or incomplete variables

The exclusion of several variables is worth mentioning. In Chapter 3, certain variables of interest (such as the number of people participants were living with; level of physical effort in/outside of work) could not be used, as participants were only questioned at one time point, or data was not collected at follow-up. Notable factors excluded due to the proportion of missing data, in all instances due to long intervals between data collection points, were: Family's average net monthly income; Average number of hours of sleep per night; Sleep difficulties over the past month; Level of physical activity on/off work; Deprivation index (EPICES Score); and participants socio-professional category (Craftsman, shopkeeper, business owner or spouse-partner; Executive, higher intellectual profession (engineer, physician, etc.); Intermediate profession (teacher, nurse, etc.); Employee (office or commercial employee, child minder, etc.); Manual worker; Has never worked; Other).

In Chapter 5, due to insufficient variation within the study population, relationship status between mother and father (98-100% across time-points); mother and father's nationality (94% of fathers and 95% of mothers being French); and father's and mother's employment status at third trimester (96%) and 1-year postpartum (95-97%) were excluded from analyses. We also relied on parents' professional class as a proxy of socioeconomic status or position (SES / SEP, henceforth referred to as SEP). However, SEP is a complex concept. Although the definition is flexible, modern research in public health and social epidemiology defines SEP in relation to constructs surrounding an individual's education, income, and occupation, as well as structural and cultural influences (208,209). Thus, our variable was likely overly simplistic. However, the homogeneity of education level within our sample made this an unfeasible determinant of SEP. For this

reason, it is possible that our results based on parents' professional class may show smaller effect sizes than that which might be seen in a more representative sample.

2.2.6 Imputation

For Chapter 5, fathers' mental health data (HADS scores) were only used where available. However, for the longitudinal trajectory analyses in Chapter 3, missing mental health data was imputed between time-points when at least two or more time points were available (422). Several approaches were applied to impute these data, all using the R Package *imputeTS* (422) designed for the imputation of time series data. The approaches used were interpolation (both linear or spline), weighted moving averages, and Kalman smoothing (423). The most suitable method was chosen based on graphical interpretation (422). However, trajectory analyses were also rerun using data generated via SAS imputation (65), and models compared. Based on model fit statistics, R-based imputation was chosen (weighted moving averages).

Regarding the measures of child development used in Chapter 5, missing data was handled according to instrument-specific recommended guidelines. For the CBCL, subscales were not included if more than 8% (rounded) missing data per participant. If there were 8% missing observations or less, missing values were imputed as zero (424). For the BRIEF-P, when questionnaires had more than 12 missing responses, they were considered invalid (406). For individual scales, raw scores were not calculated for those with more than two missing responses. For those with less than two, missing values were substituted with a value of one. For the SRS, when questionnaires had eight or more missing responses they were considered invalid (80). For less than eight missing responses, missing values were substituted with the median value for each particular item. For the WPPSI, assessments were performed during assessments by a neuropsychologist thus missing items are rare. Only two individuals had missing items. No values were imputed, and analyses were conducted for each respective subscale based on all available values (ranging 264 to 266 cases for each subscale).

For both Chapters 3 and 5, all missing data on confounders were imputed using Multivariate Imputation by Chained Equations (MICE) (425), performed using R version 4.2.2 (276). MICE, also known as "fully conditional specification" or "sequential regression multiple imputation" is a multiple imputation method that replaces missing data values in a data set under certain assumptions (426). MICE assumes that missing data are Missing At Random (MAR), meaning that missing values are systematically related to the observed

values within a dataset and not unobserved values (427,428). MICE is a flexible approach that can handle various types of variables simultaneously (e.g. categorical, binary and continuous), and, in creating multiple imputed datasets, accounts for the statistical uncertainty of the imputed results (426). Using a cyclic, iterative process, missing values are imputed x number of times, determined based on the proportion of missing data (425). This results in x completed data sets (429). In Chapter 3, overall, 20% of variable data was missing thus 20 imputed datasets were generated and used. In Chapter 5, 4.7% of data was missing across confounding variables, resulting in five imputed datasets. For both these studies, analyses were repeated on each respective dataset, and estimates from each dataset combined to obtain the final result (426).

2.3. Approaches to data analysis

2.3.1 Group-Based Trajectory Modelling (GBTM)

Trajectory analyses are capable of identifying heterogeneity within a population that may otherwise be overshadowed by a dominant group (430). This is conducted through examining individuals' patterns of behaviour, such as symptoms of mental illness, to uncover shared patterns called trajectories. Each individual is assigned to the group whose trajectory best fits their data. Trajectory analyses are commonly used in medicine, psychology, social sciences, and public health to study growth patterns, behaviour changes, and outcomes across life stages or treatments (431,432). If applied to paternal mental health, investigations of the longitudinal progression of PMI may shed light on subgroups of fathers who are most at risk, thus highlighting key targets for support or prevention initiatives. As research on paternal depression indicates that its timing is also critical when considering the impact of PMI on offspring development (25), trajectories of parental psychological distress over time are also relevant to the surrounding family. However, epidemiological studies on the trajectories of PMI are scarce, based on small samples, and most rarely extended beyond two years post-birth (433).

Various approaches to trajectory modelling have been developed. For the purposes of our study, we relied on group-based trajectory modelling (GBTM) (431). GBTM is a person-centred approach designed for modelling repeated measures of a given variable over time (432). GBTM can thus be used to identify subgroups within a population that show differential longitudinal patterns of health outcomes or development. In comparison to other methods, such as Latent Growth Curve Modeling (LGCM), group-

based trajectory modelling assumes that all individuals in a trajectory class have the same behaviour, thus differences lie between subgroups, as opposed to within (434). Considering the homogeneity of our sample, in relation to lifestyle, environment and socioeconomic determinants, GBMT was appropriate in that our population is likely to follow similar growth trends (434). Analyses were performed on SAS, using the Proc Traj procedure developed by Jones, Nagin and colleagues (64,65,432) for estimating developmental trajectories. Both categoric and continuous data can be analysed in a GBTM. Thus, two models were used based on our measures of PMI:

- 1) Censoring normal model (CNORM), used for data that exists on a defined scale where you set the upper and lower bounds, was used to analyse our continuous data. CNORM is preferred for psychometric scale data where scores tend towards zero.
- 2) The logistic model (LOGIT), used for dichotomous/binary data, was used to analyse father's self-declared mental illness (yes/no).

Model selection

Several parameters can be used to assess a given trajectory models appropriateness. Firstly, the number of trajectories (latent classes) must be determined. This can be done in consideration of the percentage of participants within each group (group membership). It is generally thought that no group should contain less than 5% of participants (431,435). Interpretation of the graphical representation of trajectories is also important. Trajectories should show distinct patterns, and confidence intervals of each group should at most overlap for only relatively short periods (64).

The researcher must also consider the intercept and slope parameters. Possible group orders are as follows: Constant (Order 0), representing a trajectory with a zero-order slope, meaning the prevalence is constant across time-points; Linear (Order 1), where the trajectory increases or decreases at a steady rate; Quadratic (Order 2), similar to linear but containing a single point of inflection where the slope changes in magnitude or direction; Cubic (Order 3), which contains two points of inflection, and so forth. When choosing the best model fit, models should start with Order 0 on all groups and increase group orders until the best fit is established. Finally, an important and frequently neglected step when selecting the final model is assessing if the chosen model responds to the research question (66).

Alongside the researcher's interpretation, there are also several statistical indicators which can be used to assess the fit of a given model (65). These include, but are not limited to, the following:

- *Average posterior probability (AvePP)*. AvePP is a measure representing the likelihood that people have been correctly assigned to a given group. AvePP is an automatic output of Proc Traj in SAS (65). Models are considered to be good if the AvePP of each group is greater than 0.7, which would indicate there is at least a 70% of individuals within a group have been correctly classified.
- *Bayesian Information Criterion (BIC)*. When deciding on the number of trajectory groups, to consider that two models are different, the difference in their BICs (ΔBIC) can provide an indication of model fit (65,431). To promote parsimony, the more complex model is selected only if its BIC is significantly higher. BIC is an automatic output of Proc Traj (65). Values are given as negative, and models with the highest (least negative) value of BIC should be selected (436). Simulation studies have shown that BIC performs better than Akaike's Information Criterion (AIC) and other statistical information criteria (437).
- *Odds of correct classification (OCC)*. OCC refers to across-class separation and thereby indicates how good the latent classes are separated (435). Ideally, OCC should be greater than five for each trajectory group. Unlike AvePP and BIC, OCC is not generated in Proc Traj and must be calculated manually for each group using the following formula: $(AvePP / (1 - AvePP)) / (\pi / (1 - \pi))$, where π = estimated group membership.

Once trajectory groups have been identified, researchers can extend these results by identifying risk factors associated with specific trajectories (432). Using CONSTANCES data, we first selected variables based on the literature (section 2.2.4), and then confirmed their significance based on the following steps. First, chi-square analyses were run independently for all potential covariates against both measures of PMI, in the year of father's first child's arrival (time-point 0). Significance at $p < 0.05$ for either outcome was considered relevant for retention. All significant variables were then tested in multivariable logistic regressions, again using data taken at time-point 0. Finally, significant variables were screened for within-variable correlation and covariate pairs with $r > 0.7$ reduced to the most relevant factor (438). All remaining variables were tested against trajectory groups via multinomial regression models, taking the trajectory group with the most stable, low indication of mental illness as the control. For the multinomial models, time-dependent

variables (employment status; the arrival of a subsequent child; living status with partner; having forgone healthcare due to financial reasons) were taken as separate events at each year.

2.3.2. Outcome wide epidemiology

The outcome-wide approach is an epidemiological method that shifts the focus from studying a single exposure-outcome relationship to providing a more holistic view of the effects of a single exposure on a broad range of outcomes (78). Whilst there are numerous statistical approaches to outcome-wide analyses (439), the techniques and theory underpinning the methods used in this thesis were primarily developed by VanderWeele and colleagues (78). VanderWeele proposes their outcome-wide approach as an alternative to “*exposure-wide epidemiology*”, which sees an outcome tested against multiple exposures simultaneously and, due to the interdependent nature of confounding factors, is likely inappropriate in an epidemiological context (440,441). As outcome-wide analyses are able to identify exposures with multiple effects on health outcomes, they thus facilitate the detection of clear or efficient targets for public health recommendations or preventive measures. For this reason, outcome-wide analyses are particularly useful for exposures that may have both beneficial and negative effects on outcomes. For example, whilst a high degree of parental involvement in their child’s education may increase academic outcomes (442), it may also increase children’s level of stress (443). In investigating a broad range of outcomes simultaneously, we may provide a more nuanced overview of such trade-offs.

The outcome-wide approach is also centred on issues in confounding and aims to counteract surrounding bias. For every outcome, all relevant confounding factors that occur prior to the exposure are controlled for. Importantly, for all models, the same set of confounding factors are used. Even though certain variables may not be statistically significant for a certain exposure/outcome association, this approach reduces the risk of bias introduced by unmeasured confounders in the causal pathway.

For the purposes of our study (Chapter 5), linear regression models were used in an outcome-wide analytic framework to test the relationship between PMI and child outcomes (444). Results are presented as standardized regression coefficients (β) with standard errors and adjusted p values. P values were taken as significant where $p < 0.05$ following correction for multiple outcomes. For each possible time-point of PMI (prenatal; 0-12 months; 12-24 months), separate regressions were conducted for all outcomes. All models were adjusted using the same common set of confounders (445). However, in line with an outcome wide

analytic approach, each model's confounding variables had to occur before both the exposure and outcome. Therefore, for each PMI exposure (prenatal; 0-12 months; 12-24 months) the confounding factors were adapted based on the given temporality. Models using prenatal PMI, for example, included no postnatal measures in the common set of confounders. The selection of confounding factors is described in section 2.2.4.

Family-wise error rate (FWER)

Due to the multitude of outcomes included in our outcome-wide analyses– four respective measures, amongst which there was a cumulative total of 21 subscales – we increased the likelihood of making a Type 1 error (446). This is known as Family-wise Error Rate (FWER): the probability of false positives when conducting multiple comparisons through the inflation of the alpha level. Several alternatives exist to protect against FWER. The most commonly used method is currently the Bonferroni correction (447,448). In the Bonferroni correction, the alpha level is divided by the number of included tests, thus creating a more stringent alpha and reducing the likelihood of a false positive (449). However, this method is known to be one of the more conservative responses to FWER, in turn increasing the risk for a Type 2 error (450). As a response, other more powerful methods have since been developed.

One of these alternatives is the Holm-Bonferroni Method. The Holm-Bonferroni Method is similar to the Bonferroni correction, but instead to simply dividing the alpha level by the number of measures, p-values are sorted in order of significance and the p value for each is adjusted in a stepwise manner (451). If the test is not significant, the procedure stops. The Šidák correction is another option, argued to be more powerful than Bonferroni but closely related. Instead of dividing the alpha level by the number of tests, the Šidák correction raises the significance level for each test by taking into account the number of tests being conducted (452). However, this approach requires the assumption that the individual tests are statistically independent, which is not the case for measures of child development (80,81,406,424). Another method gaining support is the Benjamini-Hochberg Procedure (453) – a more radical alternative to the aforementioned approaches that redirects the goal from controlling alpha to controlling the false discovery rate, the ratio of Type 1 errors to significant tests (454). This method is less conservative and more powerful than the Bonferroni correction, and ideal for situations with a large number of tests, however the control against Type 1 error is ultimately less stringent (455).

Instead of these approaches, to counteract the increased probability of a false positive result within our study, the Hochberg correction or sequential procedure (distinct from the Benjamini-Hochberg Procedure) was applied. P values were sorted in descending significance, and progressively more stringent criteria are applied. If the first value is significant at $p < 0.05$, then the second value is examined but with a threshold of $p < 0.05/2$ (0.025). If this is fulfilled, the third sequential p value is examined and considered significant if fulfilling $p < 0.05/3$ (0.017) and so forth. In comparison to Bonferroni, only the last p value would have the Bonferroni correction level applied if the previous p values were insignificant. The Hochberg correction is thought to offer a better balance between Type 1 and Type 2 errors than other methods (446), and is supported in the literature as a more powerful alternative to the traditional Bonferroni and the Holm-Bonferroni (448).

2.3.3 Moderation analysis

To assess the impact of certain potential factors known to associate with both paternal mental illness and child development, moderation analysis was used. Moderators are variables that influence the nature of the effect of an independent variable (X) on an outcome (Y) (456). A moderator may strengthen or weaken the relationship between X and Y, as well as reversing the direction (457). As opposed to confounding factors, moderators lie on the causal pathway (**Figure 6**).

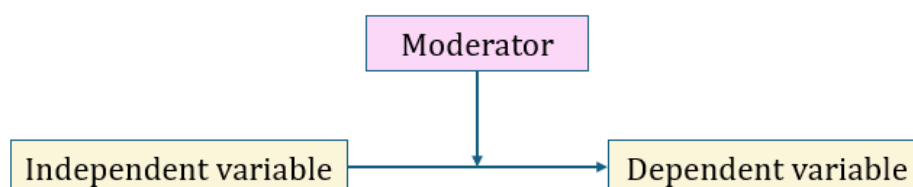


Figure 6 – *The interaction of a pure moderating factor on the association between an independent and dependent variable*

Although many variations on moderation analysis exist, for the purposes of our study we focused on single moderator analysis, taking each moderator at a time. Moderating variables are selected a priori by the researcher based on subject knowledge (457). For our analyses, three key factors were tested as potential moderating factors. The first factor tested as a potential moderator was child sex assigned at birth, referred to henceforth as child sex. Disparities on the relationship between PMI and child development in relation to child sex are inconclusive and vary considerably within the literature (39,53). As discussed (section

1.3.4), it is possible that these variations may also be due to the developmental outcome studied (314–316). Our outcome-wide approach thus presents an ideal opportunity to investigate the potential moderation by child sex on the relationship between PMI and child development across a range of developmental markers.

The second factor considered as a potential moderator was mother’s mental health (MMH). Paternal and maternal mental illness are strong and well-established risk factors for one another, with studies finding a concordance between maternal and paternal depressive symptoms as high as 70% (15,17). Whilst the presence of PMI has been found to aggravate the negative effects of maternal depression on child development, the potential moderation by MMH on the relationship between PMI and child outcomes is undetermined. Studies exist showing both no moderation by MMH (52) and significant moderation by MMH at several ages (37,45). Within our study, MMH was measured via HADS scores, recorded during pregnancy and at 1-year postpartum. The total score was used, as opposed to separating both depression and anxiety due to the high comorbidity between the two (458), and scores were kept as continuous. For models taking PMI during pregnancy, prenatal maternal HADS scores were used. For models taking PMI postnatally (0-12 months; 12-24 months), postnatal maternal HADS scores were used.

The third potential moderating factor was parent’s professional score, based on the International Standard Classification of Occupations (ISCO) categories (84). ISCO was developed to provide an international framework for comparing occupational data. Categories are grouped by skill level are shown in **Table 4**. We used the most up-to-date version, the ISCO-08. Full detail on the definitions of these groupings is open access and available on the ISCO-08 companion guide, published in 2023 (459).

Table 4 - The International Standard Classification of Occupations (ISCO) categories based on skill level (84), alongside the chosen groups used within our study (Chapter 5).

ISCO Major Groups	ISCO Skill level	Chosen study groups
1: Managers	3 and 4	3-4
2: Professionals	4	3-4
3: Technicians and associate professionals	3	3-4
4: Clerical support workers	2	2
5: Service and sales workers	2	2
6: Skilled agricultural, forestry and fishery workers	2	2
7: Craft and related trades workers	2	2
8: Plant and machine operators, and assemblers	2	2
9: Elementary occupations	2	1
0: Armed forces occupations	1, 2 and 4	Armed forces

Due to such low representation in groups other than skill level 2 or levels 3-4, with two fathers in each category and no mothers in either, only skill levels 2 and 3-4 were retained for moderator analyses. Data were available for both mothers and fathers, and were used respectively as potential moderators. Whilst it may have been interesting to create a cumulative variable taking both parents professional class together, the homogeneity within the data meant that only seven families had both parents in skill level 2, thus representation of this 'lower' skill level would have had low statistical power. Interesting findings also exist surrounding gender imbalances on the influence of mother and father's professional status on parenting and their child's development (112,460,461). Keeping scores as separate allowed us to explore this.

Modelling assumptions

Several assumptions are required for moderation analyses, although varying based on methodological approach. Firstly, the dependent variable should be measured on a continuous scale, which our measures child development fulfilled (462). There should also be little to no measurement error in the moderator variable (462). Several of our moderators were categorical (child sex and parent's professional class), thus estimation of the measurement error was not possible, however for our measures of MMH, the mean +/- standard error was 10.6 +/- 0.29 prenatally and 11.6 +/- 0.30 postnatally, indicating that both had mean values relatively close to the true mean of our overall population. The distribution of the variables should also be approximately normal, with no significant outliers (348). Using the R package *moments* (463), we tested for skewness and, where present, adjusted it using a square-root transformation for moderate skew (0.5-1.0) and a log transformation for greater skew (1.0-1.5) (464,465). A final assumption was often previously made for moderation analyses was that moderation could not be tested on insignificant associations (466). However, this has since been debated, and the more modern approach supports the idea that correlation between X and Y is not necessary (462,466).

A classical assumption for moderator analysis is also that there is no association between the dependent variable and the moderator. This is likely to have been fulfilled for parent's professional class, with class mobility uncommon and relatively slow-paced (467), particularly so in France (468). Parent's professional class is thus unlikely to have changed as a result of 2-3 years of their child's development. Whilst some literature also supports the fulfilment of this criteria based on child sex, with negligible sex-based differences based on child development seen at such a young age (469) other reviews disagree (470). However, within our sample, almost no difference on child outcomes was seen based on child sex (available

in Chapter 5, Supplementary Table 3). Regarding our third moderator, child outcomes did indeed frequently associate with maternal mental health (MMH). We thus risk obscuring the true interaction effects of MMH on the relationship between PMI and child development (471). Although not invalidating the results, the interaction no longer fulfils the more classical 'pure' moderation previously shown in **Figure 6** (472). Although commonly occurring in the literature, the interpretation of our results in relation to MMH demand increased caution for this reason (471).

Within our study, moderation analyses were conducting in R, using *fitmod* and the packages *rockchalk* (473) and *stargazer* (474). Both independent variables and child outcomes were scaled prior to modelling to centre and standardise variables, as well as aiding comparison between results, via the R *scale* function (475). Analyses were run separately based on each exposure/outcome pairing, to test any possible variation of the association between PMI and child developmental outcomes according to the four indicators previously outlined: maternal mental health, child sex, and mother and father's professional skill class (ISCO category). Separate linear regression models were used to test moderation by including an interaction term (moderator*exposure), taking a p-value of $p < 0.05$ to represent a statistically significant interaction following adjustment for multiple comparisons using a Hochberg correction (453). In the presence of a significant moderation effect, the *rockchalk* function *plotSlopes* was used to visually interpret the interaction effect (473). *PlotSlopes* plots the original slope of the relationship between X and Y against the same relationship in the presence/absence of the moderating factor, indicating the direction of interaction. The moderating variable may be continuous or categorical, thus inclusive to all our chosen moderators.

2.4 Umbrella reviews

2.4.1 A review of reviews?

Systematic reviews (SRs) and meta-analyses (MAs) are often heralded as the highest form of evidence in public health research, applying a rigorous scientific approach to synthesis a body of original empirical data into a more manageable and just overview (476). The number of SRs and meta-analyses being published is continuously increasing (123), with one 2019 study seeing a more than 20-fold increase in the number of published SRs over the past 20 years (124). Another study saw the rate of growth since 1995 for SRs in paediatric literature (4809%) to be substantially greater than that of randomised-controlled trials (208%) (477). Whilst PRISMA guidelines appear to have improved the transparency and accuracy of meta-analyses

(478), the mass production of SRs in recent decades may be increasing numerous biases, such as supporting vested sponsor interests, weak or insufficient conclusions, and misleading decision making (479). It is also not uncommon that SRs on the same research question arrive at different conclusions, even when published within the same year (480). A possible response to combat the inconsistencies in the literature is to conduct an ‘*umbrella review*’, a review of reviews that compiles all existing SRs, taking into account the quality of the investigations themselves. In doing this, contradictions amongst SRs may be better understood. Umbrella reviews are also often broader in scope (481), thus providing a wide range of findings useful to more novel or exploratory research questions.

According to Cochrane guidelines, umbrella reviews should intend to search for and include only *systematic* reviews (with or without MAs) (481). This therefore reduces the likelihood of including reviews with less rigorous or stringent methods, such as scoping reviews, which risk misrepresenting the literature through selective inclusion (482,483). Methods should be transparent, reproducible, clearly formulated and including assessments of SR quality and risk of bias.

For our study (Chapter 4), searches were conducted from December 2021 until January 2022 and considered studies published from 1980 onwards (476,484), using the search terms outlines in **Table 5**.

Table 5 – PICO (population, intervention, control, and outcomes) search terms used for an umbrella review on the relationship between paternal mental health and child development (Chapter 4). *Terms are formatted for searching on the following example databases: Web of Science; Cochrane; PsycINFO.*

Population

Paternal OR Spouse OR Father* OR Dad* OR Male OR Men AND
Child* OR Infant OR Offspring OR Baby OR Adol* OR Teen* OR Youth OR Juvenile OR Pubescent

Perinatal status

Pregnan* OR Post-partum OR Postpartum OR Post-natal OR Postnatal OR Perinatal OR Peri-natal OR Pre-partum OR Prepartum OR Pre-natal OR prenatal OR Gestation OR Antenatal OR Birth*

Mental health

Mental OR Distress OR Psychiatry OR Worry OR Mood OR Irritab* OR Sad* OR Affect* OR Depress* OR Psycho* OR Schizo* OR Anxi* OR GAD OR Panic OR Trauma* OR Post-traum OR "Post traumatic stress disorder" OR "Post-traumatic stress disorder" OR "Posttraumatic stress disorder" OR PTSD OR Stress OR "Obsessive Compulsive Disorder" OR OCD OR Phobia OR Panic* OR Suicid* OR "Emotional wellbeing"

Child development

Development OR "Behavioural outcomes" OR External* OR Internal* OR Socioemotional OR Psychological OR Cognitive OR Neuro* OR "Attention Deficit Hyperactivity Disorder" OR ADHD OR Aggressive OR Anxiety OR "Mental health" OR Withdrawn OR Depress* OR Affective OR Psychopatholog*

Review [Title]

Review OR Meta-analysis OR Metaanalysis OR "Meta analysis" OR Synthes*

Data extraction was performed across several matrices, based on an adapted PRISMA 2009 checklist (485). Our review was completed in accordance with the PRISMA 2020 guidelines for systematic reviews (486), with data coded and extracted by two reviewers, independently and blinded, with final agreement achieved via collaboration with the third reviewer. Full detail of our completion of these guidelines is available in Appendix Table 3. After data extraction, narrative analyses were first conducted in line with guidelines from both the Joanna Briggs Institute (484) and the Cochrane guidance for narrative syntheses (487). The full protocol for our review was preregistered on PROSPERO; number CRD42022298048.

2.4.1 Quality assessment

As systematic reviews are also subject to a range of biases, the assessment of their quality is of upmost importance when taking into account their results. Validated tools and guidelines are necessary to reduce both conscious and unconscious biases from authors. To critically review the studies included in Chapter 4, in line with Cochrane guidelines (481), we relied primarily on two tools, the AMSTAR-2 and GRADE scoring. AMSTAR-2 is a popular instrument for critically appraising systematic reviews (69). AMSTAR was developed as a critical appraisal tool that would be useable for those without any advanced training in epidemiology, in turn minimising the risk of bias based on users' prior education. Ranking categories are shown in **Table 6**.

However, AMSTAR-2 was originally developed for SRs of health-care interventions. Numerous questions are thus not fully applicable and require adaptation (488). For example, criteria for completing Question 8 *"Did the review authors describe the included studies in adequate detail?"* includes responses such as: *"described intervention in detail (including doses where relevant)"* and *"timeframe for follow-up"*. Whilst AMSTAR-2 has since been used in a wide range of other contexts, Puljak et al. (488) call for future studies to explore adaptations of AMSTAR-2 for other types of SR, including reviews of prevalence and/or incidence. Moreover, justifications for labelling certain domains as critical and others as non-critical is lacking, again raising questions on the capacity of this tool (489,490). AMSTAR-2 also relies on strict "yes", "partial yes" and "no" scoring, resulting in an increased tendency towards "no" responses when non applicable or undetermined (125). This may have partially driven the pertinent trend of low to critically low scores across domains.

Table 6 – Description of AMSTAR-2 rankings. *Taken from (69)*

High
<i>No or one non-critical weakness:</i> the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest
Moderate
<i>More than one non-critical weakness*:</i> the systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies that were included in the review
Low
<i>One critical flaw with or without non-critical weaknesses:</i> the review has a critical flaw and may not provide an accurate and comprehensive summary of the available studies that address the question of interest
Critically low
<i>More than one critical flaw with or without non-critical weaknesses:</i> the review has more than one critical flaw and should not be relied on to provide an accurate and comprehensive summary of the available studies
<i>*Multiple non-critical weaknesses may diminish confidence in the review and it may be appropriate to move the overall appraisal down from moderate to low confidence</i>

AMSTAR-2 rankings were conducted by two researchers, independently and blinded. To test inter-rater reliability, we used Cohen's kappa (491) using the R package *irr* (492). Responses were categorised as 1 scoring unit for "Yes", 0.5 units for "Partial Yes" and 0 for "No". Kappa was 0.468, which according to Cohen's initial recommended thresholds would classify this as moderate agreement. McHugh (493), however, argues this should be interpreted as "weak" reliability. Values between 0.41-0.6 are still commonly considering moderate but vary between studies (494,495). Final, overall consensus on rankings was reached through discussion with a third researcher. For descriptive purposes, in line with advice from the developers of AMSTAR-2, AMSTAR assessments were not divided into categories based on their overall scores but rather considered based on the respective impact of each individual item (69,496).

The second tool we used to assess the quality of evidence amongst reviews was the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (70). Developed by an international and widely representative group of researchers and developers, it provides explicit, transparent and comprehensive criteria for grading the quality of evidence ratings (126). In using GRADE, the confidence in recommendations to clinicians, patients, and policy makers can be better determined (497). Endorsed by more than 120 organisations across 19 countries, continued support for GRADE is seen

across health research (127). This may be owed to the continual and interdisciplinary collaboration of the GRADE Working Group to develop this approach, alongside the tool's flexibility in comparison to previous methods (498). Nevertheless, both AMSTAR-2 and GRADE fall prey to the discrete categorisation of something that is a continuum, the quality of evidence (497). However, the translatability of these frameworks between studies, alongside their impartiality, reproducibility and transparency, validate the continuous relevance of these tools.

Finally, an additional measure of quality screening was conducted in response to the risk of publication bias. Publication bias is a well-supported phenomenon within scientific literature that suggests studies published in peer-reviewed journals are considerably more likely to report statistically significant results than those with non-significant findings, particularly so for smaller studies (499). To address this, we constructed a funnel plot. Funnel plots are simple scatterplots of the estimated effect sizes of each individual study against a measure of each study's size (500). The presence of bias is determined based on the asymmetry of the plot; the more symmetrical the funnel plot, the weaker the apparent publication bias, with graphs resembling a symmetrical, inverted funnel in the absence of bias. Funnel plot was conducted using RevMan 5.4.1 (501).

2.4.2 Grouped meta-analyses

To visualise relevant exposure–outcome relationships within our umbrella review, grouped meta-analyses were conducted. Grouped meta-analyses, sometimes called second-order meta-analyses, work in the same way as a standard meta-analysis, in that effect sizes from independent studies are converted and synthesised to produce an overall effect (502). Grouped meta-analyses are increasing in popularity, and are able to summarise a far larger range of empirical data, in turn potentially resolving discrepancies amongst the meta-analyses available (503). There are two main approaches to grouping meta-analyses: Fixed effect or random effect modelling. Fixed effect models assume a common effect is shared across all the included meta-analyses, providing a weighted average based on study-specific effect sizes (504). It is assumed that any observed differences are due to sampling error, rather than heterogeneity. Random effects models, on the other hand, assume that effect sizes are likely to vary between studies, due to genuine variation on the results (505). Alongside allowing for heterogeneity, random effects models also give more weight to smaller sized studies when compared to a fixed effect model, based on their relative levels of precision (504). As opposed to generating an underlying 'true' effect size, as in fixed effects models, they

estimate the distributed effect across a variety of study settings. For these reasons, for the purposes of our study, random effects models were used. Analyses were performed using R version 4.0.3 (506,507) and RevMan 5.4.1 (501). Before grouping, each review's individual reported effect sizes were converted to odds ratios, and within study heterogeneity converted to the I^2 statistic (508). Further grouped meta-analyses were also conducted based on the following subgroups: child developmental output (internalising versus externalising behaviours) and each review's quality score, based on GRADE results ("Low" vs "Very low").

Chapter 3: Longitudinal trajectories and associated risk factors of paternal mental illness in the nine years surrounding the transition to fatherhood.

Chapter 3 provides one of the first investigations on the longitudinal prevalence and associated risk factors of paternal mental illness in France. Two different approaches were used to measure paternal mental health, permitting a secondary examination into the differences between methods of assessment of paternal mental illness. This article was published in the *Journal of Affective Disorders*.

Article summary

3.1 Context

Increased representation of fathers in perinatal mental healthcare is necessary. The transition to fatherhood presents numerous mental and physical challenges, with roughly 10% of fathers experiencing symptoms of perinatal depression (175) and 2.4%-51% perinatal anxiety (26). Moreover, research shows strong, continuous increases to fathers involvement in the lives and care of their children (9,509). Data within France is particularly lacking, with no investigation extending beyond 2-months postpartum. The most up to date systematic reviews and meta-analyses indicate the most heightened period of paternal mental illness during the perinatal period is 3-6 months (15), indicating that the current French estimations may thus be underestimating the prevalence of mental illness amongst fathers. Moreover, research extending beyond the perinatal period may reveal important variations in the timing and severity of symptoms. This includes the period prior to birth, which could provide valuable insight into what precedes certain postpartum changes in mental health.

The study aimed to identify the prevalence of symptoms of mental illness amongst first-time fathers across France, alongside investigating the longitudinal progression of fathers' mental health over time. We also aimed to identify risk factors associated with these longitudinal trajectories. An additional aim of this study was to investigate potential disparities on these findings based on the measure of paternal mental health assessment, thus two different measures were used to determine fathers' mental health.

3.2 Methodology

3.2.1 Population and study design

This study relied on participants from the CONSTANCES cohort. CONSTANCES is a prospective, observational, cohort targeting those affiliated to the French Social Security system (over 85% of the French population), aged 18 to 69 years at the time of inclusion (2012-2020) (56). Comprising roughly 220,000 volunteers, for the purposes of this study, we took all male participants who welcomed their first child within the study period ($n = 6299$).

Following inclusion, participants completed a health screening examination. In addition to this, every year since inclusion, participants were invited to complete self-administered questionnaires either online or on paper (home delivered), based on participants' choosing. Amongst the measures used within this study, some were collected annually (e.g., health status, life events) whilst others collected across longer intervals (e.g., family income, level of education).

3.2.2 Measures

Two measures were used to assess fathers' mental health:

1) At every year since inception, participants declared the presence of mental illness (yes/no), alongside their specific pathology as indicated in the questionnaire (subsequently grouped into "depression"; "anxiety"; other (bipolar, manic-depressive syndrome, "nervous breakdown")). This measure is described henceforth as "self-declared mental illness".

2) Symptoms of mental illness were also measured directly at several data waves, using either the Center for Epidemiologic Studies Depression scale (CES-D) (59) or the 12-item General Health Questionnaire (GHQ-12) (60). The CES-D is a 20-item, self-report questionnaire used to measure depressive moods, thoughts or feelings via a 4-item Likert scale. The GHQ-12 is the 12-item version of the GHQ frequently used to screen common mental disorders such as depressive, anxious and somatic disorders (510). It also uses a self-report, 4-item Likert scale, and for this study, we applied the corrected scoring method (C-GHQ) (61,381). Both the CES-D (62,63,376) and GHQ-12 (377,378) have been validated for use in new fathers. For measuring the prevalence of paternal mental illness, binary scoring was used, with a cut-off score of ≥ 6 for the GHQ-12 (61) and ≥ 16 for the CES-D (62,63). For all other analyses, both

scales were standardised and treated as continuous. This measure is described henceforth as “clinically significant symptom scores”.

Based on a review of the literature, the following factors variables considered as potential factors associated with paternal mental health; Fathers’ age at child’s arrival; Region of birth; French nationality status; Level of education; Marital status; Living with one’s partner; Living with children (biological or otherwise); Close relationship satisfaction (combined variable of close friends/family satisfaction and/or relationship satisfaction); Employment status; Spouse's employment status; Financial difficulties within the past year (food, rent, electricity, loans, etc.); Having foregone healthcare due to financial reasons within the past year; The arrival of subsequent children at any time point; daily alcohol use according to recommended (WHO) guidelines (421); Parental history of serious psychiatric illness; and Parental history of suicide.

Where possible, variable data was taken at either the same year of participants’ child’s arrival (for chi-square and multivariable models), or the same year as each time-point in relation to the child’s arrival (for trajectory analyses).

3.2.3. Data analysis

To assess longitudinal patterns of fathers’ mental illness from 4-years before to 4-years after their first child’s arrival, latent class group-based modelling was conducted using PROC TRAJ (64,66). The arrival of each participant’s first child was taken as year 0. Models were created respectively for both self-declared mental illness and clinically significant symptom scores. Binary logit models were used for self-declared mental illness (yes/no) and censored normal distribution models (CNORM) for symptom scores. The number and forms of latent class trajectories were determined using the Bayesian Information Criterion (BIC), posterior probabilities of class membership (AvePP), odds of correct classification (OCC), and the theoretical interpretation of the class solutions (64,65).

To select the variables to be tested as potential risk factors against trajectory groups, we first tested all variables chosen based on the literature, and available within the dataset, against paternal mental illness at year 0 (the year of the child’s arrival) using chi-square analyses. Analyses were run independently for both self-declared mental illness and clinically significant symptom score, and $p < 0.05$ for either outcome was considered relevant for retention. Following testing for within-variable correlation (438),

multivariable logistic regressions were then run using said variables against paternal mental health at time-point 0. Variables significant at $p < 0.05$ were then tested against all longitudinal trajectory groups via multinomial regression models. All missing data were imputed using Multivariate Imputation by Chained Equations (MICE) (425), performed using R version 4.2.2 (506).

3.3. Results

3.3.1 Prevalence and trajectories

At all time-points, self-reports of paternal anxiety (5-11%) were more prevalent than depression (1-3%) or other disorders. Rates of clinically significant symptom scores were consistently higher (12-27%) than self-declared mental illness, peaking at 1-year postpartum.

We identified three trajectory groups for self-declared mental illness amongst fathers: Low risk with high temporary increase (5.6% of fathers); consistent low risk (90.3%); and consistent high risk (4.1%). For clinically significant symptom scores, two trajectory groups were identified: Low with small temporary increase (75.1%); and moderate with small temporary increase (24.9%).

3.3.2 Risk factors

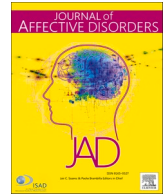
Factors that were significantly associated with either measure of parental mental health at year 0 (the year of fathers' first child's arrival), as well as the arrival of subsequent children over time, were taken and tested against all trajectory groups.

For self-declared mental illness, when compared to trajectory Group 2 (consistent low risk), risk factors for Group 1 (low risk with high temporary increase) were as follows: Being aged 35–39 [aOR: 1.61; 95% CI: 1.02-2.57]; Being unemployed (as opposed to employed) [aOR: 3.01; 95% CI: 1.63-5.32]; Having had at least one adverse childhood experience (ACE) [aOR: 2.26; 95% CI: 1.49-3.55]; and having forgone healthcare due to financial reasons [aOR: 1.75; 95% CI: 1.02-2.87]. Risk factors for Group 3 (consistent high risk) were: Being aged 40–44 [aOR: 2.48; 95% CI: 1.29-4.72]; Being aged 60+ [aOR: 4.79; 95% CI: 1.79–12.07]; Not living with one's partner (if in a relationship) [aOR: 2.59; 95% CI: 1.25-5.07]; being unemployed [aOR: 2.62; 95% CI: 1.22–5.23], and having subsequent children in the years following [aOR: 1.85; 95% CI: 1.08–3.06].

For symptom scores, when compared to symptom trajectory Group 1 (low with small temporary increase), risk factors for Group 2 (moderate with small temporary increase) were as follows: Not living with one's partner [aOR: 2.41; 95% CI: 1.48-3.93]; Having had at least one adverse childhood experience [aOR: 1.47; 95% CI: 1.16-1.88]; and having forgone healthcare due to financial reasons [aOR: 2.30; 95% CI: 1.57-3.35].

3.4 Conclusion

Within *CONSTANCES*, a large French general population cohort, symptoms indicative of mental illness began to rise 2-years before the first child's arrival and decreased from 2-years following. Paternal anxiety was consistently more prevalent than depression. Through using two different approaches to measure paternal mental illness, we also saw an apparent underdiagnosis of symptoms indicative of mental illness amongst first-time fathers during this period. Key factors associated with increasing risk of mental illness over time were being unemployed, not living with one's partner, adverse childhood experiences and having foregone healthcare due to financial difficulties unemployment. Although temporary, the identified increase in paternal mental illness falls at a particularly crucial period for child development. Thus, paternal wellbeing is particularly key during this period, and the risk factors highlighted should be used to better target those at risk.



Research paper

Longitudinal trajectories and associated risk factors of paternal mental illness in the nine years surrounding the transition to fatherhood

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ABSTRACT

Background: The arrival of one's first child is a known risk factor for mental illness, yet investigations on fathers' mental health are limited. We conducted a longitudinal investigation on paternal depression and anxiety in the nine years surrounding the transition to fatherhood.

Methods: Using a national cohort of French men (CONSTANCES, $n = 6299$), we investigated the prevalence and associated risk factors of mental illness amongst first-time fathers. Responses to the Center for Epidemiological Studies Depression (CES-D) and 12-item General Health Questionnaire (GHQ-12) scales were used to identify clinically significant symptom scores. Self-declared mental illness was also reported by participants. Group-based modelling was used to identify latent trajectory groups for both measures.

Results: Levels of self-declared anxiety (averaging 4.9 % pre-fatherhood, 7.8 % post) exceeded that of depression (1.9 % pre-fatherhood, 3.3 % post) or other disorders. However, rates of clinically significant symptom scores (17–27 %) were consistently higher. Participants' mental health appeared to worsen from two-years prior to their child's arrival and improve from two-years after. We identified three trajectory groups for fathers' self-declared mental illness: Low stable (90.3 %); Low risk with high temporary increase (5.6 %); and Consistent high risk (4.1 %). Risk factors associated with worsening mental health trajectories were unemployment, not living with one's partner, having had adverse childhood experiences and foregoing healthcare due to financial reasons.

Limitations: All measures of mental illness relied on participant self-reports and are thus subject to bias.

Conclusions: This study reveals an important period of heightened psychological vulnerability amongst first-time fathers, emphasising the need for increased and better adapted paternal mental health screening.

1. Introduction

The arrival of a child, and preparation towards, encompasses a significant amount of personal, lifestyle, and financial adjustments. Whilst for many men this entails primarily positive feelings, it is also common to struggle with such a significant transition, resulting in negative repercussions on their mental health. Research shows that increased work-family conflicts (Philpott et al., 2019) and the deterioration of previous lifestyle and sexual relationships (Williamson et al., 2008), alongside sleep deprivation (Baafi et al., 2001), create an emotionally taxing environment for fathers following their first child's arrival, with labour itself often triggering feelings of helplessness and anxiety (Genesoni and Tallandini, 2009; Philpott et al., 2017). This experience is not exclusive to the postnatal period; a review of qualitative studies on the transition to fatherhood found pregnancy to be the most demanding period for the

fathers' psychological needs, entailing a core shift in identity as well as increased disconnection with their partner (Genesoni and Tallandini, 2009). Both pre and postnatal periods may entail feelings of powerlessness and unmet expectations amongst first-time fathers (Philpott et al., 2017; Finnbogadóttir et al., 2003), and for several the pleasure, pride and excitement typically accompanying this new stage of life becomes obscured.

Global research suggests that approximately 5–10 % of fathers are susceptible to depression in the perinatal period (Paulson and Bazemore, 2010; Demontigny et al., 2013). And whilst the current literature focuses almost exclusively on paternal depression, there is accumulating evidence indicating that perinatal stress and anxiety are even more prevalent amongst fathers (Demontigny et al., 2013; Skari et al., 2002), with a systematic review showing levels of paternal anxiety during the perinatal period to range 2.4 %–51.0 % (Philpott et al., 2019). Paternal

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depression and anxiety are frequently comorbid (Leray et al., 2011; Kiviruusu et al., 2020; Philpott et al., 2022), however the inclusion of both is particularly important in investigations on paternal mental health. Not only does anxiety appear more prevalent than depression amongst fathers, but certain differences exist between the two, such as differing levels of negative effect (Rutter et al., 2024) as well as disparities in the risk factors associated with each during the perinatal period (Chhabra et al., 2022; Leach et al., 2008). Interestingly, one study (Berger et al., 2012) saw that perceived social stigma amongst men was less pervasive for paternal anxiety, when compared to depression. This is particularly relevant, as research indicates that current diagnostic methods may be underestimating the rates of mental illness amongst men (Shi et al., 2021; Branney and White, 2008). Including anxiety-related disorders in psychiatric research amongst men might partially counteract this apparent underdiagnosis (Bradley and Slade, 2011). The current research focus on paternal depression, alongside certain public health campaigns targeting fathers (Rochlen et al., 2005), may have obscured a significant proportion of the male population struggling with their mental health (Fisher et al., 2021).

The method with which paternal anxiety is assessed has been found to strongly associate with declared prevalence (Philpott et al., 2019). Symptom-based measures appear to result in a more even representation of the various types of anxiety diagnoses than using self-declared diagnoses (Davies et al., 2022), with another study highlighting that a disparity between self-report symptoms versus declared mental illness is also apparent for depression (Glanville et al., 2021). Employing multiple measures within a study may thus provide a more reliable investigation. The use of structured check-lists during diagnosis has also been found to provide more accurate assessments of men's mental health than therapists conducting diagnosis without, indicating a currently present clinical bias (Cwik et al., 2016). Structured questionnaires designed for the perinatal period, however, focus primarily on maternal symptomology, often due to a lack of knowledge surrounding fathers' mental health during this period (Berg et al., 2022). They thus risk overlooking symptoms more commonly seen amongst men, such as increased aggression or alcohol consumption, thereby under-reporting the real prevalence of paternal mental illness (Madsen, 2019). Until the nuances between paternal diagnostic methods are better understood, collaborative assessment using multiple methods may counteract some of the heterogeneity seen amongst psychological assessments of fathers.

Even more lacking than general prevalence data are investigations into the longitudinal trajectories of paternal mental health (Bruno et al., 2020). Research on the long-term progression of fathers' mental illness may reveal important variations in the timing, severity and chronicity of symptoms. Meta-analyses show rates of paternal mental illness to vary significantly with time (Paulson and Bazemore, 2010), with perinatal studies commonly finding depression amongst new fathers to peak 3–6 months postpartum (Paulson and Bazemore, 2010; Tokumitsu et al., 2020). Interestingly, a meta-analysis on paternal anxiety saw no difference between pre and postpartum rates (Leiferman et al., 2021). However, a key limitation surrounding the available prevalence studies for both depression and anxiety is that they concentrate almost exclusively on the two years following birth. Moreover, the few studies to investigate beyond the perinatal period are contradictory (Garfield et al., 2014; Giallo et al., 2012). Another particularly understudied period are the years prior to birth, which could provide valuable insight into what precedes changes in mental health postpartum. Clearly research across longer timeframes is needed, as paternal mental illness does not stop being relevant beyond the perinatal window (Scarlett et al., 2023).

Investigation of the longitudinal progression of fathers' mental health is also necessary to better target prevention methods. Certain potential risk-factors for paternal psychopathology, such as financial insecurity, risk worsening overtime. Socioeconomic factors including low income, job insecurity and access to paid paternity leave have already been seen to associate with paternal perinatal depression and

anxiety (Philpott et al., 2022; Bradley and Slade, 2011; Pedersen et al., 2021; Nath et al., 2016). In a meta-analysis on paternal postpartum depression spanning 14 countries, the largest effect sizes were seen for paternal unemployment, alongside financial instability and low levels of paternal education (Ansari et al., 2021). However, young, first-time fathers show a greater risk of depression than older fathers that remains significant even when controlling for socioeconomic factors (Bergström, 2013). This may be partly explained by other factors, such as a lack of informal social support (Lähteenmäki et al., 2019; Nakamura et al., 2020) or relationship status (Philpott et al., 2022), both of which associate with paternal mental illness. Being a first-time father, compared to having subsequent children, has also been found to increase the risk of trait anxiety symptoms in the first four days postpartum (Philpott et al., 2022). Most longitudinal studies on the risk factors for paternal mental illness, however, have relied on data from UK or Australian cohorts, and thus might not be generalisable to other settings. Cultural and social factors may reveal different patterns when explored in the French context. Only two studies have investigated paternal mental health in France, however both investigated exclusively paternal depression, and did not extend beyond four months postpartum (Nakamura et al., 2020; Séjourné et al., 2012).

This article aims to provide a unique investigation on the longitudinal trajectories of paternal mental illness, extending four years before and after fathers' first child's arrival. The assessment of fathers' mental health will incorporate both depression and anxiety. Due to the apparent heterogeneity seen amongst the methods currently used to assess paternal mental illness, paternal trajectories will be assessed using both clinically significant symptom scores and self-declared mental illness to identify any potential disparities between the two. Alongside this, sociodemographic, lifestyle and psychosocial risk factors will be explored in relation to these longitudinal patterns to identify potential risk factors for paternal mental illness during this period.

2. Methods

2.1. Population

The population for this study came from the Constances cohort, a large-scale, prospective observational cohort, designed to cover a broad scope of public health domains (Zins, 2019). It comprises a sample of 200,000 adults, aged 18–69 years at study inception. Recruitment was conducted throughout France, from 2012 to 2020, through a random-sampling scheme designed to enlist a sample representative of those enrolled in the National Health Insurance Fund (~85 % of the general population). For this study, we focused exclusively on male participants that became first-time fathers during the data collection period ($n = 6299$).

2.2. Study design

The data for this study is based on yearly self-administered questionnaires, starting from inclusion. Questionnaires were a mix of paper-and-pencil (sent to participants' homes) and internet based, to better accommodate participants and minimise selection bias. Some questionnaire data were collected annually (e.g., health status, life events) whilst others collected across longer intervals (e.g., family income, level of education). Data were linked anonymously, and all confidentiality procedures approved by the French national authorities.

2.3. Measures

2.3.1. Fatherhood status

First-time fatherhood status was determined based on the response to two questions: 1) whether or not they were a father, asked at inclusion 2) whether or not they had welcomed a child (birth, adoption and/or spouse's children from a previous union) within the past 12 months,

asked over the subsequent data waves (from 2013 to 2020). The arrival of additional children was recorded via the same question. Those who were fathers prior to inclusion in the cohort were excluded as the date of their first child's arrival was not recorded.

2.3.2. Paternal mental illness

Two measures were used to assess fathers' mental health. Firstly, at every year since inception, participants declared the presence of mental illness (yes/no), alongside their specific pathology as indicated in the questionnaire (subsequently grouped into "depression"; "anxiety"; other (bipolar, manic-depressive syndrome, "nervous breakdown")). Data from the 2013 wave were excluded due to deviations in categorisation. This measure is described henceforth as "self-declared mental illness".

Additionally, continuous symptom scales were used. Symptoms were measured at several data waves, using either the Center for Epidemiologic Studies Depression scale (CES-D) (Radloff, 1977) or the 12-item General Health Questionnaire (GHQ-12) (Goldberg, 1978). The CES-D is a 20-item, self-report questionnaire used to measure depressive moods, thoughts or feelings via a 4-item Likert scale. Total scores range from 0 to 60, with higher scores indicating the presence of increased depressive symptomatology. The GHQ-12 is the 12-item version of the GHQ, originally adopted as a screening tool for an international study on mental health conducted by the World Health Organization (WHO) (Goldberg et al., 1997). Recommended to screen common mental disorders such as depressive, anxious and somatic disorders (Goldberg et al., 1988), it also uses a self-report, 4-item Likert scale, with scores ranging 0 to 12 when using binary scoring. Both the CES-D (Nishimura and Ohashi, 2010; Mangialavori et al., 2020; Yin et al., 2018) and GHQ-12 (Tran et al., 2012; Haem and Doostfateme, 2022) have been validated for use in new fathers. For reporting the prevalence of paternal mental illness, binary scoring was used. For the GHQ-12, the corrected scoring method (C-GHQ) was applied (Anjara et al., 2020) and a cut-off score of ≥ 6 used, resulting in the highest combination of sensitivity and specificity for the C-GHQ (Lundin et al., 2016). In line with the literature and for greater congruency with the GHQ-12, a CES-D cut-off score of ≥ 16 was used (Nishimura and Ohashi, 2010; Mangialavori et al., 2020). For all other analyses, scales were treated as continuous, to reduce the risk of over-simplification and loss of information often resulting from dichotomising mental health scores. For continuous scoring, both scales were standardised before combining. This measure is described henceforth as "clinically significant symptom scores".

The overall reliability and internal consistency (Cronbach α) of the CES-D was 0.702 and the GHQ-12 was 0.874, indicating acceptable to good internal consistency and reliability.

2.3.3. Associated factors

Based on a review of the literature, we identified several socio-demographic, psychosocial and lifestyle characteristics for inclusion as potential factors associated with paternal mental health. The following variables were considered: Fathers' age at child's arrival (Giallo et al., 2012; Nath et al., 2016; Bergström, 2013); Marital status (Married/Civil partnership; Divorced/Separated; Unmarried (never married)) (Philpott et al., 2022; Baldwin et al., 2019; Matthey et al., 2000); Living with one's partner (yes/no) (Garfield et al., 2014; Bronte-Tinkew et al., 2007); Living with children (biological or otherwise) (yes/no) (Garfield et al., 2014; Bronte-Tinkew et al., 2007); Close relationship satisfaction (combined variable of close friends/family satisfaction and/or relationship satisfaction) (Demontigny et al., 2013; Philpott et al., 2022; Bergström, 2013; Lähtenmäki et al., 2019); Employment status (Employed; Unemployed; Retired; Student/Other) (Philpott et al., 2022; Bradley and Slade, 2011; Pedersen et al., 2021; Nath et al., 2016; Ansari et al., 2021); Spouse's employment status (Employed; Unemployed; Retired; Student/Other) (Nath et al., 2016; Ballard et al., 1994); Financial difficulties within the past year (food, rent, electricity, loans, etc.) (yes/no) (Philpott et al., 2022; Bradley and Slade, 2011; Pedersen et al., 2021; Nath et al., 2016; Bergström, 2013; Rosenthal et al., 2013);

Having foregone healthcare due to financial reasons within the past year (yes/no) (Bergström, 2013; Rosenthal et al., 2013); The arrival of subsequent children at any time point (yes/no) (Philpott et al., 2022); and daily alcohol use according to recommended (WHO) guidelines (Moderate consumption; No consumption; Non-recommended consumption) (World Health Organization, 2023).

Where possible, variables were taken at either the same year of participants' child's arrival (for chi-square and multivariable models), or, for longitudinal trajectory analyses, the same year as each time-point in relation to the child's arrival. For several variables, data was only recorded at inclusion, but was deemed reliable and thus retained in analyses. These were as follows: Participants' region of birth (France; Europe; Africa; Other) (Doyle et al., 2012); French nationality status (French by birth; Naturalised French; Foreign national) (Bulford et al., 2022); Level of education (No diploma; Primary, Professional/vocational certificate (9–11 years); Baccalaureate or equivalent diploma; and Baccalaureate +2–3 years; +4 years; +5 or more) (Ansari et al., 2021); Parental history of serious psychiatric illness (yes/no) (Ramchandani et al., 2008); Parental history of suicide (yes/no) (Ramchandani et al., 2008).

Factors excluded due to the proportion of missing data, in all instances due to long intervals between data collection points, were: Family's average net monthly income; Average number of hours of sleep per night; Sleep difficulties over the past month; Level of physical activity on/off work; Deprivation index (EPICES score); and participants socio-professional category. Full detail on missing data is available in Supplementary Material T1.

2.4. Data analysis

To assess longitudinal patterns of fathers' mental illness, the arrival of participants' children was taken as "time-point 0" and mental health data extrapolated, either from questionnaires or imputation, from four-years prior to four-years post. Latent class modelling - a semi-parametric group-based modelling strategy used to identify homogeneous latent trajectory classes - was conducted using PROC TRAJ in SAS (Nagin and Odgers, 2010; Jones and Nagin, 2007). Models were created respectively for both self-declared mental illness (depression, and/or anxiety), and clinically significant symptom scores, spanning four-years pre- to four-years post-fatherhood. Binary logit models were used for self-declared mental illness (yes/no) and censored normal distribution models (CNORM) for symptom scores. Participants were excluded if failing to have responses for at least two out of the nine time-points. The number and forms of latent class trajectories were determined using the Bayesian Information Criterion (BIC), posterior probabilities of class membership (AvePP), odds of correct classification (OCC), and the theoretical interpretation of the class solutions (Jones and Nagin, 2007; Jones et al., 2001). Missing mental illness data between time-points was imputed in R using either interpolation (linear or spline), weighted moving averages, or Kalman smoothing (Package: imputeTS (Moritz and Bartz-Beielstein, 2017)) (Armstrong et al., 2009). All methods were tested and the most suitable chosen based on graphical interpretation. Trajectory analyses were also rerun using the SAS-generated imputation, and models compared. Based on model fit statistics, R-based imputation was chosen.

To determine the variables to be tested against trajectory groups, factors were selected using the following steps. First, chi-square analyses were run independently for both self-declared mental illness and clinically significant symptom scores, in the year of the child's arrival (time-point 0). Significance at $p < 0.05$ for either outcome was considered relevant for retention in subsequent multivariable logistic regressions. For these models, all variable data were also taken from the year of the child's arrival (time-point 0). Prior to inclusion, potential risk factors were also tested for within-variable correlation and covariate pairs with $r > 0.7$ reduced to the most relevant factor (Nettleton, 2014). The arrival of subsequent children was also included as a covariate in all trajectory

regression models (Philpott et al., 2022).

Variables identified through these steps were then used in multinomial regression models, fitted to test associations between significant risk-factors and the longitudinal trajectory groups for both self-declared mental illness and symptom scores. For these trajectory analyses, time-dependent variables (employment status; the arrival of a subsequent child; living status with partner; having forgone healthcare due to financial reasons) were taken as separate events at each year.

Thus, data were taken from the same year of the time-point created based on participants' first child's arrival. All missing data were imputed using Multivariate Imputation by Chained Equations (MICE) (Buuren and Groothuis-Oudshoorn, 2011), performed using R version 4.2.2 (R Core Team, 2022).

3. Results

3.1. Demographics

The final number of included participants at each phase of analysis is shown in Fig. 1. Comparison between included and an age-matched sample of excluded participants is available in Supplementary Material T2. Compared to excluded men of the same age, key significant differences were that included participants were more likely to be married (84.3 % vs 57.6 %), live with their partner (74.0 % vs 95.4 %) and be satisfied in their close relationships (partner and/or friends and family) (92.6 % vs 85.5 %).

The demographics of our sample of first-time fathers are shown in

Table 1. On average, participants were aged 38 years old at inclusion. 96 % of participants had French nationality. At inclusion, 88 % of participants were living with their partners, and 66–67 % married or legally partnered. The majority of participants had completed their baccalauréat, or equivalent diploma, with roughly half (49–50 %) holding 16+ years of education. 85 % of participants were employed.

3.2. Mental illness prevalence

The estimated prevalence of mental illness during the nine years surrounding the transition to fatherhood is shown in Fig. 2. The overall rate of self-declared mental illness across the study period averaged 7.9 %, with approximately 6.5 % suffering from anxiety, 2.7 % depression and 1.4 % multiple diagnoses (comorbid anxiety, depression and/or other diagnoses). In all instances, rates of mental illness were higher following participants' child's arrival (9.7 % general; 7.8 % anxiety; 3.3 % depression), when compared to before (5.6 % general; 4.9 % anxiety; 1.9 % depression).

Levels of clinically significant symptom scores averaged 23.2 % during the study period. The average rate was 18.3 % pre-fatherhood and 25.2 % following the child's arrival.

3.3. Repeated measures latent class analysis

Two to four group, general linear models were run to assess best fit on both outputs (self-declared mental illness; symptom scores). All model fit statistics are shown in Supplementary Material T3–4.

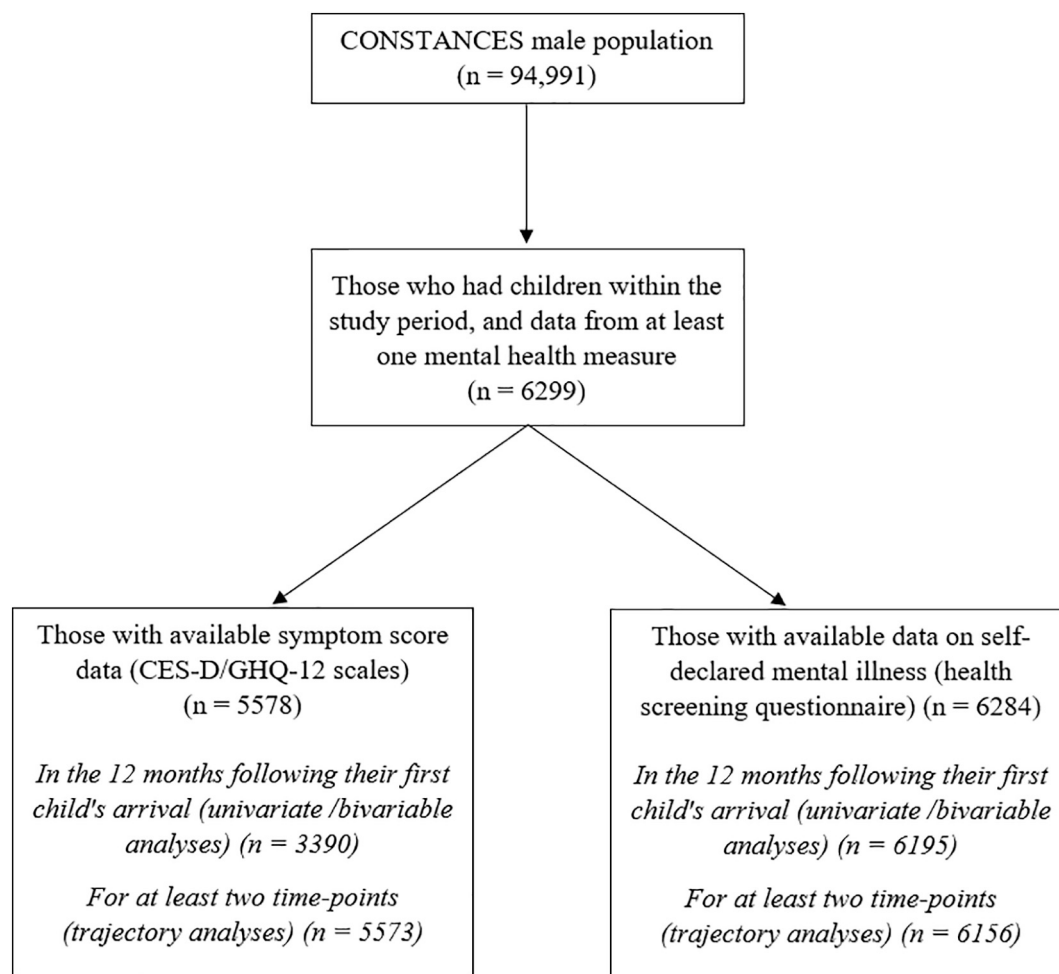


Fig. 1. Flow chart detailing the participant n values used within this study. *Constances cohort.*

Table 1

Demographic and socioeconomic information of the population of fathers with data available for analysis on either self-declared mental illness ($n = 6284$) or symptom scores (CES-D/GHQ-12 scales) ($n = 5578$), based on data taken at participants' inclusion. *Constances cohort*.

		Participants with available data on			
		Self-declared mental illness		Symptom scores	
		n	%	n	%
Age at inclusion	Mean (SD)	37.9 (10.9)		37.8 (10.8)	
Age group (years)	Under 30	1059	17 %	971	17 %
	30–34	1994	32 %	1765	32 %
	35–39	1329	21 %	1167	21 %
	40–44	650	10 %	574	10 %
	45–49	287	5 %	260	5 %
Region of birth	50–59	445	7 %	391	7 %
	60 and over	514	8 %	445	8 %
	France (including overseas territory)	5606	90 %	5016	90 %
	Europe	229	4 %	208	4 %
	Africa	296	5 %	245	4 %
French nationality status	Other	103	2 %	81	2 %
	French by birth	5721	92 %	5119	93 %
Level of education (completed)	Naturalised French	257	4 %	209	4 %
	Foreign national	237	4 %	207	4 %
	Baccalaureate + 4 or more years (16+ years)	3046	49 %	2736	50 %
	Baccalaureate + 2–3 years (14–15 years)	1514	25 %	1359	25 %
	Baccalaureate or equivalent diploma (12–13 years)	785	13 %	693	13 %
Marital status	Primary, Professional/vocational certificate (9–11 years)	756	12 %	654	12 %
	No diploma (<8 years)	82	1 %	65	1 %
	Married/civil partnership	3879	67 %	3437	66 %
	Divorced/separated	360	6 %	316	6 %
	Unmarried (never married)	1589	27 %	1437	28 %
Living with partner	Yes	5174	88 %	4605	88 %
	No	698	12 %	620	12 %
Close relationship satisfaction ^a	Satisfied	4942	92 %	4409	92 %
	Unsatisfied	430	8 %	382	8 %
Employment status	Employed	4912	85 %	4406	85 %
	Retired	394	7 %	344	7 %
	Training/education/other	178	3 %	158	3 %
Spouse employment status	Unemployed	309	5 %	264	5 %
	Employed	4369	81 %	3899	81 %
	Retired	219	4 %	189	4 %
Financial difficulties ^b	Training/education/other	254	5 %	234	5 %
	Unemployed	527	10 %	470	10 %
	No	5586	91 %	4999	91 %
Foregone healthcare due to financial reasons ^b	Yes	587	10 %	506	9 %
	No	5547	90 %	4968	90 %

Table 1 (continued)

		Participants with available data on			
		Self-declared mental illness		Symptom scores	
		n	%	n	%
Alcohol consumption	Yes	636	10 %	548	10 %
	No consumption	571	10 %	509	10 %
	Moderate consumption	4545	79 %	4063	79 %
Adverse childhood experiences	Non-recommended consumption	635	11 %	569	11 %
	None	1438	32 %	1270	32 %
	Yes, at least one	3073	68 %	2720	68 %
No. of adverse childhood experiences	Mean (SD)	1.76 (1.9)		1.76 (1.9)	
Parent history of psychiatric illness	No	6127	98 %	5437	98 %
	Yes	157	3 %	141	3 %
Parent history of suicide	No	6227	99 %	5528	99 %
	Yes	57	1 %	50	1 %

N values based on participants with available data for each respective measure.

^a Romantic partner and/or friends and family.

^b Over the past 12 months.

3.4. Self-declared mental illness (depression, anxiety and/or other)

Relative fit indices indicated that a 3-class model was the best fit for self-declared mental illness data. Groups for mental illness trajectories over time were as follows: Low risk with high temporary increase (5.6 % of fathers); consistent low risk (90.3 %); and consistent high risk (4.1 %) (Fig. 3).

3.5. Clinically significant symptom scores (CES-D/GHQ-12 scores)

Relative fit indices indicated that a 2-class model was the most appropriate fit for symptom data. Groups for symptom trajectories were as follows: Low with small temporary increase (75.1 %); and moderate with small temporary increase (24.9 %) (Fig. 3).

3.6. Associated factors

Factors associated with either self-declared mental illness or symptom scores in the year following participants' first child's arrival are shown in Table 2. Factors that were significantly associated with either measure, as well as the arrival of subsequent children over time, were taken and tested against all trajectory groups.

3.7. Self-declared mental illness (depression and/or anxiety)

When compared to mental illness trajectory Group 2 (consistent low risk), risk factors for Group 1 (low risk with high temporary increase) were as follows: Being aged 35–39 [aOR: 1.61; 95 % CI: 1.02–2.57]; Being unemployed (as opposed to employed) [aOR: 3.01; 95 % CI: 1.63–5.32]; Having had at least one adverse childhood experience (ACE) [aOR: 2.26; 95 % CI: 1.49–3.55]; and having forgone healthcare due to financial reasons [aOR: 1.75; 95 % CI: 1.02–2.87] (Table 3). Risk factors for Group 3 (consistent high risk) – when compared to Group 2 – were: Being aged 40–44 [aOR: 2.48; 95 % CI: 1.29–4.72]; Being aged 60+ [aOR: 4.79; 95 % CI: 1.79–12.07]; Not living with one's partner (if in a relationship) [aOR: 2.59; 95 % CI: 1.25–5.07]; being unemployed [aOR:

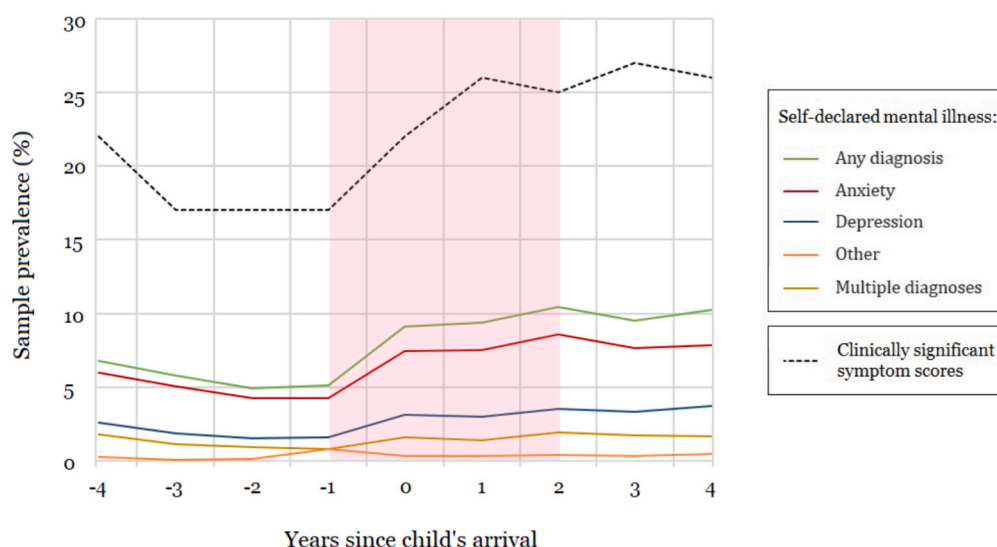


Fig. 2. The prevalence of self-declared mental illness and clinically significant symptom scores (CES-D/GHQ-12 scales) in the nine years surrounding the transition to fatherhood. Time Point 0 represents the year participants' first child arrived (birth, adoption and/or spouse's children from another union). *Constances cohort*.

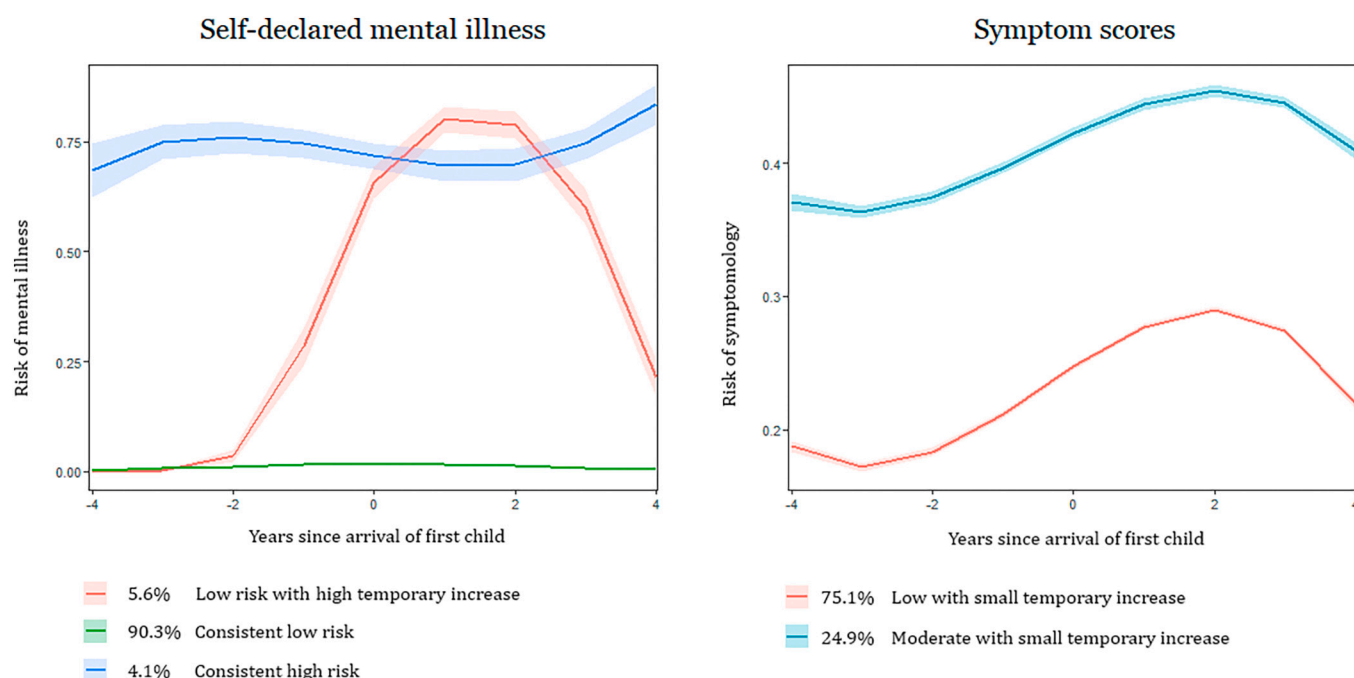


Fig. 3. Longitudinal trajectories of self-declared mental illness ($n = 6156$) and clinically significant symptom scores (CES-D/GHQ-12 scales) ($n = 5573$) amongst first-time fathers in the nine years surrounding their first child's arrival (four years prior until four years after). Area surrounding curves indicates 95 % confidence intervals. *Group-based trajectory modelling, Constances cohort*.

2.62; 95 % CI: 1.22–5.23], and having subsequent children in the years following [aOR: 1.85; 95 % CI: 1.08–3.06].

3.8. Symptom scores (CES-D/GHQ-12 scores)

When compared to symptom trajectory Group 1 (low with small temporary increase), risk factors for Group 2 (moderate with small temporary increase) were as follows: Not living with one's partner [aOR: 2.41; 95 % CI: 1.48–3.93]; Having had at least one adverse childhood experience (ACE) [aOR: 1.47; 95 % CI: 1.16–1.88]; and having forgone healthcare due to financial reasons [aOR: 2.30; 95 % CI: 1.57–3.35].

4. Discussion

This study provides a nine-year, longitudinal investigation on mental illness amongst first-time fathers. To our knowledge, it is one of few studies to have studied the mental health of new fathers across such an extended time period, encompassing four-years before to four-years following the child's arrival. Paternal anxiety was consistently more prevalent than depression. And whilst overall prevalence data showed relatively low rates of self-declared mental illness (averaging 8 %), the rates of depression and anxiety, as well as clinically significant symptom scores, were consistently higher following participants' child's arrival. Trajectory analyses revealed clear differential patterns for both self-declared mental illness and symptom scores, with all symptom score

Table 2

Adjusted risk factors for self-declared mental illness ($n = 6195$) or clinically significant symptom scores (CES-D/GHQ-12 scales) ($n = 3390$) amongst fathers, recorded in the same year as their first child's arrival. *Constances cohort. Multi-variate logistic regression.*

		Self-declared mental illness		Clinically significant symptom	
		aOR	CI	aOR	CI
Age at child's arrival (years)	Under 30	1	–	1	–
	30–34	0.68	1.00–2.10	1.05	0.67–1.35
	35–39	1.07	1.21–2.00	1.57	1.20–1.86
	40–44	1.06	1.10–2.03	1.37	0.95–1.65
	45–49	1.06	0.98–2.16	1.34	0.85–1.75
	50–59	1.08	1.09–2.33	1.40	0.95–2.03
Region of birth ^a	60 and over	1.04	0.89–2.86	1.00	0.51–1.78
	France	1	–	1	–
	Europe	0.99	0.54–1.65	0.93	0.56–1.52
	Africa	0.45	0.24–0.83	0.96	0.59–1.58
	Other	1.34	0.70–2.88	1.64	0.82–3.17
French nationality status ^a	French by birth	1	–	1	–
	Naturalised French	1.07	0.60–1.84	1.38	0.83–2.26
	Foreign national	0.82	0.44–1.60	1.20	0.73–2.09
	Baccalaureate + 4 or more years (16+ years)	1	–	1	–
Level of education ^a	Baccalaureate + 2–3 years (14–15 years)	0.98	0.80–1.27	1.06	0.86–1.31
	Baccalaureate or equivalent diploma (12–13 years)	1.15	0.89–1.53	0.94	0.75–1.27
	Primary, professional/ vocational certificate (9–11 years)	1.05	0.78–1.43	1.07	0.81–1.43
	No diploma (<8 years)	1.19	0.57–2.26	1.47	0.70–2.95
	Married/civil partnership	1	–	1	–
Marital status	Unmarried (never married)	1.20	0.92–1.55	1.10	0.82–1.34
	Divorced/ separated	0.89	0.67–1.82	1.08	0.66–1.75
Living with partner	Yes	1	–	1	–
	No	1.84	1.08–2.63	1.73	1.19–2.91
Close relationship satisfaction ^b	Satisfied	1	–	1	–
	Unsatisfied	1.17	0.77–1.35	1.08	0.92–1.56
Living with a child	Yes	1	–	1	–
	No	0.91	0.66–1.71	1.01	0.56–1.36
Employment status	Employed	1	–	1	–
	Training/ education/other	1.12	0.67–1.66	1.29	0.82–1.83
	Retired	1.11	0.57–1.82	1.17	0.55–2.02
	Unemployed	1.97	1.42–2.77	1.85	1.30–2.57
Spouse employment status	Employed	1	–	1	–
	Training/ education/other	1.29	0.82–1.92	0.90	0.63–1.45
	Retired	1.02	0.64–1.71	1.27	0.92–2.74
	Unemployed	1.07	0.84–1.43	1.13	0.88–1.44
Financial difficulties ^c	No	1	–	1	–
	Yes	1.10	0.83–1.42	1.23	0.93–1.51
Foregone healthcare due to financial reasons ^c	No	1	–	1	–
	Yes	1.47	1.04–1.83	1.29	1.02–1.75
Adverse childhood experiences (ACEs)	None	1	–	1	–
	Yes, at least one	1.57	1.25–1.91	1.43	1.10–1.61
Parent history of psychiatric illness ^a	No	1	–	1	–
	Yes	1.50	0.78–2.53	1.44	0.79–2.60

Table 2 (continued)

		Self-declared mental illness		Clinically significant symptom	
		aOR	CI	aOR	CI
Parent history of suicide ^a	No	1	–	1	–
	Yes	1.39	0.59–3.56	0.80	0.30–2.04

^a Information recorded at inclusion.

^b Romantic partner and/or friends and family.

^c Over the past 12 months aOR: adjusted odds ratio; CI: 95 % confidence intervals.

trajectories showing a temporary increase in symptomology during the transition to fatherhood. Key factors associated with these changes over time were being unemployed, not living with one's partner, adverse childhood experiences, and having forgone healthcare due to financial reasons.

4.1. Prevalence and trajectories of mental illness amongst new fathers

Rates of anxiety amongst new fathers were consistently higher than that of depression. In agreement with this, research shows the prenatal period to be a particularly anxious period for first-time fathers, with Wöckel et al. (2007) finding 80 % of expectant fathers to be fearful about the upcoming birth. Condon et al. (2001) also found young men to hold more idealised views of pregnancy and parenthood than young women. Whilst depression and anxiety are frequently comorbid (Philpott et al., 2022), this finding is important as the majority of literature on paternal mental illness focuses on depression. Greater inclusion of anxiety-related symptoms should be encouraged during perinatal assessments in men. It has also been theorised that the low rates of depression seen amongst male populations are partly due to current assessment tools lacking certain indicators more common to men (Shi et al., 2021; Branney and White, 2008). Gender-sensitive screening methods, such as (Kondou et al., 2021; Gemayel et al., 2021), may permit more accurate rates of diagnosis amongst fathers, thus better enabling appropriate support. Alternatively, a more encompassing “Perinatal Mood Disorder” has been proposed as a response to the highly heterogeneous prevalence of depressive and anxious disorders amongst fathers, as well as the consistently strong association between the two (Fletcher et al., 2006; Chen et al., 2019; O'Brien et al., 2017). In support of this, research shows that fathers may benefit from therapies targeting both anxious and depressive disorders mutually (O'Brien et al., 2017). Replacing the current focus on paternal depression with a more general target of paternal emotional distress may target a wider range of fathers in need of support.

For self-declared mental illness, the majority of fathers (90.3 %) showed consistent low risk. This aligns with previous trajectory studies, which find stable low or moderate trajectories to be the most frequent majority group. The one study to look across a seven-year timeline saw paternal mental illness to progressively decrease from birth, but only depression was considered, and data collected at 2-year intervals (Nath et al., 2016). 5.6 % of participants demonstrated a dramatic, temporary increase in self-declared mental illness from two years pre-fatherhood. Interestingly, as seen with the clinically significant symptom scores, the risk of mental illness returned progressively towards overall baseline value two years following the child's arrival. A potential explanation for this is that compulsory education in France begins at age three, which ~98 % of children attend (Insee (The National Institute of Statistics and Economic Studies / L'Institut national de la statistique et des études économiques), 2023). The initial reorganisation required in the run up to the child's arrival is often particularly demanding for first-time fathers and can result in dramatic changes to their quality of life. With the child in school, certain elements of daily life may return to a more ‘normal’ pre-fatherhood state.

Table 3

Associations between relevant risk factors and identified trajectories of self-declared mental illness and continuous symptom scores (CES-D/GHQ-12 scales), during the nine years surrounding the transition to fatherhood (four years prior to the arrival of participants' first child, until four years post). *Group-based trajectory modelling, Constances cohort.*

		Self-declared mental illness (n = 6156)				Symptom scores (n = 5573)	
		Trajectory control:		Trajectory test group:			
		"Consistent low risk"		"Low risk with high temporary increase"		"Consistent high risk"	
		aOR	CI	aOR	CI	aOR	CI
Age at child's birth (years)	30–34	reference		reference		reference	
	Under 30	2.01	0.96–3.93	0.80	0.19–2.39	0.78	0.44–1.30
	35–39	1.61	1.02–2.57	1.42	0.78–2.62	1.22	0.90–1.64
	40–44	1.02	0.53–1.90	2.48	1.29–4.72	1.11	0.76–1.61
	45–49	1.37	0.63–2.75	1.07	0.34–2.78	1.06	0.65–1.70
	50–59	1.31	0.64–2.57	1.08	0.38–2.67	1.20	0.76–1.86
Region of birth	60 and over	1.12	0.38–2.99	4.79	1.79–12.07	1.90	0.99–3.62
	France	reference		reference		reference	
	Europe	0.82	0.30–1.89	0.55	0.13–1.59	1.06	0.55–1.97
	Africa	0.54	0.13–1.52	1.24	0.45–2.86	1.21	0.67–2.11
	Other	0.80	0.18–2.44	–	–	0.57	0.19–1.51
Living with partner	Yes	reference		reference		reference	
	No	1.69	0.83–3.24	2.59	1.25–5.07	2.41	1.48–3.93
Employment status	Employed	reference		reference		reference	
	Training/education/other	1.34	0.48–4.01	0.57	0.22–1.55	0.98	0.50–1.90
	Retired	1.39	0.56–2.96	0.72	0.17–2.07	1.41	0.80–2.43
	Unemployed	3.01	1.63–5.32	2.62	1.22–5.23	1.55	0.96–2.46
Foregone healthcare due to financial reasons	No	reference		reference		reference	
	Yes	1.75	1.02–2.87	1.82	0.95–3.28	2.30	1.57–3.35
Adverse childhood experiences (ACEs)	No	reference		reference		reference	
	Yes	2.26	1.49–3.55	1.46	0.93–2.38	1.47	1.16–1.88
Arrival of subsequent children	No	reference		reference		reference	
	Yes	0.83	0.48–1.35	1.85	1.08–3.06	0.77	0.56–1.03

However, within our study, participants' symptom trajectories may provide an arguably more accurate reflection of fathers' mental health at each time-point, as they are exempt from certain potential logistical barriers, such as the waiting times and financial constraints to receiving a diagnosis. All symptom trajectories showed fathers experience deteriorating mental health in the run up to their first child's arrival. One potential explanation for this increase in negative symptoms is self-discrepancy theory (Higgins, 1987; Shorey and Chan, 2020). This describes the feeling of misalignment of fathers' expected self (the 'ideal' father) with their actual behaviour, due to the unrealistic expectations created pre-fatherhood, thereby resulting in a progressive feeling of disappointment and low self-worth. In support of this, research from Australia and Sweden found overly optimistic ideals for parenthood amongst young, childless men, with expectations including stable partner relationships and financial security (Thompson and Lee, 2011; Lampic et al., 2006). The increase in negative symptoms could also stem from a genuine lack of preparedness. Research has shown that "feeling prepared at birth" significantly associates with less state anxiety amongst first-time fathers (Daire et al., 2022). All paternal symptom trajectories started improving from two-years onwards. It may be that, with time, fathers begin to progressively feel more comfortable and secure in their capacity as a parent.

4.2. Associated risk factors

Fathers' age was a recurring relevant factor, with those aged over 60 showing an over four-times greater likelihood of having a consistent high-risk trajectory for self-declared mental illness. Within the French general population, the opposite is seen; the prevalence of both depression (Anon, 2020) and anxiety disorders (Leray et al., 2011) appear to, generally, decrease with age. Thus, our result may be specific to first-time parents. However, several studies on fathers also found increased rates of depression amongst younger fathers (Giallo et al., 2012; Nath et al., 2016; Bergström, 2013). Within these studies, young fatherhood associates with low socioeconomic status. The disparity

between their results and our study may thus be explained by our sample's demographics, as socioeconomic indicators such as participants' average income and education level were relatively high. Our findings might also be explained by the means of reproduction. Within our questionnaire, the means of the child's arrival was not specified. Fathers using alternative methods, such as surrogacy or assisted reproduction, are likely to be older at the time of their child's arrival (Halifax and Villeneuve-Gokalp, 2005). Parents who undergo the process of assisted reproduction are often at greater risk of mental illness (Courbiere et al., 2020). Another possibility is that psychiatric illness amongst fathers increases the chance of delayed parenthood. The elevated risk of psychiatric disorders amongst children exposed to paternal mental illness is significantly higher in children of older fathers (Filatova et al., 2021). When taken into consideration together with the current trend of increasing parental age in industrialised countries, this highlights the importance in further investigating this increased vulnerability amongst older fathers (Sobotka, 2010).

The relevance of not living with one's partner, particularly in such close proximity to their first child's arrival, is also a particularly important finding, as the current literature lacks investigation on non-resident fathers (Baldwin et al., 2018). Whilst this finding may result from reverse causality, in that fathers may live apart from their child due to their psychological problems, our results could indicate that non-resident fathers are indeed more susceptible to mental illness. Unsatisfactory mother-father relationships have been highlighted as a risk factor for paternal mental health problems, with French data showing that couples in which both parents are depressed postpartum were more likely to report insufficient partner support than non-depressed couples (28 % vs. 7 %) (Nakamura et al., 2020). And indeed, rates of paternal depression vary significantly based on family structure, with single, separated or divorced fathers at a higher risk for depression than those in a romantic relationship with their child's mother (Baldwin et al., 2019; Matthey et al., 2000). This may be partly explained by fathers' support networks. It has been shown that fathers perceive informal support to be a primary source of support during parenthood (Lähteenmäki et al.,

2019), with one French study finding that informal (couple) support decreased the odds of joint parental postpartum depression more so than that offered by midwives or healthcare professionals (Nakamura et al., 2020). However, it is important to acknowledge that a harmonious relationship between co-parents is not always possible. Increasing extra-familial support for fathers may partially offset this pressure placed on the surrounding family for care.

The presence of adverse childhood experiences also associated with trajectories showing higher symptom scores and a temporary increase in self-declared mental illness. This aligns with numerous studies on adult mental health (Hughes et al., 2017; Daniëlsdóttir et al., 2024; Nelson et al., 2017; Li et al., 2016). Maltreatment during childhood has been found to associate with subsequent parenting stress (Granner et al., 2023), which in turn increases the likelihood of maltreating one's child (Rodriguez and Richardson, 2007). This association may thus potentially contribute to cycles of intergenerational trauma, highlighting the possibility of paternal mental health as a protective factor. Finally, having forgone healthcare in the past year due to financial difficulties associated with both increased risk of self-declared mental illness and clinically significant symptom trajectories. Financial factors, such as unemployment, household income, and access to paid paternity leave, are already consistent risk factors for depression amongst fathers (Bradley and Slade, 2011; Pedersen et al., 2021; Nath et al., 2016; Bronte-Tinkew et al., 2007). Moreover, fathers with, or at-risk of, postpartum depression have significantly higher healthcare costs when controlling for potential confounders (Edoka et al., 2011). Yet unemployed fathers, and those from lower socioeconomic groups, are under-represented in perinatal research (Baldwin et al., 2019). Within this study, unemployment was also seen to increase the likelihood of self-declared mental illness trajectories. Whilst this finding is likely to partially result from reverse causality, in that fathers' with diagnosed mental illness may be more likely to take time off work or be excluded from the job market, this factor will only accentuate financial barriers to healthcare access. Letablier et al. (2009) describe numerous policy-based approaches that would better enhance the equitable wellbeing of families. As access to healthcare appears to have a protective effect on fathers' mental health, greater accessibility is needed.

4.3. Implications for research and practice

The rates of self-declared mental illness, when compared to clinically significant symptom scores, suggest a considerable level of under-diagnosis amongst new fathers (9.7 % self-declared vs 25.2 % symptomatic). Whilst this investigation did not extend to mothers, and thus the same phenomenon may be present for both parents, men are often more reluctant than women to seek professional help (Johansson et al., 2020; Seidler et al., 2016). Fathers are also less likely to register depression symptomology as poor mental health when compared to mothers (Johansson et al., 2020). This may be rooted in a lack of awareness; fathers are often uninformed of the signs of perinatal mental illness, expressing in interviews that they had not heard of postpartum depression before becoming a parent or receiving a diagnosis themselves (Armstrong et al., 2009). Qualitative research shows a clear desire amongst fathers for increased information about perinatal mental illness, such as descriptions of the signs and triggers (Baldwin et al., 2019). Increases to the duration and accessibility of paid paternity leave may also increase the uptake of mental health services amongst fathers postnatally. At the time of this study, fathers in France were entitled to two weeks paid paternity leave, matching the average of OECD countries offering paternity leave (The Bipartisan Policy Center, 2023). Thus, when employed, fathers' work obligations, alongside parental responsibilities, often leave them with little time for themselves (Baldwin et al., 2019). Such obligations are also likely to reduce the opportunities in which fathers can be screened for mental illness during this period, alongside hindering the time available for help-seeking behaviours or external support (Pedersen et al., 2021).

We also saw increases in all measures of mental illness in the run up to fatherhood. If stemming from a lack of preparedness, increasing the support and educational tools available to first-time fathers in the run up to their child's arrival could thus better prevent the onset of initial anxiety. Little research has been done on prenatal care and interventions for fathers, however several studies have shown beneficial effects of parenthood preparation sessions (Matthey et al., 2004), prenatal classes (Wöckel et al., 2007; Li et al., 2009) and male discussion forums (Friedewald et al., 2005) on fathers' postnatal adjustment. Studies on first-time fathers reveal a desire to be more involved during their partners pregnancy (Smyth et al., 2015), indicating that prenatal interventions may be well received. Interestingly, one study consisting solely of African American participants saw perinatal coparenting programs to have no effect on fathers' depression or anxiety at 6-months postpartum (Feinberg and Kan, 2008). Research on such interventions should make a concerted effort to include a wider demographic range, as Black and minority ethnic groups, when compared with White, have been highlighted as less likely to be offered antenatal education classes, as well as male partners being less likely to attend (Redshaw et al., 2007).

4.4. Strengths and limitations

The Constances cohort is currently the biggest general population cohort in France, thereby enabling us to study a large number of participants. In using this cohort, we managed to include fathers who were not necessarily in a relationship with the child's mother, and/or living with their child. This is particularly valuable, as non-resident or single fathers are commonly excluded from research. In including this population, we were able to identify the significance of these factors, thus highlighting the increased vulnerability of non-resident fathers to mental illness. The comprehensive range of variables from Constances also allowed our analyses to account for a wide and detailed range of personal, lifestyle, and occupational factors. Through this, we were also able to employ two different approaches to mental health screening (self-declared mental illness and continuous symptom scores). Self-report symptom scales are often argued to provide a more accurate representation of mental illness prevalence, due to lack of bias from under-diagnosis and under-reporting (Public Health England, 2020). However, the use of self-declared mental illness allowed us to see a clear gap in the rates of probable diagnoses compared to actual symptomology.

Arguably this study's largest limitation is the combined use of the CES-D and GHQ-12 in longitudinal modelling. Due to the nature of this cohort, the measure of mental health varied over time. Whilst studies show strong correlation between the two measures (Chin et al., 2015), including amongst fathers (Yin et al., 2018; Kondou et al., 2021; Gemayel et al., 2021), they intend to measure varying degrees of mental illness (Yin et al., 2018; Baumann et al., 2008). To counteract this, scores were standardised and both scales kept as continuous in trajectory modelling, to prevent incompatibility due to binary scoring. In addition, all our analyses were also conducted on participants' self-declared prevalence of mental illness, which was tested using the same question at every included time-point. Due to low respective prevalence rates, we were unable to conduct trajectory analyses on distinct mental health diagnoses (depression/anxiety/other). In relying on self-administered questionnaires, we also risk selection bias due to the voluntary participation of cohort members. Thus, this study has most likely underrepresented hard-to-reach subjects e.g. undocumented migrants. Finally, we did not have access to fathers' partners, thus could not control for maternal factors. Current available evidence reveals maternal/partner mental illness to be one of the most frequently cited risk factors for paternal depression, both pre- and post-partum (Philpott et al., 2019; Demontigny et al., 2013). However, within our study, both relationship status and satisfaction were included covariates. As maternal mental illness has been seen to correlate strongly with risk factors such as partner conflict and decreased intimacy (Paulson and

Bazemore, 2010), these may have thus acted as a partial proxy for mothers' mental health.

5. Conclusion

We conducted a nine-year analysis of fathers' mental health in the years surrounding their first child's arrival. Whilst the majority of fathers showed a consistently low risk of self-declared mental illness, roughly 10 % showed an either temporary or consistent high risk. Moreover, all participants showed an increase in symptom scores indicative of mental illness during the run up to fatherhood, starting two-years prior to their child's arrival. Risk factors seemed to be shared between trajectory groups, with financial factors shown to be particularly significant, as well as living alone, being older in age, and having had adverse childhood experiences. Our results indicate a potential under-diagnosis of mental illness amongst men, which has been highlighted by numerous studies. Paternal anxiety was consistently more prevalent than depression, arguing for an increased focus on anxiety related symptoms and associated disorders amongst fathers. Increased awareness of the relevance of mental health care, both formal and informal, starting prior to the transition to fatherhood is necessary. Here we provide evidence for a clear period of vulnerability which could help mental healthcare providers better target fathers in need for support.

Author statement

Legal

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All procedures were approved by the Institutional Review Board of the French Institute of Health (INSERM) (Opinion n°01-011, then n°21-842), and authorized by the French Data Protection Authority ("Commission Nationale de l'Informatique et des Libertés", CNIL) (Authorization #910486). All information and regulatory authorizations relating to the publication are available on the French version page 'Rights and data protection'. The Constances Cohort study has also been approved by the French Data Protection Authority ("Commission Nationale de l'Informatique et des Libertés", CNIL). Written informed consent was obtained from all participants.

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CRediT authorship contribution statement

Honor Scarlett: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Emmanuel Wiernik:** Writing – review & editing, Validation, Project administration, Data curation. **Judith van der Waerden:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Conceptualization.

Declaration of competing interest

No conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jad.2024.07.008>.

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Chapter 4: The impact of paternal mental illness on child development: an umbrella review of systematic reviews and meta-analyses.

This chapter provides an overview of the literature prior to analysis (December 2021) on the relationship between paternal mental illness and child development, through a review of reviews - hereto referred to as an umbrella review. Ten reviews were ultimately included, which focused primarily on paternal mood disorders and child socioemotional development. This review was published in *European Child & Adolescent Psychiatry*.

Article summary

4.1 Context

The literature on the relationship between paternal mental illness (PMI) and child development, whilst rapidly growing within recent years, is sparse and frequently contradictory. Often only included as an adjunct to investigations on maternal mental illness (71,153), numerous studies cite no significant relationship between PMI and offspring development (17,103,293,511), whilst others show a relationship as strong as that between children and mothers' mental health (54,351). The relationship between PMI and child development also appears to vary based on numerous factors, such as child developmental domain and child sex, however findings are often contradictory (32,39,52,53). Improving our understanding of the relevance of these factors will not only help elucidate the mechanisms underlying the relationship between PMI and child development, but may also help better target support and risk prevention. A method to combat inconsistencies in the literature is to compile all existing evidence, taking into account to quality of the investigations themselves. An umbrella review takes findings from multiple existing reviews and is one of the highest levels of evidence possible (480).

This article aims firstly to systematically investigate the information known on the relationship between paternal mental illness and child development, across all paternal diagnoses, measures of child development, and developmental periods. In critically reviewing the previous directions of the global literature, we also aim to provide a thorough assessment of the current representation of particular determinants or possible moderating factors in relation to this research question, thereby indicating potential priorities for future research.

4.2 Methodology

4.2.1 Umbrella reviews

Systematic reviews and meta-analyses are increasing in quantity, possibly due to an increased likelihood of publication and citation (123), with roughly 80 systematic reviews (SRs) published per day in 2019 (124). The same 2019 study (124) saw a more than 20-fold increase in the number of published SRs over the last 20 years, compared to just a 2.6-fold increase in all PubMed articles. Introduced in 2009, the PRISMA guidelines appear to have improved the transparency and accuracy of meta-analyses (478).

However, it is not uncommon that SRs on the same research question present contradictory results (480). A form of literature synthesis that analyses SRs themselves, thus partially addressing these issues, are ‘umbrella reviews’. An umbrella review is a review of reviews that takes into account the quality of the investigations themselves. In doing this, contradictions amongst SRs may be better understood (481).

4.2.2 Search strategy and inclusion criteria

The protocol for this review was preregistered on PROSPERO (CRD42022298048) and conducted in accordance with the PRISMA 2020 item checklist. PubMed, Web of Science, PsycINFO, MEDLINE and EMBASE databases were searched for all systematic reviews and meta-analyses of observational studies reviewing the effect of PMI on child development (CD). The format for each search varied based on the database, and all Population, Intervention, Comparator, Outcome (PICO) tables used are available in the Supplementary Material of Chapter Four. Searches were conducted for studies published between 1980 and December 2021. We included systematic reviews and meta-analyses that assessed the impact of common PMI diagnoses, excluding addiction due to potential pharmacological interference (512), 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. Studies that remained included after full text screen had relevant data coded and extracted independently by two reviewers with subsequent consensus achieved via discussion and collaboration with the third reviewer.

4.2.3 Quality assessment and GRADE

To assess the quality of the included reviews, the Assessment of Multiple Systematic Reviews 2 (AMSTAR-2) checklist was used (69), completed simultaneously, independently and blindly by two reviewers. Comprised of 16 items, as opposed to 11 in its predecessor version, it is not intended to generate an overall score; The results are instead considered based on the respective impact of each individual item. Risk of bias and certainty of evidence were further examined using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria (70), again conducted independently and blindly 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. Each article’s quality of evidence ranked either “high”, “moderate”, “low” or “very low”, where “very low” indicates the estimate of the effect is very uncertain and “high” indicates effect estimates for which further research is unlikely to change the confidence rating.

4.2.4. Data analysis

Results were first summarised in accordance with the Joanna Briggs’ (487) and Cochrane (476) guidances for narrative syntheses. To assess potential over-lap between reviews, the corrected covered area (CCA) was calculated and ranked (122). All reported exposure–outcome effect sizes were converted to odds

ratios, and within study heterogeneity converted to the I^2 statistic (508). Meta-analytic results were grouped using random effects models, based on the heterogeneity of respective study effects. Subgroup analyses were conducted based on child developmental domain (internalising vs externalising behaviours), and each review's GRADE quality score. As opposed to a fixed-effect model, which assumes that there is one true, common effect size and that variation in observed effects is due to sampling error, a random-effects model allows the possibility that the effect size varies from study to study (513). Due to our inclusion of a range of paternal exposures (e.g., depression, general psychopathology, internalising symptoms) and child outcomes (e.g., negative affectivity, anxiety, behavioural or oppositional defiant disorder), it is plausible that respective means are likely to differ. However, whilst accommodating for independent estimates, effect sizes are still assumed to be related and interdependent (513). Considering the continuous interaction and often synchronous development of child developmental domains [section 1.2.1], as well as the considerable overlap between the paternal exposures included, it is highly likely this assumption was also fulfilled. Through conducting grouped meta-analyses, we were able to see that the impact of paternal mental illness on child development did not seem to vary based on internalising or externalising behaviours, despite narrative findings suggesting otherwise. This highlights the benefit of this statistical approach.

4.3 Results

4.3.1. General findings

Ten reviews were included in the final analyses (44,51,54,71-77), eight of which found a significant association between PMI and child development. The two reviews showing no apparent association were both unique in their chosen child outcome: One investigated children's suicide-related thoughts or attempts (74) and the other (75) autism spectrum disorder. Amongst those with significant findings, across all reviews, symptoms of paternal mental illness appeared to exert a significant, negative effect on child development. Associations were seen between PMI and children's internalising and externalising behaviours, negative affect, emotional and behavioural problems, mental health and language development. Grouped meta-analyses, comprising six studies and 10 effect sizes in total, found the overall effect of PMI on CD to be significant (OR: 1.54; 95% CI: [1.36-1.74]). The total number of included fathers was 358,546, and total heterogeneity was high ($I^2 = 93\%$). Between review over-lap, measuring using the corrected covered area (CCA), was slight (3.6%) (122).

Some variation was seen based on child developmental outcome, with three reviews (51,54,71) finding that PMI associated more strongly to children's internalising problems than externalising. However, grouped meta-analyses based on child developmental output (internalising versus externalising behaviours) saw 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. Regarding temporality, two reviews saw PMI occurring prenatally exerted a weaker effect on CD than postnatal (44,73), with chronic or persistent PMI also increasing the likelihood of adverse child outcomes. Associations to certain child outcomes (emotional and behavioural problems, negative affectivity) were already evident in infancy (44,44), and extended until 21 years (51,72,73). Results stratified for child age were inconsistent between reviews. However, most commonly, the association between stronger with younger aged children (51,73,76).

Two reviews saw low socioeconomic status (SES) and an absence of social support (including partner support) significantly increased adverse child outcomes in response to PMI (73,76), and one review (54) saw SES had no significant influence. However, amongst these reviews, the measures of SES were unclear and there was no description of how it was categorised. One (71) found that studies published more recently had smaller effect sizes, however all included studies were published prior to 2001.

4.3.2 Quality assessment

All reviews demonstrated low or critically low methodological confidence. Neither meta-analyses nor non-meta-analytic reviews fulfilled all possible AMSTAR-2 critical domains. 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%). Sensitivity analyses based on GRADE scores found that better quality reviews showed 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]).

4.3 Conclusion

Across reviews, symptoms of paternal mental illness (PMI) had a significant, negative association with father's child's development (CD). Investigation was primarily limited to socioemotional and behavioural development, with the only non-significant results seen for the one review on neurodivergence (autism spectrum disorder). The relationship between PMI and CD was seen from infancy to late adolescence, with somewhat larger effect sizes seen amongst younger aged children, and was not seen to depend on child sex or gender. Overall, the quality of reviews was poor and sub-group analyses were limited by a lack of data. Future research on this topic should aim to expand investigations into a wider range of child developmental domains, such as cognition, and paternal diagnoses. The factors moderating this relationship remain unclear and understudied, particularly in relation to longitudinal trajectories.



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

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Abstract

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 of the impact of PMI on child development is overdue. This study aimed to combine and synthesise currently available evidence on the relationship between PMI and multiple domains of child development. 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 was 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. 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. These 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.

Keywords Child · Development · Father · Paternal · Mental illness · Umbrella review

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 5 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 from 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,

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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 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; measure(s) 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

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 the 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.

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 (Fig. 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 to 273,299. Included child age ranges were unspecified in two reviews [42, 43], and amongst all others ranged from 0 to 21 years, although the

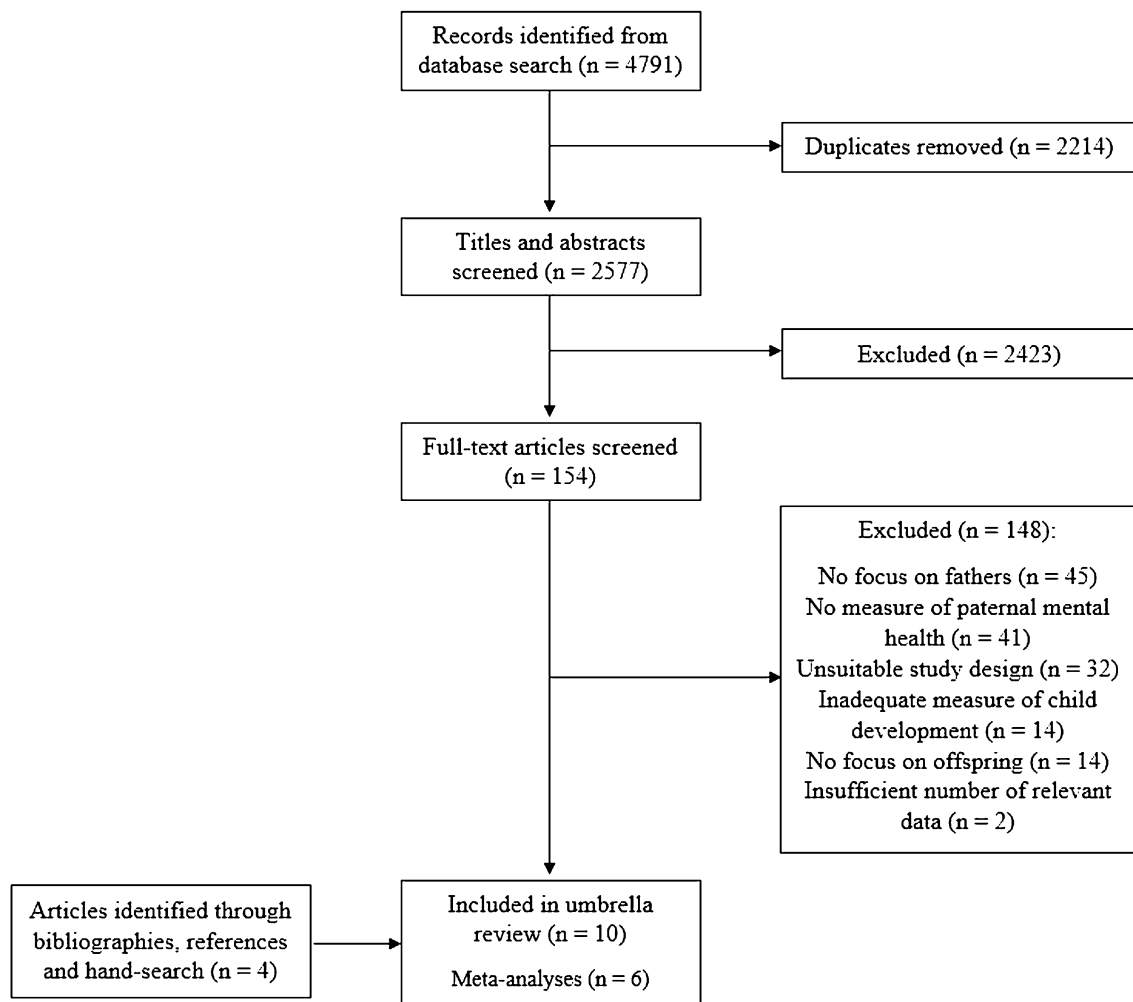


Fig. 1 PRISMA diagram of the study selection process

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 to 100% and another [20] stratified their results by gender.

Predictors

The timing and chronicity of PMI diagnoses 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 were 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 was associated more strongly with 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 in younger aged children. However, for Stein et al. this depended on the period PMI emerged (post-natal 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 the 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 Fig. 2, comprising 10 effect sizes. The funnel plot (Supplementary Fig. 1) was symmetrical, indicating a 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% to 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) (Fig. 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 Fig. 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 heterogenous, 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 fathers experienced

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
Total number of critical weaknesses	2	3	5	4	1	4	1	5	1	1
Total number of non-critical weaknesses	3	6	7	5	3	5	2	4	4	3

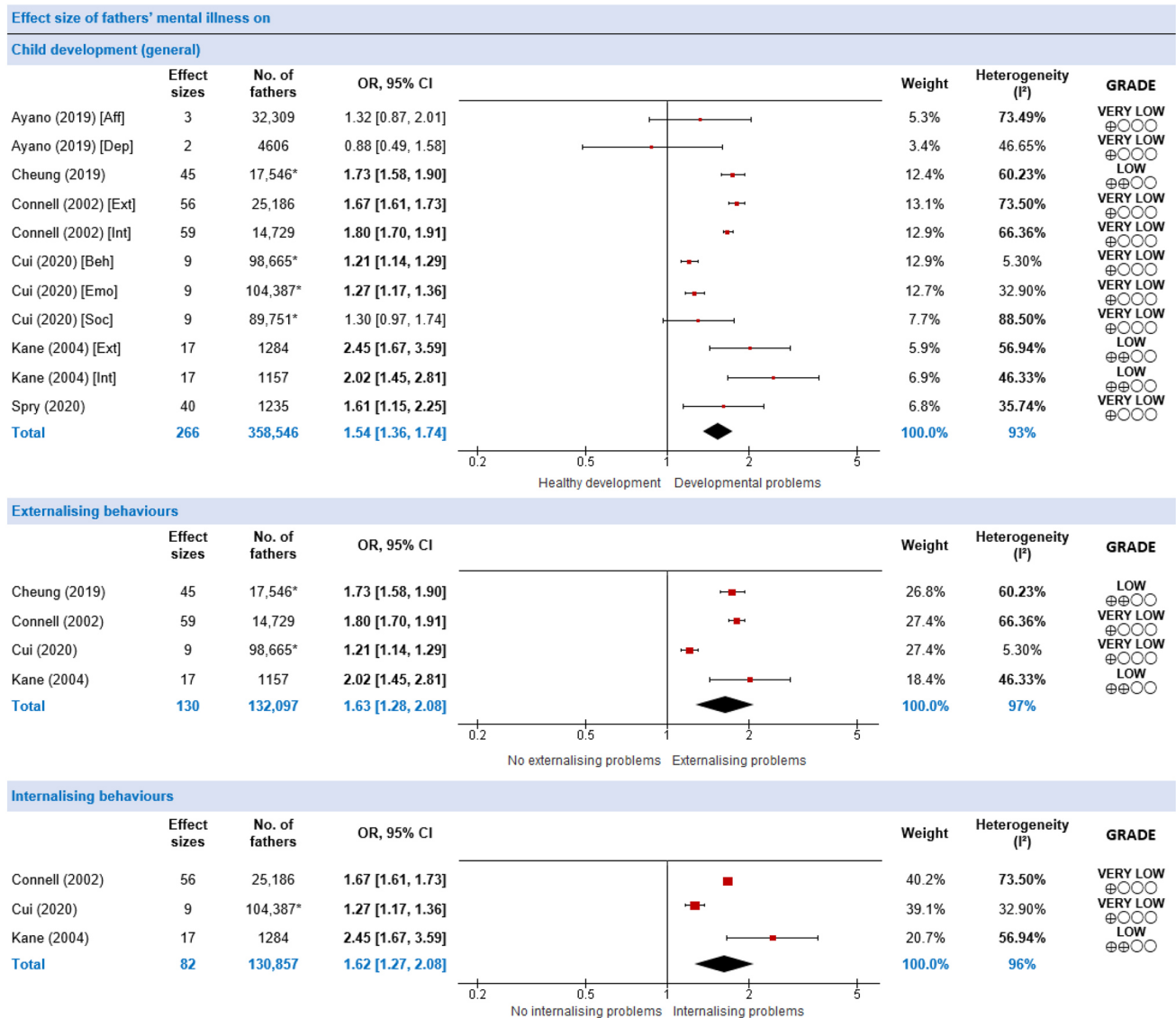


Fig. 2 Individual and grouped meta-analyses on the effect of paternal mental illness on child development (Randomised Effect, 95% Confidence Interval). *Calculated estimate, actual value unspecified by authors

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 postnatal 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 an 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 [61–63], 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, the results were contradictory. Whilst Cheung and Theule [26] did not see child age to be a 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 5 years postpartum. 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 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 to 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 of CD between both diagnoses. Nevertheless, amongst narrative reviews, results were mixed. Wickersham [12] found an association between 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, the 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 certain PMI diagnoses (ASPD, schizophrenia, bipolar disorder) due to each having under five studies. These reviews highlight the need for empirical investigation of 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 an 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 of 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-analysed 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 postpartum) 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 [80, 81]. Recent developments in legislative procedures, such as global increases in fathers' rights to paternity leave [82], and physical custody [83], 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 [84], 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, the 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 the child gender. Regarding child age, results were highly heterogenous, 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.

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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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Data availability Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Conflict of 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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Chapter 5: Paternal perinatal mental health and early child development: an outcome-wide analysis.

This chapter provides an investigation on the relationship between pre and postnatal paternal mental illness and child development between 2-3 years of age. Mothers' mental health, child sex, and parental socioeconomic status were also tested as potential moderators for this relationship. This article has been submit for peer-review.

Article summary

5.1 Context

The Developmental Origins of Health and Disease (DOHaD) concept states that the risk of chronic health disorders in childhood and adulthood, as well as possibly in the following generation(s), may be increased by environmental stressors during early development. In particular, the first 1000 days have been highlighted as one of the most important developmental windows of a child's life (55,250,514), although direct causal evidence to support this is sparse (252). Paternal wellbeing is particularly key during this period. Here we sought to investigate the relationship between early child development and paternal pre and postnatal mental illness.

This study aimed to investigate the relationship between paternal mental illness (PMI) and child development at 2-3 years in an outcome-wide analysis, encompassing socioemotional, cognitive, and behavioural domains. Both paternal depression and anxiety were included and examined respectively, as well as three potential timings of PMI exposure. In addition, we aimed to test the potential moderation of this relationship based on mothers' mental health, child sex, and parental socioeconomic position.

5.2 Methodology

5.2.1. Population and study design

This study relied on the French couple-child SEPAGES cohort, which recruited pregnant women from eight ultrasonography practices across the Grenoble metropolitan region from 2014 to 2017 (58). All fathers aged over 18 and with social security were offered to participate in the cohort, resulting in 410 eligible fathers who agreed to participate. Every year from inclusion, questionnaires, interviews and clinical examinations were used to collect information on children and their parents, both during and after pregnancy (371). This investigation focused on all 301 father-child dyads for which paternal mental health data was available within the study period.

5.2.2. Measures

Data on fathers' mental health was grouped into three timepoints: their partners pregnancy (mean response period 7.8 +/-5.6 weeks before birth; n = 166); 0 and 12 months postpartum (4.3 +/-3.7 months; n = 117) and 12-24 months postpartum (16.9 +/-3.4 months; n = 207). At all timepoints, mental health was

measured using the Hospital Anxiety and Depression Scale (HADS). The HADS is a 14-question, self-report assessment of anxiety and depression. Responses can be summed into two sub-scores for the discrete depression and anxiety scales (7 items each), with higher scores indicating higher symptomology. For reporting the prevalence, cut-off scores of ≥ 8 for depression or anxiety were used (382). For all other analyses, scores were treated as continuous.

Child outcomes were examined at both two and three years, via clinical assessments performed by trained SEPAGES fieldworkers and neuropsychologists, as well as validated questionnaires completed by the parents. At two years, the child behaviour checklist (CBCL/1.5-5) was used. At three years, several measures were available: The Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P); The social responsiveness scale (SRS); and the Wechsler Primary and Preschool Scales of Intelligence (WPPSI). For each of the indicated child developmental measures, missing data was handled according to instrument-specific recommended guidelines (81,390,394,406).

Sociodemographic, physical health and lifestyle factors, as well as exposures during pregnancy were identified within the literature and considered for inclusion as potential confounding factors. In addition, the following variables were taken as potential moderators: 1) Child sex assigned at birth (male/female) 2) Mothers' mental health at both pregnancy and 1-year postpartum (HADS score, kept as continuous) 3) Both mother and father's respective professional skill class, based on the International Standard Classification of Occupations (ISCO) categories (84) grouped into four skill groups: 1) Skill level 1: Elementary occupations; 2) Skill level 2: Clerical support workers, service and sales workers, agricultural, forestry and fishery workers, craft and related trade workers, plant and machine operators and assemblers; 3) Skill levels 3-4: Managers, professionals, technicians and associate professionals; and 4) "armed forces": All armed forces occupations.

5.2.3. Data analysis

In an outcome-wide analytic framework (78), linear regression models were used to test the relationship between PMI and child outcomes. Both depression and anxiety were taken respectively. To counteract collider stratification bias, all models were adjusted using the same common set of confounders (445). Any variable significantly (5%) associated with at least one exposure or outcome was taken as a confounder. However, in line with an outcome wide analytic approach, each model's confounding variables had to occur before both the exposure and outcome. Thus, all confounders occurring after birth were included only in models using postnatal PMI. Overall, 4.7% of data was missing across confounding variables, which was subsequently imputed using MICE (425).

Moderation analyses were conducted taking mothers' mental health, child sex and parents' professional class as potential moderators. For models using prenatal PMI, maternal HADS scores during pregnancy were used. For all postnatal PMI models, maternal HADS scores from 1-year postpartum were used. Interactions were considered significant at $p < 0.05$ following adjustment using a Hochberg correction.

5.3. Results

Analyses revealed no apparent association between neither fathers' depression nor anxiety with any studied measure of child development, both before and after adjusting for confounding factors. This was seen for all three PMI timepoints (prenatal; 0-12 months; 12-24 months).

Following correction for multiple testing, neither child sex nor fathers' professional class significantly moderated the relationship between PMI and child development for any outcome, for all three PMI timings.

However, mothers' professional class was seen to moderate the influence of PMI for four associations following correction for multiple outcomes. For prenatal paternal anxiety, moderation by mothers' professional class was seen for the CBCL attention problems ($\beta=0.37$; $SE=0.13$; $p_{Adj}<0.05$), the BRIEF-P working memory ($\beta=0.13$; $SE=0.05$; $p_{Adj}<0.05$), and the SRS social cognition ($\beta=1.24$; $SE=0.38$; $p<0.05$) subscales. Mother's ISCO score also moderated the association of paternal anxiety at 12-24 months with the WPPSI verbal comprehension index ($\beta=-32.89$; $SE=10.78$; $p_{Adj}<0.05$). Higher paternal HADS scores associated with higher attention problem scores, poorer working memory and lower visuospatial scores, but greater social cognition, amongst children whose mothers had lower ISCO scores.

Maternal mental health was also seen to moderate the relationship between prenatal paternal anxiety and the BRIEF-P working memory subscale ($\beta=0.01$; $SE=0.00$; $p_{Adj}<0.01$). Children exposed to higher prenatal paternal anxiety had worse working memory outcomes (higher scores) when exposed to higher prenatal maternal HADS scores.

5.4 Conclusion

No apparent association between fathers' depression nor anxiety was seen for any studied measure of child development at two and three years, both before and after adjusting for confounding factors. No difference in effect size was seen between pre and postnatal paternal mental health, nor in relation to child sex and fathers' professional class. However, mothers' professional class significantly moderated the association between paternal anxiety and several child outcomes. These analyses are contrary to the majority of research on this topic, which most commonly found an association between paternal mental health and child development, and are likely due to the particularly high socioeconomic status of this sample. These findings highlight the importance of socioeconomic status when studying the relationship between fathers' mental health and their child's development.

Paternal perinatal mental health and early child development: an outcome-wide analysis

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Background: Paternal mental health (PMH) has been shown to associate with numerous areas of child development, as early as infancy. However, the potential moderating influence of factors such as mother's mental health, child sex and socioeconomic status remains unclear.

Methods: Using data from the French couple-child SEPAGES cohort, PMH was measured via the hospital anxiety and depression scale (HADS), during pregnancy (n=166) and postnatally between 0-12 months (n=117), and 12-24 months (n=207). Child outcomes at two and three years included the Child Behaviour Checklist (CBCL), the Wechsler Primary and Preschool Scales of Intelligence (WPPSI) and the Social Responsiveness Scale (SRS). In an outcome-wide analytic framework, linear regression models were used to test the relationship between PMH and child outcomes. Moderation analyses were conducted by considering mother's mental health, child sex and parent's professional class as potential moderators.

Results: Analyses revealed no significant associations between father's depression nor anxiety with any of the studied measures of child development, both before and after adjusting for confounding factors. Whilst no moderating influence of child sex nor paternal professional class was found, mother's mental health and professional class appeared to moderate the association between paternal anxiety and multiple areas of child development.

Conclusions: Contrary to current research, our findings show no evidence of an association between PMH and child development, likely due to the socioeconomic status of this sample, with high levels of both maternal and paternal education and employment. This study highlights the importance of families' social class when studying the relationship between paternal mental health and child development, which may explain certain variations within the literature.

Keywords: *Father, Child, Development, Mental Health, Depression, Anxiety*

Introduction

Influences during the first 1000 days of a child's life, starting from conception, to be increasingly crucial in predicting the course of subsequent development. In particular, numerous aspects of child socioemotional, cognitive and behavioural development have been seen to depend on both pre- and postnatal parental mental health (1,2). Whilst research has predominantly highlighted the importance of maternal mental health, investigation into the relationship between fathers' mental health and early child development is necessary. Global research suggests that approximately 5-10% of fathers are susceptible to depression in the perinatal period (3), with similar figures seen in France (4). Furthermore, studies show paternal perinatal anxiety to be even more prevalent, although rates vary considerably (2.4-51%) (5,6).

Accumulating evidence indicates that paternal mental health (PMH) may affect child development to an equal extent as maternal mental illness (7-9). A grouped meta-analysis saw fathers' mental health to have a significant, detrimental impact on all studied domains of child development, with a roughly 50% higher risk for adverse child developmental outcomes in children of fathers experiencing mental illness (10). However, current evidence investigating the relevance of fathers' specific mental health diagnosis in relation to their child's developmental outcomes is mixed. One study saw only paternal depression, and not paternal stress nor anxiety, to associate with child development (11), whilst a recent meta-analysis (1) reported no difference in effect size when comparing the effect of paternal anxiety or

depression on child outcomes. Considering the heterogeneity in prevalence (3-6) and risk factors (12) between paternal anxiety and depression, investigation of both disorders is necessary. The literature has also focused primarily on postnatal PMH. Fathers are also vulnerable to mental illness prenatally, with pregnancy shown to be a demanding period for fathers' psychological needs (5), thus inclusion of prenatal PMH is important.

In addition, previous research in this context has mostly focused on just one or two specific child outcomes at a time. Whilst the effect of PMH has been shown to vary based on the area of child development, with lower effect sizes seen for measures indicative of autism (13), for example, than for internalising or externalising behaviours (10), comorbidity amongst child developmental disorders remains extremely common. The isolation of child neurocognitive domains has also come under criticism, by ways of oversimplifying the dynamic and highly integrated relationships of one domain with another (14). Outcome-wide analysis, proposed by VanderWeele and colleagues (15), may be a potential method to address this. By allowing the joint modelling of multiple outcomes, a comprehensive view of the relationship between PMH and child development can be discerned whilst allowing correlations amongst the multiple exposures and outcomes to be considered (16).

Paternal and maternal mental illness are highly interdependent (5,17), with the co-occurrence of mental illness in both parents significantly increasing the risk of major depression and anxiety in their children, particularly for anxiety disorders (18). Research also indicates that PMH

can moderate the impact of maternal mental health on child development (5,19–21), although primarily investigated in school-aged children and adolescents. Whilst studies show the effects of paternal depression on child development to remain significant after controlling for maternal mental health (22,23), few studies have explored whether the same relationship holds true for the effect of PMH.

Furthermore, the interaction between PMH and respective domains of child development may be partially moderated by child gender or sex assigned at birth - henceforth referred to as child sex. However, the direction appears inconsistent, with some reviews showing greater effect sizes for boys (24) or girls (19), and others seeing no differences (7, 25). Overall, to our knowledge these associations have not been explored extensively for PMH. Further research is important, as gender differences have previously been highlighted in child socioemotional and behavioural developmental domains (26,27).

Finally, research investigating the association between PMH and child development must take into account the wider pre and postnatal environment. PMH does not exist in a vacuum; both personal and structural factors are known to increase the risk of paternal mental illness, such as relationship conflict between coparents (4,28), fathers' education level (29), and socioeconomic status (5). Moreover, several of these factors are also known to associate with the course of child development (30,31) and may therefore exacerbate, or buffer, the impact of PMH. Socioeconomic status, for example, has been seen to partially determine child cognitive and behavioural outcomes (32). While paternal determinants of socioeconomic status have been studied much less than those related to mothers,

research indicates that lower paternal education levels predict externalising behavioural problems at 2-3 years (33) and psychosocial problems and IQ from 5-8 years (34,35). However, key socioeconomic moderators are still yet to be determined.

Taking these unresolved issues into consideration, this study aims to investigate the relationship between paternal mental health and early child development in an outcome-wide analysis, encompassing socioemotional, cognitive, and behavioural domains. Both paternal depression and anxiety will be considered respectively, as well as the timing of exposure. All associations will be subsequently explored in relationship to the mothers' mental health, child sex, and parental socioeconomic status.

Methods

Population And Study Design

The study population was taken from the French SEPAGES couple-child cohort. SEPAGES recruited pregnant women from eight obstetrical ultrasonography practices across the Grenoble metropolitan area between 2014 and 2017 (36). Inclusion criteria were being under 19-weeks pregnant at inclusion, fluent in French, and older than 18 years old, having a singleton pregnancy, being affiliated to the French national security system, planning to deliver in one of four maternity clinics in Grenoble, and living in the study area. There was a 21% participation rate amongst those approached and eligible for inclusion, resulting in a sample of 484 expectant mothers. The study area includes both urban and rural zones, and has a rather high education level compared to the average French general population due to the presence of a large

research and engineering community. Compared to pregnant women in France, included SEPAGES mothers had higher rates of employment (92.9% compared to 68.1% in the general population), level of education (94% with an undergraduate or graduate degree vs 55.4%) and French nationality (94.7% vs 85.9%) and were more likely to be in a relationship (99.8% vs 81.9%) (5). Whilst fathers' participation was not mandatory, the fathers of all expected children were offered to participate in the cohort. Inclusion criteria for fathers were being at least 18 years old and having social security. 410 fathers agreed to participate in the study and were eligible for inclusion. Our analyses focused on all 301 father-child dyads in which fathers' mental health data was available and recorded within the study period.

Every year from inclusion onwards, questionnaires, interviews and clinical examinations were used to collect sociodemographic, environmental and medical information on the children and their parents, both during and after pregnancy (37). Both mothers and fathers of the expected child signed an informed consent form for themselves and their child prior to inclusion. Ethics board approvals were obtained from the Commission Nationale de l'Informatique et des Libertés, the Comité de Protection des Personnes Sud-Est V, and the Agence nationale de sécurité du médicament et des produits de santé.

Measures

Indicators of paternal mental health

Fathers' mental health was measured during their coparent's pregnancy (mean response period 7.8 +/-5.6 weeks before birth; n = 166)

and postpartum. For postpartum measures, fathers were grouped based on the timing of assessment, forming two groups: one for responses between 0 and 12 months (4.3 +/-3.7 months; n = 117) and one from 12-24 months (16.9 +/-3.4 months; n = 207). At all timepoints, mental health was measured using the Hospital Anxiety and Depression Scale (HADS). The HADS is a self-report measure for anxiety and depression in the general population. Based on 14 questions, responses are summed to calculate sub-scores for the discrete depression and anxiety scales (7 items each). In cases where there were one or less missing values for either anxiety and/or depression scores, missing values were replaced by the individual's most frequently occurring answer for respective score. Where more than one missing value for either the anxiety or depression score was present, the case was removed. For reporting the prevalence, cut-off scores of ≥ 8 for depression or anxiety were used (38). For all other analyses, scores were treated as continuous.

Cronbach alpha (α) of the HADS within our sample was 0.897 at pregnancy; 0.841 between 0-12 months and 0.877 12-24 months postpartum, indicating good internal consistency and reliability at all time points.

Indicators of child development

Child development was assessed at both two and three years of age, using clinical assessments performed by trained SEPAGES fieldworkers, including trained neuropsychologists, as well as validated questionnaires completed by the parents.

At two years, the child behaviour checklist (CBCL/1.5-5) was used (39,40). The CBCL/1.5-5

consists of 100 items, completed by the parents. Intended to assess the emotional and behavioural problems of children from 1.5 to 5 years, it is divided into seven subscales: 1) *Emotional reactivity* 2) *Anxious/depressed symptoms* 3) *Somatic complaints* 4) *Withdrawn behaviour* 5) *Sleep problems* 6) *Attention problems* and 7) *Aggressive behaviour* subscales. These subscales may be grouped into either internalising (groups 1-4) or externalising (groups 6-7) subscales.

At three years, several measures were available. Firstly, the Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P) (41). The BRIEF-P is a 63-item, Likert-scale questionnaire, completed by the parents. Intended to evaluate executive function, it is grouped into five non-overlapping scales: 1) *Inhibition*: 2) *Shift* 3) *Emotional control* 4) *Working memory* 5) *Plan/Organise*.

Secondly, the social responsiveness scale (SRS) was used. The SRS is a 65-item, Likert-scale questionnaire completed by the parents (42). Intended to screen social behaviour and autism spectrum disorders (ASD), it is grouped into five scales: 1) *Social Awareness* 2) *Social Cognition* 3) *Social Communication* 4) *Social Motivation* 5) *Restricted Interests and Repetitive Behavior (RRB)*.

Finally, the Wechsler Primary and Preschool Scales of Intelligence (WPPSI) was also used (43). The WPPSI is a cognition test performed by a neuropsychologist. It consists of five verbal and five performance (nonverbal) subtests, with scores standardised post-examination based on child age. Three main indexes can be derived from the age-standardised scores: 1) *Verbal comprehension*: 2) *Visual Spatial* 3) *Working*

memory. The total score (derived from the sum of all standardised scores), can be used as an Intelligence Quotient (IQ). Within SEPAGES, a “psychologist effect” (shift in the score distributions based on the psychologist) was tested and confirmed for the visuospatial and the working memory indexes. For consistency, all three indexes were standardised for the psychologist effect using a 2-step approach described in Mortamais et al. (44).

For each of the indicated child developmental measures, missing data was handled according to instrument-specific recommended guidelines. The overall reliability and internal consistency (Cronbach α) of the CBCL was 0.89, 0.943 for the BRIEF-P, 0.886 for the SRS and 0.852 for the WPPSI, indicating good to excellent internal consistency and reliability across all scales.

Confounding variables

All the following confounders were considered for inclusion in statistical analysis: Fathers’ and mothers’ age at conception, ethnicity (White/other), weight, and education level (Baccalaureate +5 and more; Baccalaureate +3-4 years; Baccalaureate or equivalent diploma and under), and mothers’ professional status at first trimester (employed/unemployed). Included pregnancy and child specific variables were maternal parity, prenatal tobacco (>1 cigarette per day; yes/no) and/or alcohol consumption (no; one or less drinks per month; over one drink per month), complications during pregnancy (yes/no), gestational duration, delivery mode (vaginal/caesarean), child weight, child sex (male/female), number of weeks breastfed until week 48, and number of child hospitalisations between birth and 1 year. The main mode of childcare at 6 months was also considered

(collective care (nursery, crèche, family day care, or day care centres) vs. other (spouse, partner, family members, childminders, neighbour, unlicensed nanny etc.)) alongside the arrival of subsequent siblings (yes/no).

As an additional indicator of socioeconomic status, mother and father's respective professional skill class were calculated based on ISCO categories (45), grouped into four skill groups: 1) Skill level 1: Elementary occupations; 2) Skill level 2: Clerical support workers, service and sales workers, agricultural, forestry and fishery workers, craft and related trade workers, plant and machine operators and assemblers; 3) Skill levels 3-4: Managers, professionals, technicians and associate professionals; and 4) All armed forces occupations.

Maternal mental health (MMH) was measured in the third trimester (T3) and 1-year following birth using the Hospital Anxiety and Depression Scale (HADS). The total score grouping both anxiety and depression was used, and scores were kept as continuous.

Due to insufficient variation within the study population, relationship status between mother and father; and father's and mother's employment status at third trimester and 1-year postpartum were excluded from analyses.

Data analysis

Prior to analyses, chi-square and unpaired t-tests were used to compare included fathers' demographics with those of excluded participants, as well as all child developmental outcome scales and subscales.

Linear regression models were used to test the association between PMH and child development, through an outcome-wide analytic

approach (15). For all analyses, both depression and anxiety were used respectively as PMH exposures. To counteract collider stratification bias, a common set of confounding factors was used for all models (46) - meaning that all models were adjusted for any variable significantly (5%) associated with at least one exposure or outcome. For outcome wide analyses, confounding variables had to occur before both the exposure and outcome. Thus, all confounders occurring postnatally were only included in models using postnatal PMH as the exposure, as opposed to prenatal PMH. For all models, associations were tested both non-adjusted and adjusted for confounding variables. Due to the exploratory nature of our investigation, and to control for multiple outcome bias, the significance threshold of p-values was subsequently adjusted using a Hochberg correction (47). Correction for multiple outcome bias was based on assessment year, with child outcomes at two and three years considered respectively and corrected as such. Missing data for confounders was imputed based on an assumption of missing at random using the MICE package (48). Before imputation, 4.7% of data was missing across all variables considered for confounding. Full information on missing data is available in **Supplementary Table 1**.

Moderation analyses were then used to test possible variation of the association between PMH and child developmental outcomes according to the three indicators previously outlined: maternal mental health, child sex (male; female) and parents' professional skill class (ISCO category). Separate linear regression models were used to test moderation by including an interaction term (moderator*exposure), taking a p-value of <0.05 to represent a statistically significant interaction

following adjustment using a Hochberg correction. For models using prenatal PMH, maternal HADS scores during pregnancy were used. For all postnatal PMH models, maternal HADS scores from 1-year postpartum were used. For both mother and father's respective professional skill class (ISCO scores), only two professional skill groups (2 and 3-4) were retained in moderator analysis, due to low representation within the other two groups (two fathers in Group 1, two in the armed forces; no mothers in either group).

All analyses were conducted using R version 4.3.2.

Results

Descriptives

The demographic information of our study population is shown in **Table 1**, as well as comparison with those excluded from our analyses in **Supplementary Table 2**. No significant difference between included and non-included families was seen for any demographic variable except mothers' education level and professional skill class. Mothers of included children were more likely to be more educated and of a higher skill level (90.7% skill level 3-4%) than excluded participants (81.9%).

Based on clinical HADS cut-offs, 27% (n=45) of fathers experienced anxiety prenatally, 22% (n=26) 0-12 months postpartum and 26% (n=53) 12-24 months postpartum. 27.1% of fathers experienced depression prenatally, 2.6% 0-12 months postpartum and 26% 12-24 months postpartum.

Regarding measures of child development, no significant differences amongst scores were

observed between included and excluded children.

Relationship between PMH and child development

The association between prenatal PMH and child development was non-significant for all measures of child development following correction for multiple testing (**Tables 2a-c**), both before and after adjusting for confounding factors.

The same was seen for postnatal PMH occurring between 0-12 months and 12-24 months, both before and after adjusting for confounding factors.

Moderation effects

Maternal mental health

Following corrections for multiple testing, maternal mental health (MMH) was only shown to moderate one association between PMH and child development, out of a possible 126 (six PMH exposures; 21 developmental outputs) (**Supplementary Table 3**). A significant moderation effect was seen for MMH on the relationship between prenatal paternal anxiety and the BRIEF-P working memory subscale ($\beta=0.01$; $SE=0.00$; $p_{Adj}<0.01$), children exposed to higher prenatal paternal anxiety had worse working memory outcomes (higher scores) when also exposed to higher prenatal maternal HADS scores.

Child sex

Child sex was not seen to significantly moderate the relationship between PMH and child development for any outcome, for all three PMH timepoints (prenatal; 0-12 months; 12-24 months).

Professional class

Fathers' professional class (ISCO score) was not seen to significantly moderate the relationship between PMH and child development for any outcome, at all three time points.

Mothers' professional class (ISCO score) was seen to be the most significant moderator, moderating the influence of PMH for four associations following correction for multiple outcomes. For prenatal paternal anxiety, moderation by mothers' ISCO was seen for the CBCL attention problems ($\beta=0.37$; $SE=0.13$; $p_{Adj}<0.05$), the BRIEF-P working memory ($\beta=0.13$; $SE=0.05$; $p_{Adj}<0.05$), and the SRS social cognition ($\beta=1.24$; $SE=0.38$; $p<0.05$) subscales. Mother's ISCO score also moderated the association of paternal anxiety at 12-24 months with the WPPSI verbal comprehension index ($\beta=-32.89$; $SE=10.78$; $p_{Adj}<0.05$).

Higher paternal HADS-A scores associated with higher attention problem scores, poorer working memory and lower visuospatial scores, but greater social cognition, amongst children whose mothers had lower ISCO scores.

Discussion

This study is one of the first to examine associations between both paternal perinatal depression and anxiety on child socioemotional, cognitive, and behavioural development at two and three years of age, using an outcome-wide analysis controlling for known confounders. The potential moderation by mothers' mental health, child sex and parents' professional class was also investigated. The rates of both depression and anxiety amongst fathers were within expected global and French ranges (3–6). Overall, within the SEPAGES population, neither paternal

anxiety nor depression were directly associated with any studied measure of child development. Notably, whilst neither child sex nor paternal professional class moderated this relationship, we observed that maternal professional class significantly moderated the association between paternal anxiety and several aspects of child development.

Association of PMH to child development

Though inconsistent throughout the literature, significant associations have been found between paternal mental health (PMH) and child development (10). The non-significant association between PMH and child development in our study was thus unexpected. Additionally, there was no apparent difference in effect sizes between pre- and postnatal PMH or according to paternal diagnosis, which agrees with Spry et al. (1) and Sweeney and MacBeth (49). Currently, the mechanisms through which prenatal PMH interacts with child development remain unclear, likely to be through a multitude of contextual mediators (49)(50). However, PMH is also likely to impact both the frequency and quality of parent-child interactions, thus suggesting a greater impact following birth. Studies have shown associations between postpartum mental illness and parenting stress (51,52), which has in turn been shown to mediate the effect of postnatal symptoms of depression on the socio-emotional behaviour of children at 18 months (53) and child total problems at 24 months (5). In a review on the relationship between PMH and child development from infancy to late adolescence, larger effect sizes were indeed reported in studies where paternal symptoms were assessed postnatally as opposed to prenatally (10).

It is also possible that the impact of PMH on the child depends on the frequency of exposure during their lifetime, with chronic exposure potentially amplifying associations. Indeed, an increase in fathers' postnatal depressive symptoms over time has been seen to produce a stronger effect on child behaviour at two years of age (54) as well as adolescence (55). The overall lack of association amongst our findings could also be driven by the timing of the studied child developmental measures (2-3 years). One meta-analysis spanning toddlerhood through adolescence found paternal psychopathology more closely related to problem behaviours amongst older children as opposed to those aged ≤ 6 years (19). However, associations between PMH and child development have been seen as early as 2-months (1,49), with numerous other reviews finding the association between PMH and child development to be stronger in younger children than older children (2,56). It is also possible that we investigated certain outcomes too early in childhood. Indeed, several of the child measures used in our study were indicators of autism and attention deficit or hyperactivity disorder (ADHD), and internalising and externalising behaviours, which are often identified at later developmental stages. However, multiple studies have shown PMH to impact similar measures of child development within the age range of our study, such as ADHD at three years (57), and social withdrawal at 4-18 months (58). It is thus unlikely that our measures occurred too early.

It is important to note that within our included families, 94-98% of fathers and 88-96% of mothers were in employment, as well as 98% of fathers and 96% of mothers with a baccalaureate degree or higher. When compared to the rate of

employment within the French general population (68%), this indicates a considerably high socioeconomic status (SES) amongst participants. Low SES has been seen to accentuate the adverse child outcomes that associate with PMH (2,56). The highly specific demographics of our sample may have thus led to an underestimation of the relationship between PMH and child development. In support of this, one study (54) found the impact of fathers' depression and child behaviour problems at 48-months disappeared once controlling for socioeconomic factors. The high rate of employment amongst our sample might have also impacted the degree of paternal involvement, in that fathers may be less involved due to work obligations. Several reviews have shown the degree of paternal involvement to moderate the impact of PMH on child development (20,49,59). Interestingly, amongst a sample of high-SES fathers, greater paternal depressive and anxiety symptoms were seen to associate with higher child IQ and fewer behavioural difficulties (11). The lack of association seen within our sample might thus be indicative of a presence of positive associations within certain father-child dyads negating the expected negative association amongst others, resulting in an overall non-significance.

Moderating factors

Several potential moderators were examined in our study, of which the most significant one was found to be parents' professional class. Parents' professional class is a key indicator of SES. However, moderation by parents' professional class was seen exclusively for mothers. This may partially stem from the gender roles surrounding parenting responsibilities. Despite ongoing changes, mothers remain overall more present

than fathers in their children's upbringing, showing greater parenting responsibilities (60) and time commitment (5,61). Thus, their professional situation and associated factors may carry greater weight on their child's developmental outcomes. Lower ISCO scores associate with greater constraints relative to working hours (62), which may in turn impede the duration or quality of parental involvement. Indeed, children of parents with lower ISCO scores showed primarily worse developmental outcomes when exposed to higher paternal anxiety. Studies also show that mothers and fathers with more stimulating and autonomous jobs use less harsh or restrictive parenting, opting for a more positive, warm and responsive parenting approach (63–66). Interestingly, one study saw that whilst mothers' work experiences predicted changes in fathers' observed parenting, fathers' work experiences were largely unrelated to fathers' or mothers' parenting (64). This supports our finding that maternal profession was more relevant to child outcomes than that of fathers in the context of PMH.

Except for one subscale of the BRIEF-P (working memory) at 3 years, maternal mental health did not appear to moderate the relationship between PMH and child development. This is a particularly interesting finding, as numerous studies show PMH to be an important moderator of the effect of maternal mental health on offspring development (5,19). Whilst few studies have examined this amongst children as young as our study, parental psychopathology has been reported to significantly associate with children's externalising and internalising behaviours at 18 months (21) and behavioural problems at 2 and 3 years (33) only when present in both parents.

Child sex did not appear to moderate the relationship between PMH and child development. The current literature available on the importance of child sex in relation to the effects of PMH is mixed. Whilst one review observed larger effect sizes for externalising problems amongst boys (24), another saw greater externalising problems amongst girls (19). The relevance of child sex may be dependent on the domain of child development. For example, one study saw paternal depression interact with a total problem score amongst both sexes, but only conduct problems amongst boys (67). However, considering the wide range of developmental measures included in our study, the relationship between PMH and child developmental appeared overall independent to child sex.

Strengths and limitations

Several strengths and weaknesses of this study must be highlighted. Firstly, in using four validated measures of child development, we investigated a large range of child outcomes, including potential indicators of autism, attention deficit disorder, and internalising and externalising behaviours. Secondly, the SEPAGES questionnaires provided numerous, detailed waves of potential pre- and postnatal confounders, as early as the first trimester of pregnancy. Child development was also measured at both two and three years of age, ages between which significant changes occur in child temperament, autonomy, the child-parent relationship, gender roles, and peer relationships (68). Finally, child development was assessed by both parent self-report and clinical psychologists. This is particularly important, as reports on child development may differ based on the objectivity of the observer (69). Relying

solely on parent-reports could have therefore introduced bias.

However, four key limitations are worth noting. Firstly, our sample size is relatively small and unrepresentative of the French national population, thus limiting the external validity of our results. Second, fathers' participation was optional, thus risking selection bias in favour of more engaged fathers, which has in turn been seen to associate with improved child outcomes (70,71). Third, PMH was measured in a cross-sectional manner, thus the duration of symptoms was not accounted for in analyses. However, the fact that measurements of PMH occurred prior to all measures of child development allowed us to partially minimise the risk of bidirectional effects. Finally, data were unavailable for several key potential confounding factors known to associate with either PMH or child development, due either to the questionnaire design, such as information on paternal leave or involvement, or homogeneity within the study cohort, such as parent's employment status. However, due to the extensive number of other confounding variables, alongside the analytical choice to use a common set of confounders amongst all models, it is likely many of these factors were partially accounted for. Moreover, regarding employment status, Perry-Jenkins et al. (72) argue that, when linking parental employment and children's development, the type of work may be more important than employment status itself. Thus, our choice of parents' professional category as opposed to employment status may have permitted a more sensitive moderator analysis.

Conclusion

This study provides an outcome-wide assessment of the association between pre- and postnatal paternal mental health and child development at 2-3 years old, spanning numerous child outcomes (IQ, socioemotional behaviour and cognition). Neither fathers' depression nor anxiety appeared to significantly associate with any measures of their child's development at both ages. However, we found that within a sample of relatively homogenous, high socioeconomic status families, parents' professional class had a moderating effect on the relationship between fathers' mental health and child development. This effect was observed only for mothers' professional class, suggesting a potentially gendered imbalance in parenting responsibilities and involvement. Family social class appears to play an important role in the relationship between paternal mental health and child development. These findings are especially relevant considering the number of widening disparities between children from low and high-income households. Future research on the effect of fathers' mental illness on their child should focus on actively recruiting participants from more diverse socioeconomic backgrounds and equity-deserving populations often underrepresented in current research.

Ethics

Ethics board approvals were obtained from the Commission Nationale de l'Informatique et des Libertés (CNIL, authorisation n°2014-263, 2014-06-26), the CPP (Comité de Protection des Personnes Sud-Est V, authorisation n°13-CHUG-44, 2014-02-25) and the Agence nationale de sécurité du médicament et des produits de santé (ANSM, authorisation n°2013-A01491-44, 2013-12-17).

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Table 1: Father-child demographics, mental health data and developmental outcomes of the included study population. *SEPAGES cohort*.

		Study population (n = 301)	
		n	%
Child sex assigned at birth	<i>Female</i>	139	46.2%
	<i>Male</i>	162	53.8%
Father's age at inclusion, years	<i>Mean (SD)</i>	35.0 (5.1)	
Father's ethnicity	<i>White</i>	290	96.3%
	<i>Other</i>	11	3.7%
Father's level of education	<i>Baccalaureate +5 and more</i>	185	64.5%
	<i>Baccalaureate +3 to 4 years</i>	48	16.7%
	<i>Baccalaureate or lower</i>	54	18.8%
Father employment status - T2	<i>Employed</i>	269	93.7%
	<i>Unemployed (inc. paternity or sick leave)</i>	18	6.3%
Father employment status - T3	<i>Employed</i>	241	97.9%
	<i>Unemployed (inc. paternity or sick leave)</i>	13	6.2%
Father professional skill category*	<i>Skill level 3-4</i>	242	85.8%
	<i>Skill level 2</i>	36	12.8%
	<i>Skill level 1</i>	2	0.7%
	<i>Armed forces</i>	2	0.7%
Father's weight (kg) - 1 year	<i>Mean (SD)</i>	74.0 (10.3)	
Mother relationship status- T1	<i>In relationship with father</i>	294	100.0%
	<i>Not in relationship with father</i>	0	0.0%
Mother's age at conception, years	<i>Mean (SD)</i>	32.7 (3.7)	
Mother's ethnicity	<i>White</i>	289	97.0%
	<i>Other</i>	9	3.0%
Mother's level of education	<i>Baccalaureate +5 and more</i>	181	60.5%
	<i>Baccalaureate +3 to 4 years</i>	75	25.1%
	<i>Baccalaureate or lower</i>	43	14.4%
Mother employment status - T1	<i>Employed</i>	258	87.8%
	<i>Unemployed</i>	36	12.2%
Mother employment status - 1 year	<i>Employed</i>	200	95.7%
	<i>Unemployed</i>	9	4.3%

Mother professional skill category	Skill level 3-4	264	90.7%
	Skill level 2	27	9.3%
	Skill level 1	-	-
	Armed forces	-	-
Mother's weight (kg) - T1	Mean (SD)	63.7 (10.1)	
Mother's tobacco consumption during pregnancy	1 or less cigarettes /day	273	96.8%
	Over 1 cigarette /day	9	3.2%
Mother alcohol during pregnancy	No	91	30.4%
	One or less drinks per month	108	36.1%
	Over one drink per month	100	33.4%
Mothers' prenatal mental health score (HADS, T3)	Mean (SD)	10.6 (4.9)	
Mothers' postnatal mental health score (HADS, 1 year)	Mean (SD)	11.4 (4.9)	
Diagnosed complications during pregnancy	No	266	89.6%
	Yes	31	10.4%
Gestational duration (weeks)**	Mean (SD)	39.7 (1.4)	
Birth weight (child), g	Mean (SD)	3278.2 (417.1)	
Delivery mode	Vaginal	259	86.0%
	Caesarean	42	14.0%
Mother's parity at birth	0	142	47.2%
	1	130	43.2%
	2	29	9.6%
No. of weeks breastfed before week 48	Mean (SD)	27.0 (15.9)	
Number of hospitalisations between birth and 2 months old	0	273	91.9%
	1	23	7.7%
	2	1	0.3%
Number of hospitalisations between 2 and 12 months old	0	282	96.9%
	1	9	3.1%
	2	0	0.0%
Main mode of childcare at 6 months	Collective day care	173	60.9%
	Other	111	39.1%
Main mode of childcare at 12 months	Collective day care	227	79.9%
	Other	57	20.1%
Number of children in household (inc. part-time) - T1	Mean (SD)	0.7 (0.7)	
Number of brothers and sisters - 1 year	Mean (SD)	0.7 (0.7)	
Paternal mental health			
		n	%
Prenatal Anxiety***	No	121	72.9%
	Yes	45	27.1%
Prenatal Depression***	No	121	72.9%
	Yes	45	27.1%
Postnatal Anxiety*** - 0-12 months	No	91	77.8%
	Yes	26	22.2%
Postnatal Depression*** - 0-12 months	No	114	97.4%
	Yes	3	2.6%
Postnatal Anxiety*** - 12-24 months	No	154	74.4%
	Yes	53	25.6%

Postnatal Depression*** - 12-24 months	<i>No</i>	154	74.4%
	<i>Yes</i>	53	25.6%
Child developmental outcomes			
Child Behaviour Checklist (CBCL)		n	Mean (SD)
	<i>Emotional reactivity</i>	286	0.5 (0.3)
	<i>Anxiety/Depression</i>	286	0.3 (0.3)
	<i>Somatic complaints</i>	285	0.4 (0.3)
	<i>Withdrawn behaviour</i>	286	0.2 (0.2)
	<i>Sleep problems</i>	286	0.5 (0.3)
	<i>Attention problems</i>	286	0.5 (0.2)
	<i>Aggressive behaviour</i>	286	1.0 (0.2)
	<i>Other problems</i>	286	0.9 (0.2)
	<i>Total score</i>	286	32.5 (14.4)
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	<i>Verbal comprehension</i>	265	112.2 (11.7)
	<i>Visuospatial index</i>	266	110.4 (10.6)
	<i>Working memory</i>	264	105.7 (10.7)
	<i>Total Intelligence Quotient (IQ)</i>	265	112.9 (11.0)
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	<i>Inhibitory control and impulsivity</i>	279	4.9 (0.5)
	<i>Shift</i>	284	1.1 (0.1)
	<i>Emotional control</i>	284	3.8 (0.5)
	<i>Working memory</i>	277	1.3 (0.1)
	<i>Planning/organisation</i>	282	3.7 (0.4)
Social Responsiveness Scale (SRS)	<i>Social Awareness</i>	280	5.8 (2.7)
	<i>Social Cognition</i>	280	2.4 (0.7)
	<i>Social Communication</i>	280	0.9 (0.2)
	<i>Social Motivation</i>	280	0.8 (0.2)
	<i>Repetitive Behaviour (RRB)</i>	280	0.6 (0.3)
	<i>SRS Total</i>	280	1.4 (0.2)

*T1 /T2/T3= First/Second/Third trimester. *Based on ISCO scoring. Skill level 1: Elementary occupations; Skill level 2: Clerical support workers, service and sales workers, agricultural, forestry and fishery workers, craft and related trade workers, plant and machine operators and assemblers; Skill levels 3-4: Managers, professionals, technicians and associate professionals. **Calculated from mother's last menstrual period ***Hospital Anxiety and Depression Scale (HADS); cut-off score of 8.*

Table 2a - The effect of prenatal (7.8 +/-5.6 weeks before birth; n = 166) paternal mental health on child development. Linear regression modelling, both non-adjusted and adjusted for confounding Variables. B = Unstandardised Coefficient, SE = Standard Error, P_{adj} = P value adjusted for multiple outcomes (Hochberg Correction).

		Pregnancy							
		Non-adjusted				Adjusted			
		Paternal anxiety*		Paternal depression*		Paternal anxiety*		Paternal depression*	
		β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}
CBCL	<i>Emotional reactivity</i>	-0.01 (0.04)	0.81 / 0.97	0.02 (0.08)	0.84 / 0.96	0 (0.02)	0.82 / 0.82	0 (0.02)	0.95 / 0.95
	<i>Anxiety/Depression</i>	0 (0.04)	0.97 / 0.97	0 (0.07)	0.96 / 0.96	0.01 (0.02)	0.44 / 0.82	0.01 (0.02)	0.34 / 0.95
	<i>Somatic complaints</i>	0.04 (0.04)	0.25 / 0.97	0.09 (0.07)	0.24 / 0.96	0.02 (0.02)	0.02 / 0.16	0.01 (0.02)	0.16 / 0.95
	<i>Withdrawn behaviour</i>	0.03 (0.03)	0.37 / 0.97	0.06 (0.06)	0.28 / 0.96	0.01 (0.02)	0.29 / 0.82	0.01 (0.02)	0.22 / 0.95
	<i>Sleep problems</i>	0.02 (0.04)	0.67 / 0.97	0.1 (0.08)	0.2 / 0.96	0.01 (0.02)	0.3 / 0.82	0.01 (0.02)	0.13 / 0.91
	<i>Attention problems</i>	0.01 (0.03)	0.8 / 0.97	-0.01 (0.07)	0.91 / 0.96	0 (0.02)	0.62 / 0.82	0 (0.02)	0.8 / 0.95
	<i>Aggressive behaviour</i>	0.02 (0.03)	0.57 / 0.97	0.11 (0.06)	0.06 / 0.48	0 (0.01)	0.7 / 0.82	0.01 (0.02)	0.08 / 0.64
	<i>Other problems</i>	-0.01 (0.02)	0.68 / 0.97	0.06 (0.05)	0.24 / 0.96	0 (0.01)	0.78 / 0.82	0.01 (0.02)	0.27 / 0.95
WPPSI	<i>Verbal comprehension index</i>	1.23 (1.8)	0.49 / 0.97	-0.26 (3.69)	0.94 / 0.96	0.31 (0.72)	0.4 / 0.91	0.2 (0.81)	0.63 / 0.95
	<i>Visuospatial index</i>	-2.08 (1.6)	0.19 / 0.97	-1.42 (3.3)	0.67 / 0.96	-0.5 (0.67)	0.14 / 0.91	-0.26 (0.75)	0.5 / 0.95
	<i>Working memory index</i>	0.92 (1.64)	0.58 / 0.97	0.38 (3.36)	0.91 / 0.96	0.24 (0.68)	0.49 / 0.91	-0.08 (0.76)	0.84 / 0.95
BRIEF-P	<i>Inhibitory control and impulsivity</i>	-0.08 (0.07)	0.29 / 0.97	-0.08 (0.15)	0.59 / 0.96	-0.01 (0.03)	0.4 / 0.91	0 (0.03)	0.95 / 0.95
	<i>Shift</i>	-0.02 (0.01)	0.13 / 0.97	0.01 (0.03)	0.83 / 0.96	0 (0.01)	0.45 / 0.91	0 (0.01)	0.81 / 0.95
	<i>Emotional control</i>	-0.02 (0.06)	0.8 / 0.97	0.1 (0.12)	0.42 / 0.96	-0.01 (0.03)	0.63 / 0.91	0.02 (0.03)	0.23 / 0.95
	<i>Working memory</i>	-0.02 (0.01)	0.18 / 0.97	-0.04 (0.02)	0.13 / 0.96	0 (0.01)	0.31 / 0.91	0 (0.01)	0.27 / 0.95
	<i>Planning/organisation</i>	-0.07 (0.05)	0.19 / 0.97	-0.05 (0.11)	0.64 / 0.96	-0.01 (0.02)	0.27 / 0.91	-0.01 (0.03)	0.45 / 0.95
SRS	<i>Social Awareness</i>	-0.01 (0.37)	0.97 / 0.97	1 (0.76)	0.19 / 0.96	-0.06 (0.16)	0.46 / 0.91	0.15 (0.17)	0.09 / 0.95
	<i>Social Cognition</i>	0.04 (0.09)	0.7 / 0.97	-0.07 (0.2)	0.71 / 0.96	0 (0.04)	0.91 / 0.91	-0.01 (0.04)	0.67 / 0.95
	<i>Social Communication</i>	-0.01 (0.03)	0.81 / 0.97	0 (0.06)	0.96 / 0.96	0 (0.01)	0.83 / 0.91	0 (0.02)	0.62 / 0.95
	<i>Social Motivation</i>	-0.02 (0.03)	0.56 / 0.97	0.06 (0.07)	0.41 / 0.96	0 (0.02)	0.57 / 0.91	0 (0.02)	0.65 / 0.95
	<i>Repetitive Behaviour (RRB)</i>	0.02 (0.04)	0.57 / 0.97	0.1 (0.08)	0.21 / 0.96	0.01 (0.02)	0.45 / 0.91	0.02 (0.02)	0.02 / 0.26

*Hospital Anxiety and Depression Scale (HADS). CBCL = Child Behaviour Checklist; WPPSI = Wechsler Primary and Preschool Scales of Intelligence; BRIEF-P = Behaviour Rating Inventory Of Executive Function, Preschool Version; SRS = Social Responsiveness Scale.

Table 2b - The effect of postnatal (0-12 months; n = 117) paternal mental health on child development. Linear regression modelling, both non-adjusted and adjusted for confounding Variables. B = Unstandardised Coefficient, SE = Standard Error, P_{adj} = P value adjusted for multiple outcomes (Hochberg Correction).

		0-12 months							
		Non-adjusted				Adjusted			
		Paternal anxiety*		Paternal depression*		Paternal anxiety*		Paternal depression*	
		β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}
CBCL	<i>Emotional reactivity</i>	-0.03 (0.05)	0.54 / 0.84	-0.02 (0.05)	0.71 / 0.91	-0.01 (0.02)	0.33 / 0.98	0 (0.02)	0.81 / 0.99
	<i>Anxiety/Depression</i>	-0.07 (0.05)	0.15 / 0.84	-0.02 (0.05)	0.64 / 0.91	0 (0.02)	0.65 / 0.98	0 (0.02)	0.67 / 0.99
	<i>Somatic complaints</i>	0.05 (0.05)	0.25 / 0.84	-0.01 (0.05)	0.8 / 0.91	0.01 (0.02)	0.27 / 0.98	0.01 (0.02)	0.42 / 0.99
	<i>Withdrawn behaviour</i>	0.08 (0.03)	0.02 / 0.16	0.05 (0.03)	0.12 / 0.91	0.01 (0.01)	0.16 / 0.98	0.01 (0.01)	0.13 / 0.99
	<i>Sleep problems</i>	-0.05 (0.06)	0.41 / 0.84	-0.03 (0.05)	0.61 / 0.91	0 (0.02)	0.75 / 0.98	0 (0.02)	0.57 / 0.99
	<i>Attention problems</i>	-0.02 (0.04)	0.66 / 0.84	0 (0.04)	0.91 / 0.91	0 (0.01)	0.98 / 0.98	0 (0.02)	0.57 / 0.99
	<i>Aggressive behaviour</i>	-0.01 (0.04)	0.84 / 0.84	-0.01 (0.04)	0.86 / 0.91	0 (0.01)	0.71 / 0.98	0 (0.02)	0.46 / 0.99
	<i>Other problems</i>	-0.02 (0.04)	0.64 / 0.84	-0.02 (0.04)	0.66 / 0.91	-0.01 (0.01)	0.21 / 0.98	0 (0.01)	0.99 / 0.99
WPPSI	<i>Verbal comprehension index</i>	0.09 (2.15)	0.97 / 0.98	-0.77 (2.08)	0.71 / 0.99	0.05 (0.59)	0.88 / 0.88	-0.32 (0.66)	0.33 / 0.88
	<i>Visuospatial index</i>	1.55 (1.94)	0.42 / 0.98	-0.03 (1.88)	0.99 / 0.99	0.18 (0.58)	0.53 / 0.88	0.05 (0.65)	0.88 / 0.88
	<i>Working memory index</i>	1.51 (1.9)	0.43 / 0.98	-1.58 (1.83)	0.39 / 0.99	0.18 (0.59)	0.55 / 0.88	-0.24 (0.66)	0.48 / 0.88
BRIEF-P	<i>Inhibitory control and impulsivity</i>	0.04 (0.1)	0.69 / 0.98	0.13 (0.1)	0.19 / 0.99	0.01 (0.03)	0.45 / 0.88	0.01 (0.03)	0.39 / 0.88
	<i>Shift</i>	0.01 (0.02)	0.56 / 0.98	0.03 (0.02)	0.08 / 0.99	0 (0.01)	0.82 / 0.88	0 (0.01)	0.86 / 0.88
	<i>Emotional control</i>	-0.03 (0.09)	0.75 / 0.98	0.06 (0.08)	0.47 / 0.99	0.01 (0.03)	0.54 / 0.88	0 (0.03)	0.72 / 0.88
	<i>Working memory</i>	0.01 (0.02)	0.55 / 0.98	0.01 (0.02)	0.69 / 0.99	0 (0.01)	0.27 / 0.88	0 (0.01)	0.44 / 0.88
	<i>Planning/organisation</i>	0.06 (0.06)	0.37 / 0.98	0.08 (0.06)	0.21 / 0.99	0.01 (0.02)	0.44 / 0.88	0.01 (0.02)	0.45 / 0.88
SRS	<i>Social Awareness</i>	-0.01 (0.49)	0.98 / 0.98	0.47 (0.47)	0.32 / 0.99	0.01 (0.14)	0.84 / 0.88	0.12 (0.15)	0.12 / 0.88
	<i>Social Cognition</i>	0.1 (0.13)	0.43 / 0.98	0.18 (0.12)	0.13 / 0.99	0.01 (0.03)	0.48 / 0.88	0.04 (0.04)	0.02 / 0.24
	<i>Social Communication</i>	-0.04 (0.05)	0.41 / 0.98	0.01 (0.05)	0.8 / 0.99	0 (0.01)	0.82 / 0.88	0.01 (0.01)	0.08 / 0.88
	<i>Social Motivation</i>	0.06 (0.04)	0.17 / 0.98	0.04 (0.04)	0.34 / 0.99	0.01 (0.02)	0.35 / 0.88	0.01 (0.01)	0.11 / 0.88
	<i>Repetitive Behaviour (RRB)</i>	-0.03 (0.06)	0.61 / 0.98	-0.02 (0.05)	0.66 / 0.99	0.01 (0.02)	0.36 / 0.88	0.02 (0.02)	0.02 / 0.24

*Hospital Anxiety and Depression Scale (HADS). CBCL = Child Behaviour Checklist; WPPSI = Wechsler Primary and Preschool Scales of Intelligence; BRIEF-P = Behaviour Rating Inventory Of Executive Function, Preschool Version; SRS = Social Responsiveness Scale.

Table 2c – The effect of postnatal (12-24 months; n = 207) paternal mental health on child development. Linear regression modelling, both non-adjusted and adjusted for confounding Variables. B = Unstandardised Coefficient, SE = Standard Error, P_{adj} = P value adjusted for multiple outcomes (Hochberg Correction).

		12-24 months							
		Non-adjusted				Adjusted			
		Paternal anxiety*		Paternal depression*		Paternal anxiety*		Paternal depression*	
		β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}	β (SE)	p / p _{Adj}
CBCL	<i>Emotional reactivity</i>	-0.01 (0.03)	0.71 / 0.99	-0.01 (0.03)	0.73 / 0.94	0 (0.03)	0.74 / 0.8	0 (0.03)	0.98 / 0.98
	<i>Anxiety/Depression</i>	-0.01 (0.03)	0.71 / 0.99	0 (0.03)	0.94 / 0.94	-0.01 (0.02)	0.3 / 0.8	0.01 (0.03)	0.56 / 0.98
	<i>Somatic complaints</i>	0.03 (0.03)	0.36 / 0.99	0.01 (0.03)	0.65 / 0.94	0.01 (0.02)	0.44 / 0.8	0 (0.03)	0.91 / 0.98
	<i>Withdrawn behaviour</i>	0.04 (0.02)	0.12 / 0.96	0.03 (0.02)	0.17 / 0.94	0.02 (0.02)	0.01 / 0.08	0.01 (0.02)	0.18 / 0.98
	<i>Sleep problems</i>	-0.01 (0.03)	0.75 / 0.99	-0.02 (0.03)	0.6 / 0.94	-0.02 (0.03)	0.19 / 0.8	0 (0.03)	0.92 / 0.98
	<i>Attention problems</i>	0 (0.03)	0.99 / 0.99	-0.02 (0.03)	0.5 / 0.94	-0.01 (0.02)	0.56 / 0.8	0.01 (0.03)	0.58 / 0.98
	<i>Aggressive behaviour</i>	0.01 (0.03)	0.83 / 0.99	0.02 (0.02)	0.45 / 0.94	0 (0.02)	0.8 / 0.8	0 (0.02)	0.97 / 0.98
WPPSI	<i>Other problems</i>	-0.02 (0.03)	0.45 / 0.99	-0.01 (0.03)	0.79 / 0.94	-0.01 (0.02)	0.55 / 0.8	0 (0.02)	0.9 / 0.98
	<i>Verbal comprehension index</i>	-1.51 (1.47)	0.3 / 0.98	-1.57 (1.39)	0.26 / 0.94	0.71 (0.91)	0.12 / 0.96	0.58 (1.12)	0.3 / 0.74
	<i>Visuospatial index</i>	0.18 (1.4)	0.9 / 0.98	0.47 (1.32)	0.72 / 0.94	0.55 (0.86)	0.21 / 0.96	0.21 (1.06)	0.69 / 0.74
	<i>Working memory index</i>	0.04 (1.39)	0.98 / 0.98	-1.15 (1.32)	0.38 / 0.94	0.42 (0.87)	0.33 / 0.96	-0.23 (1.06)	0.66 / 0.74
BRIEF-P	<i>Inhibitory control and impulsivity</i>	0.03 (0.06)	0.59 / 0.98	0.02 (0.06)	0.75 / 0.94	0 (0.05)	0.96 / 0.96	0.03 (0.06)	0.26 / 0.74
	<i>Shift</i>	0 (0.01)	0.96 / 0.98	-0.01 (0.01)	0.5 / 0.94	0 (0.01)	0.38 / 0.96	0.01 (0.01)	0.03 / 0.39
	<i>Emotional control</i>	0.04 (0.05)	0.48 / 0.98	0.01 (0.05)	0.78 / 0.94	-0.01 (0.04)	0.68 / 0.96	0.03 (0.05)	0.26 / 0.74
	<i>Working memory</i>	0 (0.01)	0.79 / 0.98	0 (0.01)	0.94 / 0.94	0 (0.01)	0.23 / 0.96	0.01 (0.01)	0.21 / 0.74
	<i>Planning/organisation</i>	0.02 (0.05)	0.67 / 0.98	0.02 (0.04)	0.6 / 0.94	0.01 (0.03)	0.38 / 0.96	0.02 (0.04)	0.19 / 0.74
SRS	<i>Social Awareness</i>	-0.03 (0.33)	0.93 / 0.98	0.39 (0.31)	0.21 / 0.94	0.06 (0.23)	0.59 / 0.96	0.26 (0.28)	0.06 / 0.72
	<i>Social Cognition</i>	0.04 (0.08)	0.65 / 0.98	0.09 (0.08)	0.27 / 0.94	0.02 (0.06)	0.58 / 0.96	0.06 (0.07)	0.1 / 0.74
	<i>Social Communication</i>	-0.01 (0.03)	0.61 / 0.98	0.02 (0.03)	0.52 / 0.94	0 (0.02)	0.86 / 0.96	0.01 (0.03)	0.29 / 0.74
	<i>Social Motivation</i>	0.01 (0.03)	0.79 / 0.98	0.03 (0.03)	0.35 / 0.94	0.02 (0.02)	0.06 / 0.78	0.02 (0.03)	0.21 / 0.74
	<i>Repetitive Behaviour (RRB)</i>	-0.01 (0.04)	0.8 / 0.98	0.03 (0.03)	0.4 / 0.94	0 (0.03)	0.8 / 0.96	0.01 (0.03)	0.74 / 0.74

*Hospital Anxiety and Depression Scale (HADS). CBCL = Child Behaviour Checklist; WPPSI = Wechsler Primary and Preschool Scales of Intelligence; BRIEF-P = Behaviour Rating Inventory Of Executive Function, Preschool Version; SRS = Social Responsiveness Scale.

6. Synthesis, discussion and perspectives

This chapter presents a general discussion of the findings from this thesis in relation to the current literature. I will first present an overall synthesis of our results, starting with the prevalence, detection and perception paternal mental health itself, followed by a subsequent discussion on the relationship between fathers' mental health and their child's development, with specific reflection of the methodological limitations of the included work, and terminating with a discussion of the implications of these findings and international perspectives for future research.

6.1. Overall synthesis of results

Amongst first-time fathers in France, the prevalence of self-declared paternal mental illness (PMI) appears slightly lower than global perinatal averages, with self-declared anxiety (averaging 6.5%) exceeding that of depression (~2.7%). However, symptom scores (CES-D/GHQ-12) indicate a high rate of clinically significant psychological distress (~25.2%). We provided one of few studies to have investigated PMI beyond the perinatal period, with a particularly unique inclusion of pre-conception data. Symptoms of PMI appear to increase two years before father's first child's arrival, and improve two to three years following, thus falling at a crucial period for child development (55). Non-resident, unemployed or older fathers were at increased risk of worsening mental health over time, as well as those who themselves had experienced adverse childhood experiences.

Overall, the literature shows a significant relationship between PMI and child development [OR: 1.54; 95% CI (1.36–1.74)], with grouped meta-analyses seeing no difference between internalising (OR: 1.62; 95% CI: [1.27–2.08]) and externalising (OR: 1.63; 95% CI: [1.28–2.08]) behaviours. However, in a sample of French families of high socioeconomic position (SEP), no significant association was seen between PMI and child socioemotional, behavioural or cognitive outcomes, although mother's professional class was seen to partially moderate this relationship. The findings throughout this thesis suggest that the relationship between PMI and child development is not specific to one particular aspect of socioemotional, behavioural or cognitive development, with little difference in effect size being seen between domains. Our results also dispute the relevance of child sex or gender in this relationship, however, in line with the literature, children in families with low SEP appear to be at greater risk for adverse outcomes.

6.2. Paternal mental health: Where are we now?

6.2.1. General prevalence

In Chapters 3 and 5, the prevalence rates seen for both paternal depression and anxiety appear to be lower than those of the French general male population. Although in Chapter 5 our sample was small and particularly unrepresentative of fathers in France, Chapter 3 used data from CONSTANCES and is relatively comparable to the demographics we may expect amongst new fathers. The grouped prevalence of self-declared mental illness across the study period averaged 7.9%, with 6.5% suffering from anxiety and 2.7% depression. Within the French male population, a health survey from 2013-2015 found the rate of depression was roughly 4.8% (515), with another seeing the average prevalence of anxiety disorders from 1999-2003 was estimated to be 17.5% (516). More recent prevalence data in France shows even higher rates (94), however these studies were conducted in the context of the COVID-19 pandemic which occurred after our main periods of data collection, therefore rendering these figures less comparable. Whilst we saw rates of all mental illnesses to increase following participants' transition into fatherhood, rising to 7.8% for anxiety and 3.3% depression, these rates still fall lower than the apparent national average. However, when looking at clinically significant symptom scores, the average rate was 25.2% across the four years following fathers' first child's arrival. Not only does this exceed national rates of both depression and anxiety amongst men in France, but the aforementioned health survey (515) relied on the Patient Health Questionnaire (PHQ-8), also a self-administered symptom scale. Chapter 3's prevalence based on symptom scores is thus arguably more comparable. As further evidence for increased risk of mental illness amongst fathers, within our study population, the average rate pre-fatherhood of clinically significant symptoms was just 18.3%. Our findings thus suggest that symptoms of common mental illness increased following the transition to fatherhood.

6.2.2. Longitudinal trajectories of PMI

Few studies have been conducted on the longitudinal progression of father's mental health. In using group-based modelling, we were able to identify meaningful subgroups of longitudinal mental health trajectories amongst first-time fathers. For self-declared mental illness (depression and/or anxiety), the majority (~90%) of fathers were grouped as consistently low risk, which aligns with previous trajectory studies (98,518,519). However, the remaining 10% showed either a temporary, high increase in risk around two

years prior to their child's arrival, followed by a decline from 2-3 years following, or a consistently high risk. This suggests that approximately 10% of fathers in France are at high risk of mental illness during the perinatal period. Additionally, when looking at fathers' symptom scores, 25% of fathers fell into the moderate-risk category, as opposed to the low-risk group. Furthermore, all fathers showed an increase in symptom scores from roughly two years before their child's arrival until 2-3 years after. Thus, both self-reported mental illness and symptom scores appear to begin rising approximately two years prior to their first child's arrival.

These findings are important, as we provide one of the only studies to have investigated father's mental health prior to the prenatal period. It is possible that the increase in PMI seen pre-conception actually represents a return to baseline following a prior temporary improvement in mental health. Studies indicate that in Europe, people most commonly have children following several few years of cohabitation and/or marriage to their partner (520,521). Both being in a relationship and cohabiting with one's partner are known to be beneficial to mental health, particularly so for men (522,523). It is possible that men's mental health may have thus temporarily improved in the years preceding the observed prenatal decrease. In support of this, one of the only other longitudinal studies to consider PMI prior to conception (25) saw that symptoms of paternal depression significantly improved from 4 to 0 years prior to fathers' child's arrival. As expected, depressive symptoms then suddenly rose following birth. This trend was only seen for resident fathers, which aligns with our study (within which ~88% were residing with their partner). However, as data on PMI within this study was recorded at 4–5-year intervals, the observed improvement in fathers' mental health could have occurred at any point within the four years prior to birth, whilst we were able to give a more detailed insight on patterns occurring during this period. Within our study, it would have been particularly interesting to examine the percentage of people with worsening mental health prior to conception that experienced difficulties conceiving or relied on assisted reproduction, as this is a known predisposing factor for psychological distress (524) and may partially explain our pre-conception findings.

Regarding our postpartum findings, meta-analytical findings on perinatal PMI trajectories also show an increase in PMI following birth, although peaking slightly earlier at 3-6 months postpartum (15). However, this meta-analysis investigated only paternal depression. Rates may change following the inclusion of paternal anxiety, an important addition considering our finding that paternal symptoms of anxiety appear to be more common than that of depression. Moreover, the same meta-analysis also revealed the first three

postpartum months to show the lowest rate of paternal depression. Our findings were based on 12-month intervals, thus variations based on months could not be determined. However, it is possible that similar fluctuations within 1-year may have partially minimised a peak at 3-6 months. Considering the majority of PMI trajectory studies investigate only the perinatal period (15,518,519), few comparisons beyond two years are available. One study using the Longitudinal Study of Australian Children (LSAC) saw fathers report relatively little change in paternal psychological distress over time, from birth to 7-years (98). Similar to our results, 92% of fathers showed minimal distress which slightly decreased with time. However, the remaining 8% persistent and increasing distress, unlike our findings which saw symptoms of PMI decrease from 2-3 years. In a similar example, Nath et al. (102) saw paternal depressive symptoms decrease over time from 9 months to 7 years. However, these data were collected at 2-year intervals, meaning the next measurement following 9 months was at 3 years. Any temporary increase, such as we observed, occurring between 9 months to 3-years would have thus gone undetected.

6.2.3. Where to target: Fathers at risk

i. Older fathers

Within CONSTANCES, we saw that, amongst first-time parents, fathers' age was a recurring relevant factor, with those aged over 60 showing an over four-times greater likelihood of having a consistent high-risk trajectory for self-declared mental illness. However, other studies on fathers have found increased rates of depression amongst younger fathers (98,99,102). Within these studies, young fatherhood also associated with low socioeconomic status. The disparity between their results and our study may thus be explained by our sample's demographics, as socioeconomic indicators such as participants' education level were relatively high. Another possibility is that psychiatric illness amongst fathers increases the chance of delayed parenthood. These findings are important as the risk of psychiatric disorders amongst children is significantly higher in children of older fathers (335,525,526), which may be further exacerbated when they are additionally exposed to PMI. When taken into consideration together with the current trend of increasing parental age in industrialised countries, this highlights the importance in further investigating and preventing this increased vulnerability for PMI amongst older fathers (527).

ii. Non-resident fathers

The results from this thesis also highlight the relevance of non-resident fathers, with Chapter 3 revealing that not living with one's partner increased the likelihood of both a consistent high risk of declared mental illness and increased symptoms indicative of mental illness over time. Whilst this finding may result from reverse causality, in that fathers may live apart from their child due to their psychological problems, our results could also indicate that non-resident fathers are indeed more susceptible to mental illness. The literature supports this, with non-resident fathers reporting higher levels of both depression and anxiety (97,528,529); Moreover, single fathers have over double (33.6%) the risk of a common mental disorder compared to those in dual-parent households (13.3%) (93). Even outside of the context of fatherhood, living alone has been highlighted as a risk factor for anxiety disorders within the French general population (530,531). This is particularly relevant as the rates of single-parent households are rapidly increasing (94–96). In 2023, approximately 12.4% of households with dependent children in the European Union (47 million households) consisted of single parents (96), of which France contributed a particularly high rate (19.4%).

iii. Mother-father conflict and support

The increased risk for paternal mental illness in relation to not living with one's partner may also be a result of fathers' relationship to their child's mother. Unsatisfactory mother-father relationships are known to increase the risk of paternal mental health problems (33). Fathers' relationship status also associates with rates of depression, with single, separated or divorced fathers at a higher risk (13,532). When combining this with the demands of co-parenting, single fathers are especially vulnerable to reduced levels of social support, in turn associating with adverse mental health (533,534). Longitudinal findings also support this, with one study from birth to 7-years identifying low relationship satisfaction as the strongest predictor of persistent paternal psychological distress over time (98). Evidence has shown that fathers perceive informal support, such as friends and family, to be a vital source of support during parenthood (535), equally, if not more, important than that offered by midwives or healthcare professionals (33). Shorey et al. (160) saw many fathers coped by working through problems with their partners, with similar behaviours found to be an effective coping mechanism for mothers as well (536). Many also acknowledge that their family members recognised their declining mental health before they themselves had realised (11,13). And regarding child development, the mother-father relationship appears to be a key mechanism through which

children are subsequently affected (74), with one study finding marital conflict accounted for 27.4% of the total effect of paternal depression on child outcomes at age 3.5 years and 27.2% of the total effect at follow-up (37). Supporting a healthy co-parent relationship is thus a potential intervention point to help both father and child.

vi. Experienced fathers

It is important to note that in Chapter 3 we were limited to first-time fathers. Fathers' feelings and needs during the perinatal period also differ depending on if they have previously had other children or not (160,199,537), meaning that the risk factors for PMI identified in our study may be specific to first-time fathers. Being a subsequent father is also a unique risk-factor for stress, depression, and anxiety in the postnatal period (33,87,538). Interestingly, a longitudinal investigation on paternal depression saw that the exclusion of fathers who later had subsequent children seemed to strengthen the linear trend of symptoms decreasing over time (102). And indeed, in our analyses we saw the arrival of subsequent children was a risk factor for trajectories showing a consistent, high risk of mental illness. Taken together, these findings suggest subsequent births may potentially contribute to the maintenance of depressive or anxious symptoms over time.

6.3. The importance of fathers' mental health to child development

6.3.1. Overall association

Our umbrella review revealed a clear relevance of father's mental health to their child's development. Across almost all included reviews, a significant association was seen between PMI and child development, with greater symptoms of PMI corresponding to more adverse child development. This was confirmed by grouped meta-analyses, with better quality reviews showing an even stronger relationship between PMI and child outcomes. PMI associated with multiple child outcomes, including internalising and externalising behaviours, negative affect, mental health and language development. Importantly, the comparison between internalising versus externalising behaviours revealed no difference in effect size. Similarly, in Chapter 5, we examined a wide range of outcomes, spanning socioemotional, behavioural and cognitive domains, and once again saw no clear difference in effect size across outcomes. Whilst development occurs across multiple integrated pathways and behavioural levels, the categorisation of child development into isolated domains has come under criticism for obscuring the holistic nature of the individual (101). Our

finding that the relationship between PMI and child development appeared somewhat independent of developmental outcome supports this, suggesting that the interrelatedness of developmental domains may prevent highly specific, isolated effects on one sole domain. However, we found that the existing literature is primarily centred on socioemotional behaviours, with 80% of reviews focusing exclusively on socioemotional development. More investigations on cognitive domains and neurodevelopment are necessary to further understand variations in the relationship between PMI and child outcomes based on child developmental area.

Interestingly, in Chapter 5, we saw the effect size of PMI on their child's development did not differ between paternal anxiety or depression. In Chapter 4, the only meta-analysis to compare the two (44) also saw no difference in effect sizes between both diagnoses. Amongst narrative reviews, however, results varied, with one review on adolescent depression and anxiety (72) seeing significant findings only for paternal depression. However, results for all other paternal diagnoses (including anxiety) were inconclusive, as opposed to non-significant, and greatly restricted by the number of studies available. Indeed, few studies have investigated differences in the effect of PMI based on father's diagnosis. Challacombe et al. (32), in comparing paternal perinatal stress, depression and anxiety saw that only paternal stress at 3 and 24 months postpartum associated with child total problems at 24 months. Another study saw paternal anxiety and depression to impact child IQ, but only depression to predict behavioural difficulties (52). Parental psychopathology also appears to align with that of their child during adolescence, such as paternal anxiety associating with increased rates of anxiety disorders (539) and paternal depression with depressive symptoms (540) amongst father's children. Although, it must be noted that there is a tendency to investigate the same pathology within a study. Moreover, as within the general population, PMI diagnoses are highly comorbid (539). Overall, conclusions are thus hard to draw on the importance of paternal diagnosis in relation to child outcomes due to the low number of studies. Considering the prevalence of paternal anxiety seen throughout this thesis, further research comparing the impact of either paternal depression or anxiety would be particularly interesting.

Arguably one of the most unexpected findings within this thesis was the consistently non-significant relationship between PMI and child development seen in our analysis of the SEPAGES cohort data, which contrasts with findings amongst the literature we reviewed. However, it is important to note we are not the sole study reporting non-significant associations between PMI and child development. One investigation,

using a large nationally representative sample of fathers in the UK, saw that paternal depressive symptoms did not significantly predict child temperament from 9-months to 7 years old (102). Another also found fathers' depression to have no impact on child behaviour problems at 48 months (103). Some of these non-significant findings may partially result from underdiagnosis or inaccuracies in the detection of paternal mental illness (section 1.1.4). For example, men have been found to under-report their levels of depression to a greater extent than women (104,105), which could result in less accurate PMI scores, in turn contributing to smaller than expected effect sizes. Epidemiological studies (104) have also found a strong bias towards underreporting depressive symptoms in self-report measures, which some find is accentuated amongst men but results remain inconclusive (541). Interestingly, a meta-analysis on the risk of depression amongst children exposed to their father's depression saw a higher risk when PMI was defined by paternal depressive disorders as opposed to methods reliant on a nonclinical symptom scale (542). Considering our measurement of PMI in Chapter 5 was reliant on symptom scales, this may have influenced the effect sizes seen.

6.3.2. Co-occurring maternal and paternal mental illness

Another potential explanation for our non-significant findings, as well as the inconsistencies within the literature, may be that the impact of fathers' mental health is reliant on that of the co-parent. In a similar study to our own, examining both anxiety and depression in parents and assessing child outcomes at 3-years of age, only maternal mental illness associated with adverse child outcomes (106). However, PMI was seen to exacerbate anxious/depressed behaviours in young children when both parents were experiencing mental illness. This pattern is found across numerous studies; Kahn et al. (107) found that whilst paternal psychological distress exerted no effect on child behavioural and emotional problem scores from ages 3 to 12 years, having both parents experience psychological distress resulted in a greater risk of externalising problems than seen for mother's mental health alone. Similarly, Foley et al. (108) found that, unlike maternal depression, paternal depression alone was not associated with an increased likelihood of depression symptoms in their child. However, when both parents were depressed, the risk of children developing depressive symptoms was significantly higher. Finally, Saptarini et al. (109) saw the percentage of developmental delay in 3-5 year old children more than doubled (37%) in the presence of concordant parental depression, compared to when only mother (15%) or father (13%) was depressed. Again, the effect of paternal depression was only statically significant when co-occurring with maternal depression. Further

investigation on the factors mediating the impact of concurrent parental mental illness on children is necessary, as people experiencing mental illness are more likely to have a partner with a diagnosis (110,111), a tendency also confirmed amongst parents (15). This research question remains unexplored, to our knowledge, in non-heterosexual or non-monogamous coparent contexts. Taken together, these studies imply that PMI may only influence child development when maternal mental illness is also present.

In support of this, other work has shown maternal mental health to moderate the relationship between PMI and child development at later stages (542), such as cognitive development at ages 6-8 years (52) and depression in adolescent daughters (45). However, when investigating the moderating influence of mothers' mental health in Chapter 5, its influence on the relationship between PMI and child development was much weaker than expected; Following correction for multiple comparisons, mothers' mental health was seen to moderate only one association between PMI and child development, out of 126 possible associations. One could argue that our findings may have been influenced by the SEP of our sample, as more affluent or privileged families often present a greater number of protective factors available to both children and their parents, potentially buffering the effects seen in other populations (272,273). In support of this, in a similarly high SEP sample, maternal mental health was also not seen to moderate the effect of father's depression nor anxiety on child behavioural and cognitive outcomes (52). It may also be that co-occurring mental illness in co-parents impacts the child through an indirect mediator that was less applicable within our sample, for example family exposure to natural disaster or war (543,544). It is also possible that the effect of co-occurring paternal and maternal mental illness is more pertinent at later stages of development, as most of the aforementioned studies investigate children older than within our study.

6.3.3 Child sex

An important finding in both Chapters 4 and 5 was that child sex had no clear influence on the relationship between PMI and child development. This challenges the assumption that fathers have greater influence on their sons than their daughters, based on mechanisms such as identifying more closely with the same sex (3). However, there still exist numerous studies showing a clear, significant difference in effect sizes based on child sex (317,318,545–547). One explanation for this may be that child sex could act as a proxy for other predisposing or determining factors, such as differences in parenting behaviours and socialisation based on gender constructs. For example, whilst some studies have found that father involvement varies based on child sex (313,548), Santos et al. (549) saw that these variations were reliant on sex-based differences in

children's temperament. These results may also just reflect broader developmental disparities known to associate with child sex, such as earlier communication and language development (550) and advanced socioemotional development in early childhood (470) amongst girls. Additionally, research based in Occidental, industrialised societies has shown boys start to engage in significantly more physical aggression than girls from around 3-years of age (551). Interestingly, this aligns with the increased risk of conduct problems seen amongst boys exposed to PMI, as opposed to girls, in Ramchandani and colleagues study (39). Boys may thus be more susceptible to this manifestation of adverse outcomes, as results were similar for boys' and girls' emotional and behavioural outcomes. Our findings challenge the automatic inclusion of child sex as a confounding factor. Often, child sex or gender is added into analyses by default, increasing the likelihood of positive associations being found due to repeated testing (446,552). More nuanced mediators and moderators should be explored to better explain the inconsistencies surrounding the relationship between PMI and child development as an alternative to child sex.

6.3.4. Temporality of the relationship between PMI and child development

i. Prenatal versus postnatal

Chapter 4 saw paternal mental illness to frequently show larger effect sizes when occurring postnatally, as opposed to prenatally (3, 28, 39-41). However, in Chapter 5 we saw no difference in effect size based on the timing of PMI measures (prenatal and 0-12 or 12-24 months postnatal). The prenatal period remains understudied amongst fathers (34-36), with our umbrella review finding that, despite the included reviews themselves covering the entire perinatal period, prenatal diagnoses were underrepresented. Sweeney and MacBeth (25) saw only 24% (n = 5) of included studies measured paternal prenatal depression. There remains therefore uncertainty surrounding the mechanisms through which prenatal PMI may influence child development. As previously discussed (section 1.3.7), prenatal mechanisms like foetal programming are unlikely to be the main mechanism underlying the relationship between PMI and child development. Rather, PMI might impact foetal development through a multitude of contextual mediators (51) such as the pregnant mother's associated stress or wellbeing (553). Nevertheless, paternal depressive symptoms during pregnancy have been shown to increase likelihood of excessive infant crying (28), as well as higher scores on emotional symptoms scales (29, 30) and greater risk of internalising and externalising problems (31) when compared with children of fathers without depression.

If the relationship between PMI and child development relies more on changes to paternal involvement, parenting practices or direct mimicking of the child by the father, then one may expect the impact of postnatal mental illness to be greater. And indeed, accumulating research on the impact of postnatal PMI and child development is showing significant results. One review provides evidence of associations between paternal depression occurring in the postnatal period and both internalising and externalising problems from early to late childhood, with associations present in children aged 2 months to 8 years old (51). Data from the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort of over 10,000 fathers found paternal depression measured 8-weeks after birth associated with an increased chance of subsequent behavioural and emotional problems in children at 3.5 years (39) and psychiatric diagnoses at 7 years (115). Interestingly, whilst comparison of the effects of solely pre or postnatal depression on child outcomes within this cohort found no difference in effect size on child outcomes at either time-point, children exposed to paternal depression at both periods (pre and postnatal) had the highest risks of subsequent psychopathology (115). The cumulative effect of both pre and postnatal paternal mental illness on child development is worth exploring, as it may indicate beneficial targets for preventative measures.

ii. During the child's life course

Looking beyond the perinatal period, a large body of evidence indicates that children are more at risk to the adverse effects of PMI when younger; In Chapter 4, results regarding child age were heterogenous, however most commonly higher effect sizes were seen amongst younger children. This may relate to the mechanisms by which fathers' mental health can affect the child. As opposed to US-based data, which finds fathers tend to be more involved with older children than in early childhood (3), European findings show that both parents spend more time overall with their children during earlier childhood (554). If the effects of paternal mental illness on their child's development are mediated through paternal involvement, age may indeed be a moderating factor. Father-child interactions are also likely to change across the child's life course. with social activities and reading, and less personal care and play, as children age (55). The impact PMI may have on parenting may vary based on type of activity. Negative affect amongst depressed fathers, for example, has been seen to influence father's playfulness (555) and frequency of reading to their child (556). Early childhood is also crucial period of neuroplasticity, during which parents provide an essential source of support and protection against stress-inducing stimuli (310). Disruption to this support, as a result of PMI or associated factors, may thus be more impactful (557).

However, the significance of PMI is not limited to early childhood. We saw an impact of PMI on child outcomes across all ages studied in Chapter 4, thus extending until late adolescence. Paternal depression associates with an increased risk of internalising symptoms in offspring aged 11–21 years old (42, 43) as well as various psychological problems (48,558) and suicidal behaviour (5, 8, 9). Nuances surrounding the importance of child age between reviews suggest that differential effects based on child age-bracket may be in fact related more so to the chronicity and severity of PMI. A meta-analysis on the risk of depression amongst children exposed to that of fathers found higher effect sizes for lifetime exposure to paternal depression than that for depression occurring solely during postpartum or early childhood periods. To respond to these findings, directional analysis would be well received. Many reviews seen in Chapter 4 mentioned a desire for future studies to consider this (37, 38).

6.4 The importance of family socioeconomic position (SEP)

In our umbrella review we saw that the SEP of study samples was both underreported and rarely discussed. However, various determinants of SEP were significant in both of our empirical studies. Indicators of low SEP were seen to associate with worsening paternal mental health across the transition to fatherhood, as well as significantly increasing the risk of adverse child outcomes in relation to fathers' mental health. Here we discuss these findings in more detail and explore potential explanations for these findings.

6.4.1. Relevance to father's mental illness

Trajectories of increasing symptoms of fathers' mental illness were associated with both paternal unemployment and having forgone healthcare due to financial reasons. This finding is consistent with the well-known association between poverty and mental health seen across micro, meso and macro-levels (559). Higher rates of paternal mental illnesses are seen amongst more socially deprived fathers (560), with factors such as low income and living in rented accommodation associating with elevated symptoms (99,100). Unemployment is also consistently associated with mental illness amongst fathers (97,98,560); In a study investigating paternal unemployment, poverty and depression, whilst both unemployment and poverty independently associated with increased rates of paternal depressive symptoms, unemployment was found to have a much stronger impact on the likelihood of depression in fathers (177). Whilst this association may be relatively established, our findings remain pertinent, as financial inequalities continue to increase worldwide (561).

6.4.2. Child development, PMI and socioeconomic position

As highlighted in section 1.3.5, as well as Chapters 4 and 5, low SEP is also closely related to child outcomes in the context of PMI. The bidirectional effect between child developmental problems and fathers' mental health then introduces another potential pathway through which the prevalence of PMI may increase in the context of financial difficulties. There are numerous ways through which SEP may impact child development (section 1.3.7), many of which may be altered in the presence of PMI. For example, differences in father involvement based on SEP are well documented; Taking the SEP indicator used in Chapter 5 - parents' occupational class - higher skilled professions associate with fewer constraints to working hours (562), thus allowing fathers in higher-status occupations to be more involved than other fathers (275). And indeed, fathers in managerial or professional occupations have been seen to dedicate significantly more time towards childcare than fathers in other occupations (85,274). Taking education status as another indicator of SEP, we also see trends in paternal involvement, with more educated fathers appearing to spend more time with their children than those with lower levels of education (85,114,276). Increased parental involvement as a result of SEP may then increase children's exposure to their fathers' symptoms of mental illness.

The impact of PMI on child development might also be mediated through changes to parenting behaviours as a result of father's symptoms (section 1.3.7iii). Variations in paternal involvement according to SEP could thus also influence the frequency the child is exposed to these behaviours. Alongside the amount of time spend with their child, studies show differences in parenting based on parent's professional class. For example, parents in stimulating and autonomous employment have been found to use less strict or restrictive parenting, opting for more positive and responsive parenting approaches (461,563–565). SEP may then act as a buffer to certain changes in parenting behaviours typically associated with PMI. It is also possible that the level of education associated with SEP partially mediates the impact of PMI on child behaviours, as father's may have greater understanding of healthy protective behaviours for themselves or their child. Finally, higher family SEP may simply provide increased access to protective factors for the child, such as access to better schooling or variations in childcare; Inequalities in early childcare have been seen to affect child outcomes in France (566,567).

Taken together, the apparent relevance of SEP may explain the non-significant association between PMI and child development seen in Chapter 5. Interestingly, a recent study from Jones et al. (52) in a similarly high SEP sample saw greater prenatal paternal depressive symptoms actually predicted *fewer* child behavioural difficulties and better cognitive outcomes (higher IQ). In support of the relevance of SEP to this finding, the influence of fathers on their child's IQ has been seen to depend on SEP (292), with high SEP fathers making more difference to the child's IQ through paternal investment than those of low SEP. It is therefore possible that our non-significant results might then also be a result of co-occurring positive and negative effects within our sample, resulting in an overall null correlation. As in our study, maternal mental health also had no moderating effect on the relationship between PMI and child outcomes.

Interestingly, we saw the moderation by parents' professional class was only present for mother's professional class, as opposed to that of fathers. In agreement, Badini et al. (112), when investigating the association between SEP and child psychopathology, saw that whilst child behavioural symptoms were moderated by maternal SEP, that of fathers had no effect. This might be a reflection of mothers' increased presence, parenting responsibilities (113) and time commitment (114,460), still present in society. In the context of PMI, increased pressure may be placed on mothers or co-parents to work, which may in turn negatively impact the child. Studies have also shown that the more time mothers dedicate to paid work, the more equally childcare is shared between parents (276,460). It is therefore possible that mother's professional class influences the impact of PMI on child development by impacting the time fathers spend with their child. One study also saw that mothers' work experiences predicted changes in fathers' parenting behaviours (461). Finally, as seen with fathers, mothers' professional class is also likely to impact their degree of involvement. As seen (section 6.3.2), the impact of PMI on child development frequently depends on maternal factors. It could then be that the degree of maternal involvement may act as a buffer against the effects of PMI on the child. Future research should aim to take into account the SEP of both co-parents, where present, during analyses.

6.5. Reflections on methodology

The data and methods used throughout this thesis are subject to certain limitations that must be addressed. In the section below we outline the most relevant constraints, alongside the approaches taken to improve the validity, reproducibility and robustness of our findings.

6.5.1. Umbrella reviews

Decisions in clinical research and healthcare should be based on all of the available evidence to draw reliable conclusions and support policy making (122). In conducting an umbrella review, we were able to summarise an enormous body of evidence of which there was little overlap between included reviews. The association between PMI and child development was seen to span infancy to adolescence, defending the increased inclusion of fathers in research in this field. In using an umbrella review, we were able to partially counteract certain inconsistencies within the literature; For example, narratively, we saw contradictory findings based on the impact of PMI on child internalising or externalising behaviours. However, in synthesising all meta-analyses and stratifying based on these outcomes, we saw almost identical effect sizes for both internalising and externalising behaviours. This highlights the importance of including multiple child outcomes within a study, as disparities between internalising and externalising in previous studies may indicate that certain populations are more sensitive to a specific outcome. The measures used to assess child development were also highly heterogenous, indicating a degree of reliability in our findings in that they appeared consistent, independent of research methods.

6.5.2. The scope of the current literature

The scarcity of data on the topics breached in this thesis was particularly noticeable when attempting subgroup analyses. To take fathers' specific diagnosis, for example, the overall dearth of research on PMI in general until recent decades means that few reliable conclusions can be drawn from the more understudied conditions. Sub-group analyses were also limited by the underreporting of sample demographics and confounding variables such as the timing of PMI, child sex and socioeconomic position. Improved reporting of these factors in future research is necessary to understand their potential influence on the relationship between PMI and child development. This is particularly important, as all three aforementioned variables (PMI chronicity, child sex and socioeconomic position) appeared to moderate the relationship between PMI and child development in at least one review, whilst showing an inconsistent pattern of effect between reviews.

Nevertheless, 80% of the studies included in Chapter 4 were published in the last 10 years, indicating an increase in attention on the association between fathers' mental health and child development. There was very little repetition amongst the included empirical studies; The corrected covered area (CCA) of studies

included in reviews was calculated and ranked (122), and between review over-lap (CCA) was slight (3.6%). This supports the robustness of our findings, as we are less likely to have given disproportionate statistical power to multiple primary studies (568). However, this also draws questions to the efficacy of the statistical review process, in that such a high proportion of reviews failed to include all relevant literature. And indeed, our AMSTAR-2 and GRADE assessments highlighted several causes for concern, with the overall quality of reviews low and with numerous critical methodological weaknesses. This pattern is echoed across publications in epidemiology, psychiatry and paediatrics employing AMSTAR and AMSTAR-2 (569,570), as well as other domains (571), and is particularly concerning considering the relatively recent publication dates of most of our included reviews. Whilst no explicit hierarchy of evidence is unanimously accepted, systematic reviews and meta-analyses are frequently championed as the highest level of evidence (123). Considering the primarily low quality scores of reviews seen across scientific domains (569–571), increased care and scrutiny should be taken when interpreting systematic reviews results. Future research should prioritise more rigorous investigative methods. Nevertheless, despite a certain degree of reduced confidence, the quality of included reviews is not likely to invalidate our findings, as sensitivity analyses saw higher quality reviews found a stronger association between PMI and CD than lower quality reviews.

6.5.3. Population cohorts

The cohort used in Chapter 5, SEPAGES, is unrepresentative of the French population, scoring high in numerous determinants of SEP. This therefore limits the external validity of our results. However, this issue is not unique to this cohort. Response and selection bias is an issue present throughout large-scale epidemiological research, with voluntary participants often being more health conscious as well as presenting better subjective health than non-participants (572). This decreases the external validity of studies in that they may be less applicable to the general population, and has been labelled the “healthy volunteer” effect (573). Taking the UK biobank as an example, the all-cause mortality rate is roughly half that of the actual UK population (574). Nevertheless, several authors argue (572,575) that non-representativeness does not necessarily hamper the scientific validity or inference of a given study. Both articles provide several counterarguments for why representative samples are not necessary, such as that non-representative studies may permit higher follow-up rates and in turn greater statistical power, as well as enabling heterogeneity in other variables of interest. Another potential bias within both our cohorts is the Hawthorne Effect. The Hawthorne Effect is the theory that the act of being monitored within a cohort

leads to better outcomes, through behaving better due to of support as well as an increased level of perceived support. This may have contributed to the non-significance of findings seen in Chapter 5. However, whilst there is some significant evidence supporting the Hawthorne Effect, findings are heterogenous, multifaceted and currently inconclusive (576). Good study design seen to nullify the significance of the Hawthorne Effect, supporting an optimistic pathway to challenge this bias in future cohort studies (577).

6.5.4. Measures of PMI: Validity of questionnaires

As seen (section 1.1.4), there are numerous possible pathways through which men may be under or misdiagnosed in diagnostic interviews. However, our umbrella review saw that within the literature, father's mental health has been almost exclusively assessed via validated, self-report questionnaires. In Chapter 3, we also relied on validated questionnaires, using a combination of the Center for Epidemiologic Studies-Depression scale (CES-D) and the 12-item General Health Questionnaire (GHQ-12). Both the CESD and GHQ-12 have also been seen to correlate strongly with one of the only original scales developed specifically to assess the mental health of childrearing fathers, the Mental Health Scale for Childrearing Fathers (MSCF) (578). Moreover, whilst one study found the GHQ-12 to be an unreliable measure of parental mental health in early childhood (5 years following birth), this was only seen in relation to maternal data. In reviewing paternal data, the GHQ-12 was supported and even outperformed the Edinburgh Postnatal Depression Scale (EPDS) and the Zung Self-Rating Anxiety Scale (SAS) in terms of discriminant validity in one study (377). In Chapter 5, fathers' mental health was assessed using the Hospital Anxiety and Depression Scale (HADS). Comparisons of the concurrent validity of HADS and the GHQ also show the two have close to identical sensitivities and specificities (79,579,580). Thus, collectively, our measures of PMI are likely to be reliable and align well with much of the previous literature discussed in this thesis. For all measures, in both Chapters 3 and 5, their overall reliability and internal consistency was tested and confirmed by Cronbach's alpha (581)

However, a possible limitation of our study design in Chapter 3 is the combination of CES-D and GHQ-12 scores. Numerous studies have used both methods to identify different things (582); In one study, the CES-D was used to measure depression and the GHQ-12 to measure quality of life (583). In another, the CES-D recorded depression and the GHQ-12 "general psychiatric morbidity" (584). Nevertheless, in all studies the measures correlate highly with each other, including a study using both on a population of fathers (376).

The GHQ-12 has also been validated for use to screen depression in adult males, when compared to clinical diagnoses (379). Moreover, although each were used at specific waves of data collection (e.g., the CES-D in 2015 and the GHQ-12 in 2016), all time-points in our study were scaled relative to the year of each participant's child's arrival. For instance, for participants who became fathers in 2016, scores at time-point 0 were based on the GHQ-12, whereas for those who welcomed their child in 2015, CES-D scores were used. Thus, each time-point included a combination of both measures, reducing potential bias that could have arisen from relying on a single measure at a given time-point.

In relying on these tools, we were not able to further categorise our findings on symptom scores into either depression or anxiety. Considering the CES-D is specifically designed for the detection of depressive symptoms (59), it is possible that our symptom scores were more representative of depression than anxiety disorders. Seeing as father's self-declarations of mental illness showed a higher rate of anxiety than depression, our results based on CES-D/GHQ-12 scores may have therefore underestimated father's true symptoms of psychological distress. However, one study also found the CES-D, using the same cut-off score as our study (≥ 16), to show almost identical predictive value for depression and anxiety (based on *MINI* Mini international neuropsychiatric interviews), with the mean scores for each of the 20 individual CES-D items not differing between depressive and anxiety disorders (384).

6.5.5 Reporter bias

A key limitation of both our empirical findings and many of the articles included throughout this thesis is the reliance on self-reports to assess fathers' mental health. Both Chapter 3 and Chapter 5, as well as many of the articles in Chapter 4's umbrella review, used questionnaires completed by the fathers themselves. Across epidemiological studies, fathers' self-reports are consistently the most common measure of mental health assessment (51), with a 2010 review of studies on paternal depression finding 93% of studies ($n = 40$) relied on self-report measures (15). Their reduced objectivity compared to diagnostic interviews or medical records may have increased the likelihood of inaccurate findings within our investigations. Interestingly, diagnostic interviews are known to be a typically more conservative method of diagnosis than self-report questionnaires, producing lower rates of observed mental illness (51). This is supported by studies in fathers, with Paulson and Bazemore (15) finding that using questionnaire methods for identification of paternal depression in the perinatal period produced higher rates (11.0%) than interviews (4.9%), although only three studies used diagnostic interviews in this review. This may have partially

contributed to the discrepancy seen between self-declared mental illness and symptom scales seen in Chapter 3, although the self-declarations were not necessarily based on a previous diagnosis.

Regarding measures of child development, a key limitation discussed amongst studies was also often bias introduced by the method of assessment. Relying on parent reports when investigating parental mental health risks two forms of bias; firstly, parents' reduced objectivity when concerning their own children, and secondly, the potential influence of their psychological state on their observations (51). For example, a review on parental substance use disorder saw that teacher reports generated differential findings when compared to parent reports on their children's academic and socioemotional behaviour (585). Paternal symptoms of depression or anxiety could impact their perceptions of both the father-child relationship and their child's behaviours (586). However, a recent study from Sapin et al. (587) found that neither parents symptoms of depression nor anxiety impacted the validity of their reports on their child's behaviour via the Strengths and Difficulties Questionnaire. Moreover, therapists, psychologists and psychiatrists can also have underlying biases. Our analyses in Chapter 5 support this; In performing the WPPSI at 3-years, trained neuropsychologists were used. We therefore tested for shifts in the score distributions based on the reporter (418) and differences were indeed found to be significant and thus controlled for. As well as these clinical assessments, the measurement of child outcomes we used in Chapter 5 was also simultaneously conducted through validated questionnaires completed by the parents. In Chapter 4, we also saw a wide range of methods used to assess child development, including parent, teacher and self-reports, medical records, clinical assessments and National registries. No method of assessment is without its shortcomings, but the plurality of assessments used is likely to have somewhat prevented bias based on reporters of child outcomes.

However, an important bias worth mentioning in relation to assessments of child development is the common reliance on maternal reports. In some cohorts (31), this even extends to reports of the fathers' behaviour and/or involvement. For example, in the ALSPAC study (24), measures of both child behaviour and paternal non-involvement were based on maternal reports. This is an important issue with the epidemiological literature surrounding fathers. In birth cohorts, questionnaires given to the mothers are often longer and more comprehensive than those given to fathers. This was seen with both cohorts used in this thesis (SEPAGES and CONSTANCES); In SEPAGES, not only were fathers' questionnaires significantly shorter than those of mothers, but questions relating to the child, where not based on independent

examinator, were answered almost exclusively by the mother. This included questions such as “*how many days a month does a child spend with their father?*”. And in CONSTANCES, certain questions pertaining to children e.g., their birth date, were asked only in the “women’s health” section and thus exclusive to mothers. In equalising the format of questionnaires presented to all parents, not only would we reduce reporter bias based on the mothers’ interpretation of fathers’ parenting behaviours, but we may also somewhat challenge the assumed societal norm that the mother is the primary caregiver.

6.5.6. Controlling for multiple comparisons

It is important to note that when reviewing the methods for dealing with Family-wise Error Rate (FWER), there is no universally accepted approach. Recommendations are often unclear, which risks introducing bias, as authors may adapt the significance of their findings based on their choice of method (588). The preference for the classical Bonferroni approach in the literature may be partially due to its simplicity, as it is the easiest method to implement (589). Regardless of the method used, the correction for multiple comparisons has also come under criticism for potentially misrepresenting the actual reality (590). Amongst these critiques, the use of these methods is often defended only in situations where it is important not to make any type I errors at all (448,450,590). Considering the stigma surrounding parental mental illness, as well as the remaining precariousness of fathers’ position in the household (section 1.1.1) both culturally and legally, it can be argued that it was indeed important to avoid false positives in relation to our research question.

Finally, determining what qualifies as a distinct outcome is not always evident. For example, within our study, each subscale was taken as a different outcome. However, taking the CBCL for example, it is possible to group emotional reactivity, withdrawn behaviours, somatic complaints, and anxious/depressed problems categories as “internalising behaviours” and aggressive behaviour and attention problem categories as “externalising behaviours”. Had we applied this approach, we could have reduced the number of CBCL outcomes from eight to four. We instead chose to keep all subscales as they were, as with all the child assessment methods used, to allow greater conformity between measures. For example, in keeping the WPPSI and BRIEF-P subscales ungrouped, two “working memory” categories were available, thus enabling a certain degree of comparison. Nevertheless, these choices have a direct impact on the significance of findings. Both the method used to correct for multiple comparisons, and the parameters chosen, leave room for potential human bias. To counteract this bias, whether conscious or unconscious, we

conducted sensitivity analyses using all four aforementioned Family-wise Error Rate methods. The results of these analyses, which are detailed in the supplementary material of Chapter 5, showed no difference in significance across any measures.

6.5.7. Missing data

i. Attrition

Fathers are still commonly recruited via their child's mother, thus increasing the risk of certain biases such as favouring fathers with more positive co-parent relationships. Similarly, attrition in studies may reflect the deterioration of such protective factors. It is thus possible that in the majority of the included studies fathers had better mental health than the true population average. This is relevant for both father and child, as the quality of mother-father relationships has been frequently linked to their child's development (45,591). Moreover, experiences like divorce are now classified as adverse childhood experiences (592), known to in turn negatively impact child development into adulthood (593,594). This bias is likely applicable to many of the studies reviews depended on in Chapter 4. In Chapter 3, the rate of attrition amongst fathers was not calculated as the duration of the study varied based on each participant; Time Point 0 was determined based on the arrival of each father's first child's arrival, thus the period of data collection and study inclusion varied greatly between individuals. However, CONSTANCES is neither a parent-child nor birth cohort, and participation was independent of fathers' relationship to either their partner (if present) or child. This bias is thus much less applicable.

In Chapter 5, however, the cohort we used was indeed constructed based on mothers and their children. Attrition and comparison between participants and non-participating fathers is discussed in section 2.2.1. Although statistical comparison was inappropriate due to the number of fathers in each group, there was indeed a higher proportion of mothers in a relationship with their child's father amongst families with participating fathers (99%) compared to those without (94%). However, very few significant differences amongst SEPAGES children were seen in relation to child development based on their father's participation. Once participating, although attrition of fathers during the duration of the study was low (2.9%), we once again see higher rates of mothers in a relationship with the father in included families (99%) than families where the fathers dropped out (91%). This pattern is important considering the relevance of the mother-father relationship previously highlighted (sections 1.3.7; 6.3.2), for both father and child. A future approach

to challenge this bias may be to reconsider study designs, particularly for birth or parent cohorts, in recruiting fathers directly as opposed to via their child's mother.

ii. Missing or incomplete variables

In Chapter 3, we only had access to fathers' data, thus information on their partner or their child's mother's mental health was not available. Mothers' mental illness is one of the most significant risk factors for that amongst fathers (section 1.1.5) and would have thus been interesting to include as a potential covariate for fathers' mental health trajectories. However, within our study, both relationship status and satisfaction were included covariates, which may have acted as a partial proxy for mothers' mental health. We also lacked data on paternity leave. Paternity leave has been seen to associate with fathers' mental health, with one study finding the uptake of paternity leave in France reduced fathers' odds of depression (595). Within our sample, 85% of our fathers were in employment. Fathers' work obligations limit the time available for themselves (13), as well as that for help-seeking behaviours or external support (11,14). Moreover, regarding our exposure of self-reported mental illness, full-time employment is also likely to have reduced the opportunities in which fathers can be screened for mental illness during this period, thus potentially impacting fathers' awareness of their own diagnoses where present. Few studies have been done on the longitudinal impact of paternity leave on fathers' subsequent mental health. Considering the direct link to healthcare policy, more in-depth inquiry is necessary to contextualise public health decisions being made. Increases to the duration and accessibility of paid paternity leave may increase fathers' wellbeing during the period of vulnerability highlighted in Chapter 3, as well as the uptake of mental health services amongst fathers postnatally.

6.6. Implications

6.6.1. Recommendations for future research

i. Beyond the perinatal period

More long-term analyses of PMI are necessary. Currently, longitudinal studies on PMI are sparse, restricted to the perinatal period and focused primarily on mood disorders (25,518,519). The results in Chapter 3 demonstrate the value of looking at mental health trajectories over time, most notably the inclusion of the period prior to conception, a period almost non-existent in the literature on paternal mental health. Had we considered PMI only perinatally, we would have missed the preceding increase in depression and anxiety

symptoms, giving the false impression that fathers' mental health was more stable. Not all parents arrive at parenthood from the same preceding experience. A considerable number of individuals are likely to be already experiencing mental illness well before conceiving their first child. Failing to account for these pre-existing conditions can lead to an inaccurate representation of mental health patterns following the child's arrival. By considering individual's previous mental health state, we can better understand how this may impact the progression of their subsequent symptoms. This highlights the importance of considering these groups separately, as relying on cumulative averages would obscure some of these findings.

ii. Improved screening methods for paternal mental illness

We also found a considerable disparity between the rates of self-declared mental illness amongst men (averaging 8%) when compared to the actual symptoms present (averaging 22%). This difference was apparent at all time-points studied, from 4-years prior to 4-years following father's first child's arrival, suggesting a substantial rate of underdiagnosis amongst men. Numerous studies have previously highlighted the issue of underdiagnosis amongst both men and fathers (12,67,596). Although often heralded as the gold-standard of assessment, there are also numerous pathways through which misdiagnosis by healthcare professionals themselves may link to gender. Some evidence suggests individuals are more likely to be given diagnoses concordant with their respective traditional gender stereotype (597,598). For example, it has also been theorised that symptoms more distanced from certain assumed gender roles are more likely to be pathologised, e.g. aggression amongst women as opposed to that amongst men (599,600). Structured diagnostic interviews are supported as a method to partially safeguard against misdiagnosis due to clinician bias, enabling more accurate and reliable evaluations (599).

Looking specifically at the perinatal period, the screening methods used to identify perinatal mental illness often lack reflection of father-specific symptoms (section 1.1.4) (179). This is an important consideration for future research on PMI, as several studies indicate numerous gender differences between symptoms of common mental illness (92). A potential solution would be to use assessment methods designed specifically for fathers. Several father-specific scales have been developed but are not yet frequently implemented. The Mental Health Scale for Childrearing Fathers (MSCF) (578) contains items similar to the EPDS alongside those specific to childrearing fathers. The MSCF screens for both depression and anxiety and is particular in that it includes items that exclusively evaluate not only physical and mental conditions but also family

relationships and life as a father. It thus accounts for men's physical, mental, and social wellbeing. However, further progress is still required. To our knowledge, this is one of very few scales centred directly on paternal psychopathology, and it is only applicable to fathers in employment (601). More inclusive screening tools, encompassing fathers' not in employment, single fathers, or queer family dynamics, are necessary to better represent the true prevalence of paternal mental illness.

iii. Looking in the wrong place: An increased prevalence of paternal anxiety over depression

An important finding throughout this thesis was that paternal anxiety was consistently more prevalent than paternal depression. The literature supports this (86,87,602,603). Yet paternal anxiety remains considerably understudied, with current findings almost exclusively limited to the perinatal period and presenting highly heterogeneous results (88). A 2011 literature review on the range, prevalence and predictors of mental health problems experienced by fathers in the first year after their baby's birth found most articles ($n = 21$) focused on depression (604). The current bias towards investigating paternal depression instead of anxiety may thus be underestimating the levels of psychological distress amongst fathers. Expanding research to more often include paternal anxiety might also challenge the assumption that mothers are at greater risk for mental illness than fathers: One study found that although mothers showed higher rates of prenatal depression than fathers (9.7% versus 4.3%), both mothers and fathers showed the same rate of prenatal anxiety (7.8%) (32). One of the only, and most-cited, meta-analyses on paternal perinatal anxiety concludes that the prevalence is 2.4-51% (26), owing the heterogeneity in rates to the method of assessment. This further highlights the need for more research on this topic.

iv. Expanding the range of paternal diagnoses studied

A particular element lacking from empirical investigations is diversity amongst paternal diagnoses. In Chapter 4, whilst all paternal diagnoses were included except SUDs due to pharmacological interference, we were unable to stratify results based on diagnosis due to the homogeneity of investigations (60% comprising depression or affective disorders, and the remaining 40% general psychopathology). Subgroup analyses were also limited within reviews themselves, with one review (71) deciding against investigation based on certain paternal diagnoses (anti-social personality disorder, schizophrenia, bipolar disorder) due to each having under five studies. SUDs are currently the second most prevalent psychiatric disorder following mood and neurotic disorders amongst men in France (605), yet the relationship between paternal SUDs and child development is understudied. Interestingly, in Chapter 5, fathers' alcohol consumption was

tested as a potential confounding factor but did not reach significance. However, the prevalence of SUD is also closely tied to social inequalities, with low SEP resulting in higher rates (606), thus the high SEP of this population may have also driven the lack of significance. In line with section 6.5.1.i, longitudinal investigations on PMI are particularly limited to mood disorders. One of the only studies to account for other disorders saw paternal ADHD was a particularly strong risk factor for subsequent comorbid depression and anxiety (602). Considering the increasing incidence of persons diagnosed as neurodivergent (607,608), future research should aim to accommodate this in fathers. Investigating the effects of paternal diagnoses outside of depression could also help elucidate some key mechanisms through which father's psychopathology may influence children.

v. Calls for increased inclusion of father figures in research: targets for recruitment

A conscious effort to recruit more fathers would further validate and support the importance of men's role in parenting, childcare and the family unit. This thesis highlights several subpopulations of fathers that recruitment should focus on. Firstly, fathers of low socioeconomic position (SEP). As seen throughout this thesis, not only does SEP appear to be strongly associated with both fathers' mental health and child development, but also the relationship between the two. Low SEP fathers are consistently underrepresented in research, with some studies acknowledging that their findings may underestimate rates of PMI due to their lack representation of socioeconomically disadvantaged fathers (98).

The literature also lacks investigation on non-resident fathers and step-fathers (128). In Chapter 3, we saw that not living with one's partner was a pertinent risk factor for fathers' negative mental health trajectories. Considering research often only accounts for resident fathers (25), exclusion of non-resident fathers may also be contributing to an underestimation of the true prevalence of paternal mental illness. Increased attention on-resident fathers is also relevant to child-based research, as almost all research on child development has focused exclusively on fathers living with their children (10) or even just those both living with their children *and* biologically related (14). This is supported by our findings in Chapter 4. Greater inclusion of non-resident fathers is important, as father absence has been linked to significantly higher levels of child poverty (609), as well as greater child emotional distress (610), internalising and externalising behaviours (611), early-onset drug and alcohol use (612), and delinquent or antisocial behaviour (610).

Broadening investigations to include non-biological fathers is also particularly important for better understanding the presence of possible genetic mechanisms underlying the association between paternal psychopathology and child outcomes (section 1.3.7i) (128). The underrepresentation of non-biological fathers in research renders homosexual and/or father-only couples unlikely to be accounted for (87). Whilst CONSTANCES allowed for all types of fathers (e.g. non-biological, queer), no data were available on the specificities of their fatherhood status. And although SEPAGES participants are not necessarily heterosexual, the study design of a couple-child cohort for mother-father couples would have certainly introduced a bias towards heteronormativity. An increased effort should be made to better include LGBTQIA+ fathers, as research shows they face distinct mental health challenges (613–616). Moreover, whilst differential child outcomes have also been seen in relation to father's sexuality, with children of fathers identifying as gay often showing significantly better outcomes (324), one study found that variation in children's SDQ scores based on parent's sexuality disappeared following adjustment for parental psychological distress (617).

A final area that is important for future research to explore is both paternal mental illness and its relationship to child development in low- and middle-income countries. Most research on father-child relationships has primarily centred on high income countries (31,117) and thus might not be generalisable to other settings. Whilst in Chapter 5 we provided one of the first studies to present empirical data from France, this remains in the global north. Worldwide, about 95% of children under five living with developmental disabilities live in low-income and middle-income countries (118). Extending research into other countries may benefit a greater number of children and families, and increased representation is crucial in supporting those at high risk.

6.6.2. Recommendations for public health

i. Increased inclusion of fathers in healthcare and policy

The engagement and inclusion of fathers in perinatal mental health outreach and care also needs to come from top-down approaches. Fathers' mental health is often excluded from health visitors' training, leaving them feeling unprepared and ill-equipped to spot the signs (183,618). However, progressive change does appear to be taking place. In 2020, the French government formed a committee of experts to focus on the 'first 1000 days', aiming to propose a new pathway for support parents and children (619). Their first report

calls for increased attention to be made on fathers, for example in improving the current diagnostic measures for PMI (620). The prevalence of mental illness seen during the period surrounding the transition to fatherhood in Chapter 3 further defends the need for improving the care and support for men during the perinatal period. Fathers may also benefit from a more conscious, concerted effort to reach those either in full-time employment or not living with their child. Continuous perinatal healthcare services would allow for greater flexibility surrounding fathers' potential work obligations (22), for example a greater incorporation of remote access to services (160). Another avenue for increasing fathers' access to health information and consultation is directly in the workplace (621,622). However, this can only benefit fathers in employment and, considering our finding that unemployment was a particularly significant risk factor for paternal mental illness, may thus exclude those in arguably greater need.

This thesis has also highlighted the importance of mothers to both father's mental health and its impact on the child, with mother's professional status more relevant than that of fathers. Currently, fathers' partners are frequently highlighted as one of the most important forms of psychological support, with men commonly preferring this to professional help (623). Some articles showing female partners strong influence on men's health behaviours (624,625) propose that we can effectively change men's behaviour by targeting women who act as motivators of help-seeking behaviours (626). In improving the public mental health care available to fathers, we may increase the degree of health autonomy amongst fathers, as opposed to the burden of care falling on their partners (621). Numerous policy proposals have been suggested to improve equity within parenting and in the home, such as work-family approaches increasing part-time work, job sharing, and telecommuting that allow for parents to balance their work and family commitments (133,134). However, these policies disproportionately focus on mothers. Cultural assumptions relating to the division of labour and childcare have to be challenged, to create space for fathers and alleviate some of the pressure on mothers.

ii. Stigma

Another important consideration for public health and PMI is the surrounding stigmatisation. The stigma surrounding men and fathers' mental health remains present and contributes to avoidance and denial (11,13,160). Not only may this be contributing to underdiagnosis across studies, as highlighted by the results of this thesis, but touches on a more serious issue of men's reluctance to seek help (188). Supporting fathers' education, alongside global awareness of paternal mental health, may reducing the stigma during

this time and encourage fathers to seek the support they need. Interestingly, whilst the majority of fathers in qualitative research express a preference for informal support, amongst fathers that preferred formal support, a primary reason was to avoid disclosing information to their partners or close friends (13). This suggests digital or privately accessible health services may be more appealing to certain fathers. Remote healthcare services may better suit fathers still struggling with reluctance to address their mental illness publicly (13). Such services are also often more affordable (627), which is relevant considering we saw financial barriers to healthcare increased the risk of negative mental health trajectories amongst fathers.

iii. Paternal education and interventions

Our findings support the need for paternal mental health interventions during the transition to fatherhood, particularly so for the at-risk families outlined in section 6.6.1v. However, research on paternal mental health interventions remains extremely limited. A recent review saw only 10 published interventions on paternal perinatal depression, with just three finding significant effect sizes (628). None of these exclusively targeted paternal mental health, supported by a review on public health interventions targeting men that found not one single study specifically focused on mental health (621). Expanding investigations to include all mental health outcomes, Rominov et al. (629) found 11 PMI interventions, eight of which were conducted exclusively in the prenatal period. And indeed, prenatal interventions appeared the most effective, however the majority of studies did not consider the high comorbidity of mental health problems such as depression and anxiety.

Another potential approach to counteract the prevalence of paternal mental illness presented in this thesis would be to increase efforts surrounding paternal education. Studies have found fathers are often unaware of the signs of perinatal mental illness (12), expressing in several instances that they had not heard of postpartum depression until becoming a parent or receiving a diagnosis themselves (11). This may have contributed to the low rate of self-reported mental illness seen in comparison to symptom scores. Challenging these patterns is important, as fathers also appear less likely to express a desire for counselling or support than mothers (12) and employ effective, healthy coping strategies when mentally ill (630). Both men and fathers are also less likely less likely to have a primary care physician (89,90) or to declare their diagnosis to healthcare professionals (12,68,91) than women or mothers.

Chapter 3 saw symptoms of mental illness amongst first-time fathers begin to increase two years prior to their child's arrival. And indeed, research shows fathers have difficulty accessing information on external prenatal support (11). Father-focused information (e.g. leaflets or classes) would not just benefit fathers by better equipping them for the birth of their child, but might also create an environment in which fathers felt more comfortable to ask questions about their own mental health (13). Moreover, a desire for increased information about perinatal mental illness, such as descriptions of the signs and triggers, has been expressed by fathers and would be an easy measure to implement (13).

Finally, programmes supporting the role of fathers in the household may also be useful in improving paternal self-esteem and reducing feelings of anxiety (11,12,631), thus supporting both father's mental health and their child's development. Father involvement parenting programs have also been seen to improve the co-parenting relationship (632,633), one of the largest predictors of PMI (15,18–21) as well as non-resident fathers' involvement with their children (634,635). Targeting both parents simultaneously may also be beneficial. One effective family-based intervention on children's behavioural outcomes in relation to either a mother or father with mood disorders (with a 57.8% male sample of parents) (558) saw 34% the initially non-targeted parents within the families had a incidence of lifetime mood disorder as well.

Conclusion

This thesis investigated the prevalence and risk factors of paternal mental illness (PMI) in France, alongside its relationship to child socioemotional, cognitive and behavioural development. We provided one of very few studies to have investigated paternal mental illness beyond the perinatal period, with a particularly unique inclusion of pre-conception data. In doing so, we found that father's mental health appeared to worsen from roughly two-years prior to the child's arrival amongst first-time fathers in France. One in four (25%) fathers showed symptom scores indicative of psychological distress across the four years following fathers' first child's arrival, compared to 18% pre-fatherhood. Our results suggest a consistent, high rate of undiagnosed symptoms of mental illness amongst fathers, calling for reflection on the current screening methods and diagnostic tools.

A particularly important finding was the relevance of paternal anxiety. Symptoms of anxiety were consistently more prevalent amongst fathers than depression, despite receiving comparatively far less attention and inclusion in research. Increased inclusion of anxious disorders in research on father's mental health, and ultimately public health interventions and support, is also particularly important considering the impact seen on child outcomes. The relationship between PMI and child development was significant within our meta-analyses, and did not appear to vary significantly based on child outcome, within the context of socioemotional, behavioural and cognitive development.

In agreement with the current literature, this thesis also highlights the importance of socioeconomic position (SEP) for both paternal mental health and its relationship to child development. Low SEP significantly increased the risk of PMI and adverse child outcomes in relation to fathers' mental health. Fathers of low SEP are also at greater risk of mental illness, despite being frequently underrepresented in research. Future studies would benefit from targeted recruitment of families of low SEP, as well as non-biological and non-resident fathers. A cultural shift towards the inclusion of fathers as independently valid parties would benefit both the father, child and surrounding family. However, ideally, research on child development should account for the entire family unit, as neither mother nor father exist in isolation. Finally, as the mechanisms underpinning the relationship between paternal mental illness and child development remain unclear and effective preventative methods are yet to be developed, more longitudinal analyses are needed to investigate the progression of this relationship over time.

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Appendix and Supplementary data

Appendix Table 1 – Comparison of fathers who participated in the SEPAGES cohort with those whose family participated but chose not to participate, as well as that were lost due to attrition during the study period. *SEPAGES cohort*.

		Father participation (since inclusion)			Father drop-out (during the study)		
		No	Yes	p	No	Yes	p
Child sex at birth	<i>Female</i>	29 (42.0)	193 (47.1)	0.518	188 (47.2)	5 (41.7)	0.930
	<i>Male</i>	40 (58.0)	217 (52.9)		210 (52.8)	7 (58.3)	
Father's age at inclusion, years	<i>Mean (SD)</i>	-	-	-	34.9 (5.1)	36.4 (7.5)	0.352
Father's ethnicity	<i>White</i>	-	-	-	378 (95.0)	12 (100.0)	NA*
	<i>Other</i>	-	-	-	20 (5.0)		
Father's level of education	<i>Baccalaureate +5 and more</i>	-	-	-	186 (64.1)	3 (75.0)	NA*
	<i>Baccalaureate +3 to 4 years</i>	-	-	-	49 (16.9)	0 (0.0)	
	<i>Baccalaureate or lower</i>	-	-	-	55 (19.0)	1 (25.0)	
Father employment status - T2	<i>Employed</i>	-	-	-	276 (93.9)	4 (100.0)	NA*
	<i>Unemployed (including paternity or sick leave)</i>	-	-	-	18 (6.1)	0 (0.0)	
Father employment status - T3	<i>Employed</i>	-	-	-	241 (97.9)	2 (100.0)	NA*
	<i>Unemployed</i>	-	-	-	5 (2.0)	0 (0.0)	
Father professional skill class	<i>Skill level 1</i>	-	-	-	3 (1.0)	0 (0.0)	NA*
	<i>Skill level 2</i>	-	-	-	37 (12.8)	0 (0.0)	
	<i>Skill level 3-4</i>	-	-	-	246 (85.4)	4 (100.0)	
	<i>Armed forces</i>	-	-	-	2 (0.7)	0 (0.0)	
Father's weight (kg) - 1 year	<i>Mean (SD)</i>	-	-	-	73.9 (10.3)	71.5 (16.3)	0.740
Mother relationship status- T1	<i>In relationship with father</i>	63 (94.0)	391 (99.0)	NA*	381 (99.2)	10 (90.9)	NA*
	<i>Not in relationship with father</i>	4 (6.0)	4 (1.0)		3 (0.8)	1 (9.1)	
Mother's age at conception, years	<i>Mean (SD)</i>	32.1 (3.9)	32.6 (3.9)	0.358	32.5 (3.8)	34.0 (4.0)	0.185
Mother's ethnicity	<i>White</i>	54 (91.5)	391 (96.8)	0.112	381 (96.7)	10 (100.0)	NA*
	<i>Other</i>	5 (8.5)	13 (3.2)		13 (3.3)		
Mother's level of education	<i>Baccalaureate +5 and more</i>	32 (43.2)	240 (58.8)	0.002	102 (25.8)	6 (50.0)	NA*
	<i>Baccalaureate +3 to 4 years</i>	19 (25.7)	108 (26.5)		236 (59.6)	4 (33.3)	
	<i>Baccalaureate or lower</i>	23 (31.1)	60 (14.7)		58 (14.6)	2 (16.7)	

Mother employment status - T1	<i>Employed</i>	47 (87.0)	337 (86.4)	1.000	328 (86.3)	9 (90.0)	NA*
	<i>Unemployed</i>	7 (13.0)	53 (13.6)		52 (13.7)	1 (10.0)	
Mother employment status - 1 year	<i>Employed</i>	28 (93.3)	245 (95.7)	0.899	241 (95.6)	4 (100.0)	NA*
	<i>Unemployed</i>	2 (6.7)	11 (4.3)		11 (4.4)		
Mother professional skill class*	<i>Skill level 3-4</i>	40 (75.5)	346 (89.4)	0.007	338 (89.7)	8 (80.0)	NA*
	<i>Skill level 2</i>	13 (24.5)	41 (10.6)		39 (10.3)	2 (20.0)	
Mother's weight (kg) - T1	<i>Mean (SD)</i>	66.1 (11.5)	64.0 (10.7)	0.125	64.0 (10.8)	64.4 (7.5)	0.906
Mother's tobacco consumption (pregnancy)	<i>1 or less cigarettes /day</i>	51 (94.4)	357 (95.5)	NA*	349 (95.9)	8 (80.0)	NA*
	<i>Over 1 cigarette /day</i>	3 (5.6)	17 (4.5)		15 (4.1)	2 (20.0)	
Mother alcohol consumption (pregnancy)	<i>No</i>	23 (39.7)	126 (31.3)	0.380	122 (31.0)	4 (40.0)	NA*
	<i>One or less drinks per month</i>	16 (27.6)	141 (35.0)		139 (35.4)	2 (20.0)	
	<i>Over one drink per month</i>	19 (32.8)	136 (33.7)		132 (33.6)	4 (40.0)	
Mothers' prenatal mental health score (HADS, T3)	<i>Mean (SD)</i>	11.5 (6.1)	10.5 (4.8)	0.156	10.4 (4.7)	12.6 (9.0)	0.245
Mothers' postnatal mental health score (HADS, 1 year)	<i>Mean (SD)</i>	11.5 (5.3)	11.1 (4.9)	0.709	11.2 (4.9)	4.0 (0.0)	0.038
Diagnosed complications during pregnancy	<i>No</i>	60 (83.3)	361 (89.4)	0.203	350 (89.3)	11 (91.7)	NA*
	<i>Yes</i>	12 (16.7)	43 (10.6)		42 (10.7)	1 (8.3)	
Gestational duration (weeks)**	<i>Mean (SD)</i>	39.5 (1.6)	39.7 (1.5)	0.145	39.8 (1.4)	38.9 (3.5)	0.065
Birth weight (child), g	<i>Mean (SD)</i>	3351.2 (484.3)	3275.6 (448.8)	0.199	3283.4 (436.0)	2994.1 (760.7)	0.035
Delivery mode	<i>Vaginal</i>	15 (21.4)	66 (16.1)	0.358	63 (15.8)	3 (27.3)	0.547
	<i>Caesarean</i>	55 (78.6)	343 (83.9)		335 (84.2)	8 (72.7)	
Mother's parity at birth	<i>0</i>	29 (39.2)	193 (47.1)	NA*	187 (47.0)	6 (50.0)	NA*
	<i>1</i>	43 (58.1)	171 (41.7)		167 (42.0)	4 (33.3)	
	<i>2</i>	2 (2.7)	46 (11.2)		44 (11.1)	2 (16.7)	
No. of weeks breastfed before week 48	<i>Mean (SD)</i>	26.0 (16.2)	26.6 (15.9)	0.771	26.7 (15.8)	24.4 (22.2)	0.751
Number of hospitalisations between birth and 2 months old	<i>0</i>	46 (82.1)	369 (91.8)	0.0204	360 (91.6)	9 (100.0)	NA*
	<i>1+</i>	10 (17.9)	33 (8.2)		33 (8.6)	0 (0.0)	
Number of hospitalisations between 2 and 12 months old	<i>0</i>	42 (97.7)	370 (97.1)	NA*	365 (97.1)	5 (100.0)	NA*
	<i>1+</i>	1 (2.3)	11 (2.9)		11 (2.9)	0 (0.0)	

Main mode of childcare at 6 months	<i>Collective day care</i>	24 (63.2)	229 (62.7)	1.000	227 (62.9)	2 (50.0)	NA*
	<i>Other</i>	14 (36.8)	136 (37.3)		134 (37.1)	2 (50.0)	
Main mode of childcare at 12 months	<i>Collective day care</i>	33 (86.8)	293 (80.3)	0.445	290 (80.3)	3 (75.0)	NA*
	<i>Other</i>	5 (13.2)	72 (19.7)		71 (19.7)	1 (25.0)	
Number of children in household (inc. Part-time) – T1	<i>Mean (SD)</i>	0.8 (0.7)	0.7 (0.8)	0.570	0.7 (0.8)	0.7 (0.8)	0.979
Number of brothers and sisters - 1 year	<i>Mean (SD)</i>	0.7 (0.6)	0.7 (0.7)	0.713	0.7 (0.7)	1.5 (0.7)	0.131
Child Behaviour Checklist (CBCL)	<i>Emotional reactivity</i>	0.5 (0.3)	0.5 (0.3)	0.986	0.5 (0.3)	0.3 (0.4)	0.116
	<i>Anxiety/Depression</i>	0.3 (0.3)	0.3 (0.3)	0.779	0.3 (0.3)	0.3 (0.4)	0.813
	<i>Somatic complaints</i>	0.4 (0.3)	0.4 (0.3)	0.743	0.4 (0.3)	0.4 (0.1)	0.768
	<i>Withdrawn behaviour</i>	0.2 (0.3)	0.2 (0.2)	0.015	0.2 (0.2)	0.1 (0.2)	0.411
	<i>Sleep problems</i>	0.5 (0.4)	0.5 (0.3)	0.800	0.5 (0.3)	0.4 (0.3)	0.417
	<i>Attention problems</i>	0.5 (0.3)	0.5 (0.2)	0.780	0.5 (0.2)	0.3 (0.2)	0.187
	<i>Aggressive behaviour</i>	1.0 (0.3)	1.0 (0.2)	0.256	1.0 (0.2)	0.9 (0.2)	0.163
	<i>Other problems</i>	0.9 (0.3)	0.9 (0.2)	0.646	0.9 (0.2)	0.8 (0.3)	0.357
	<i>Total score</i>	33.1 (20.3)	31.9 (14.2)	0.620	32.0 (14.3)	22.5 (8.1)	0.186
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	<i>Corrected verbal comprehension index</i>	113.9 (11.8)	112.0 (11.6)	0.357	112.0 (11.6)	115.7 (23.6)	0.654
	<i>Corrected visuospatial index</i>	111.8 (11.6)	110.3 (10.7)	0.405	110.3 (10.7)	114.7 (8.0)	0.563
	<i>Corrected working memory index</i>	106.0 (11.6)	106.3 (10.7)	0.869	106.2 (10.7)	115.2 (0.3)	0.235
	<i>Corrected total Intelligence Quotient (IQ)</i>	115.2 (12.8)	112.9 (10.9)	0.206	112.8 (10.8)	121.5 (10.6)	0.259
Behaviour Rating Inventory of Executive Function, Preschool Version (BRIEF-P)	<i>Inhibitory control and impulsivity</i>	4.9 (0.7)	4.9 (0.5)	0.822	4.9 (0.5)	4.9 (0.4)	0.815
	<i>Shift</i>	1.1 (0.1)	1.1 (0.1)	0.537	1.1 (0.1)	1.1 (0.1)	0.575
	<i>Emotional control</i>	3.8 (0.5)	3.8 (0.4)	0.894	3.8 (0.4)	3.5 (0.2)	0.260
	<i>Working memory</i>	1.3 (0.1)	1.3 (0.1)	0.776	1.3 (0.1)	1.3 (0.1)	0.492
	<i>Planning/organisation</i>	3.8 (0.4)	3.7 (0.4)	0.047	3.7 (0.4)	3.9 (0.3)	0.411
Social Responsiveness Scale (SRS)	<i>Social Awareness</i>	5.4 (3.2)	5.7 (2.6)	0.632	5.7 (2.6)	5.0 (2.8)	0.727
	<i>Social Cognition</i>	2.4 (0.6)	2.4 (0.7)	0.801	2.4 (0.7)	1.9 (0.2)	0.269
	<i>Social Communication</i>	0.9 (0.2)	0.9 (0.2)	0.972	0.9 (0.2)	0.7 (0.1)	0.168
	<i>Social Motivation</i>	0.8 (0.2)	0.8 (0.3)	0.065	0.8 (0.3)	0.7 (0.1)	0.532
	<i>Repetitive Behaviour (RRB)</i>	0.6 (0.3)	0.6 (0.3)	0.733	0.6 (0.3)	0.5 (0.6)	0.553
	<i>SRS Total</i>	1.4 (0.2)	1.4 (0.2)	0.793	1.4 (0.2)	1.3 (0.0)	0.324

Appendix Table 2- Distribution of child WPPSI Scores at three years based on the psychologist (“psy”) conducting the assessment. *SEPAGES Cohort*.

WPPSI Index	n	Psy 1, n = 164 ¹	Psy 2, n = 24 ¹	Psy 3, n = 81 ¹	Psy 4, n = 26 ¹	Psy 5, n = 40 ¹	Psy 6, n = 29 ¹	Other, n = 18 ¹	p-value ²
Total IQ	381	112 (107, 121)	115 (103, 124)	110 (103, 118)	108 (103, 113)	108 (100, 117)	105 (101, 114)	111 (104, 115)	0.046
Verbal Comprehension	381	110 (104, 120)	116 (103, 123)	113 (104, 120)	115 (108, 119)	113 (103, 123)	116 (103, 121)	115 (106, 122)	>0.9
Visuospatial	382	109 (103, 120)	109 (100, 116)	106 (100, 115)	102 (94, 109)	102 (94, 112)	103 (94, 109)	106 (101, 109)	<0.001
Working Memory	380	106 (100, 112)	108 (96, 118)	106 (103, 115)	112 (102, 120)	103 (93, 112)	102 (92, 107)	100 (93, 114)	0.008

¹ Median (*Iqr*) ² Kruskal-Wallis Rank Sum Test

Appendix Table 3 – Completion of the PRISMA 2020 guideline checklist in relation to the umbrella review (Chapter 2), taken from (475).

Section and Topic	Item	Checklist item	Location where item is reported (Chapter 2)
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 2; 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 3
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 3; Supplementary Table 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Pages 3 - 4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Pages 3 - 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pages 3 - 4
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 4
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 4
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Pages 3 - 4

Appendix Table 3 – Completion of the PRISMA 2020 guideline checklist in relation to the umbrella review (Chapter 2), taken from (475).

Section and Topic	Item	Checklist item	Location where item is reported (Chapter 2)
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 4
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 4
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 4
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Page 4
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Page 4
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 4
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 4
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 5; Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Supplementary Table 2
Study characteristics	17	Cite each included study and present its characteristics.	Supplementary Table 3
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 7; Table 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Page 5; Supplementary Table 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 7;
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Pages 7-8; Figure 2; Supplementary Figure 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Pages 7 - 8
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Page 8
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Page 7; Supplementary Figure 1
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Supplementary Table 4

Appendix Table 3 – Completion of the PRISMA 2020 guideline checklist in relation to the umbrella review (Chapter 2), taken from (475).

Section and Topic	Item	Checklist item	Location where item is reported (Chapter 2)
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 8 - 11
	23b	Discuss any limitations of the evidence included in the review.	Page 11
	23c	Discuss any limitations of the review processes used.	Pages 11 - 12
	23d	Discuss implications of the results for practice, policy, and future research.	Page 12
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Page 3
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 13
Competing interests	26	Declare any competing interests of review authors.	Page 13
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Page 13

Supplementary Tables - Chapter 3 (C3)

C3 Supplementary Table 1a - Missing mental health data at each time point, where time point 0 = The year of participant's first child's arrival. *CONSTANCES cohort*.

Mental health measure	Time point (years)	Missing data - raw		Missing data - final*	
		n	%	n	%
Self-declared mental illness	-6	175	97%	-	-
	-5	436	93%	-	-
	-4	888	86%	888	86%
	-3	1709	73%	1709	72%
	-2	3093	51%	3093	50%
	-1	4307	31%	4307	30%
	0	6192	1%	6082	1%
	1	3752	40%	3742	39%
	2	2580	59%	2579	58%
	3	1605	74%	1603	74%
	4	896	86%	896	85%
	5	497	92%	-	-
	6	229	96%	-	-
Symptom scores (CES-D, GHQ-12)	-6	147	98%	-	-
	-5	458	93%	-	-
	-4	900	86%	865	84%
	-3	1296	79%	1265	77%
	-2	2737	56%	2655	52%
	-1	4751	24%	4295	23%
	0	3387	46%	3336	40%
	1	2262	64%	2254	60%
	2	1476	76%	1472	74%
	3	836	87%	836	85%
	4	488	92%	488	91%
	5	248	96%	-	-
	6	59	99%	-	-

*Having excluded all participants with less than two data points

C3 Supplementary Table 1b - Missing covariate data at each time point, where time point 0 = the year of participant's first child's arrival. *CONSTANCES cohort*.

	Factor	Self-declared mental illness									Symptom scores								
	<i>Time point (years)</i>	-4	-3	-2	-1	0	1	2	3	4	-4	-3	-2	-1	0	1	2	3	4
Included	<i>French nationality status</i>	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	<i>Employment status</i>	13%	13%	14%	15%	18%	12%	11%	10%	11%	14%	15%	14%	16%	19%	13%	12%	11%	12%
	<i>Region of birth</i>	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	1%	1%	1%	1%	1%	1%
	<i>Age</i>	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	<i>Marital status</i>	47%	47%	49%	52%	53%	51%	50%	50%	51%	49%	50%	49%	52%	54%	48%	50%	53%	49%
	<i>Living with partner</i>	12%	11%	12%	14%	17%	11%	10%	10%	10%	12%	13%	12%	15%	17%	12%	12%	12%	12%
	<i>Close relationship satisfaction</i>	81%	81%	79%	78%	79%	79%	80%	79%	78%	81%	80%	79%	78%	78%	79%	80%	79%	77%
	<i>Alcohol consumption</i>	44%	44%	45%	45%	47%	43%	42%	40%	39%	43%	45%	45%	46%	47%	43%	41%	39%	37%
	<i>Financial difficulties</i>	51%	53%	53%	51%	53%	52%	51%	49%	46%	51%	53%	52%	52%	55%	53%	52%	48%	45%
	<i>Spouse employment status</i>	24%	22%	21%	21%	24%	17%	16%	15%	15%	24%	22%	21%	21%	24%	18%	16%	15%	15%
	<i>Adverse childhood experiences</i>	16%	20%	24%	28%	31%	26%	22%	19%	15%	17%	28%	24%	29%	37%	31%	28%	27%	25%
	<i>Level of education</i>	2%	1%	2%	2%	2%	1%	1%	1%	1%	2%	1%	1%	1%	1%	1%	1%	1%	1%
	<i>Living with child</i>	56%	48%	41%	33%	35%	26%	24%	21%	19%	54%	44%	39%	31%	33%	27%	23%	21%	18%
	<i>Foregone healthcare due to financial reasons</i>	51%	52%	53%	51%	53%	52%	51%	49%	46%	50%	53%	52%	52%	55%	53%	52%	48%	45%
	<i>Parent history of psychiatric illness</i>	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	<i>Parent history of suicide/attempts</i>	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Excluded	<i>Socio-professional category</i>	87%	86%	84%	83%	83%	85%	86%	87%	88%	87%	86%	83%	84%	84%	86%	87%	88%	89%
	<i>Physical effort at work</i>	86%	84%	83%	81%	82%	84%	85%	87%	88%	86%	84%	81%	83%	82%	84%	86%	87%	89%
	<i>Family's average net monthly income</i>	79%	78%	78%	76%	77%	78%	78%	79%	78%	79%	78%	76%	77%	77%	78%	80%	78%	77%
	<i>Deprivation index (EPICES Score)</i>	80%	79%	78%	77%	78%	79%	79%	80%	80%	80%	80%	77%	78%	79%	80%	80%	80%	82%
	<i>Average hours sleep per night</i>	85%	84%	82%	81%	81%	83%	84%	85%	86%	85%	84%	82%	81%	82%	84%	85%	86%	87%

C3 Supplementary Table 2 – Comparison between the study population and a random, age-matched sample of excluded participants. *CONSTANCES cohort. chi-square and student's t-test.*

		Excluded population		Included population		p
		%	n	%	n	
Age (Years)*	<30	454	7.2%	454	7.2%	1.000
	30–34	1944	30.9%	1944	30.9%	
	35–39	1635	26.0%	1635	26.0%	
	40–44	826	13.1%	826	13.1%	
	45–49	376	6.0%	376	6.0%	
	50–59	419	6.7%	419	6.7%	
	60+	645	10.2%	645	10.2%	
Region of birth	France	5611	89.5%	5618	89.9%	0.200
	Europe	240	3.8%	229	3.7%	
	Africa	283	4.5%	298	4.8%	
	Other	135	2.2%	104	1.7%	
French Nationality status	French by birth	5737	91.8%	5734	92.0%	0.839
	Naturalised French	264	4.2%	257	4.1%	
	Foreign national	251	4.0%	239	3.8%	
Level of education	Baccalaureate + 4 and more	2669	42.6%	3053	49.3%	<0.001
	Baccalaureate + 2 or 3 years	1522	24.3%	1521	24.5%	
	Baccalaureate or equivalent diploma	926	14.8%	786	12.7%	
	Primary, Professional/vocational certificate (9-11 years)	1007	16.1%	757	12.2%	
	No diploma	142	2.3%	81	1.3%	
Parent history of psychiatric illness	No	6140	97.5%	6142	97.5%	0.955
	Yes	159	2.5%	157	2.5%	
Parent history of suicide/attempts	No	6221	98.8%	6242	99.1%	0.084
	Yes	78	1.2%	57	0.9%	
Financial difficulties	No	5494	88.6%	2581	85.9%	<0.001
	Yes	704	11.4%	424	14.1%	
Marital status	Married/Civil partnership	3550	57.6%	2347	84.3%	<0.001

	<i>Divorced/Separated</i>	341	5.5%	75	2.7%	
	<i>Unmarried (never married)</i>	2276	36.9%	362	13.0%	
Living with partner	<i>Yes</i>	4632	74.0%	5847	95.4%	<0.001
	<i>No</i>	1625	26.0%	285	4.6%	
Employment status	<i>Employed</i>	4855	79.5%	5047	82.8%	<0.001
	<i>Retired</i>	537	8.8%	518	8.5%	
	<i>Training/Education/Other</i>	205	3.4%	222	3.6%	
	<i>Unemployed</i>	509	8.3%	311	5.1%	
Spouse employment status	<i>Employed</i>	3582	77.5%	4602	78.5%	<0.001
	<i>Retired</i>	324	7.0%	332	5.7%	
	<i>Training/Education/Other</i>	407	8.8%	218	3.7%	
	<i>Unemployed</i>	311	6.7%	709	12.1%	
Alcohol consumption	<i>Moderate consumption</i>	4352	76.4%	2429	74.7%	<0.001
	<i>No consumption</i>	614	10.8%	463	14.2%	
	<i>Non-recommended consumption</i>	729	12.8%	360	11.1%	
Adverse Childhood Experiences (ACEs)	<i>None</i>	948	30.8%	1437	31.9%	0.337
	<i>Yes</i>	2130	69.2%	3072	68.1%	
Number of Adverse Childhood Experiences	<i>Mean (SD)</i>	1.8 (2.0)	1.8 (1.9)	0.209		
Close relationship satisfaction**	<i>Satisfied</i>	4297	85.5%	440	92.6%	<0.001
	<i>Unsatisfied</i>	728	14.5%	35	7.4%	
Foregone healthcare due to financial reasons	<i>No</i>	5463	88.1%	2719	90.5%	0.001
	<i>Yes</i>	739	11.9%	286	9.5%	

*N values based on participants with available data for each respective measure. *age at inclusion, for non-fathers/those excluded; age at child's arrival for fathers. **Romantic partner and/or friends and family*

C3 Supplementary Table 3 - All tested within-model orders for the trajectories of self-declared mental illness (n = 6156) and symptom scores (n = 5573) amongst first-time fathers. *CONSTANCES* cohort. Group based, latent class modelling via PROC TRAJ.

Self-Declared Mental Illness			Symptom Scores		
<i>Model</i>	<i>Groups, Order</i>	<i>BIC</i>	<i>Model</i>	<i>Groups, Order</i>	<i>BIC</i>
Model B.0	3 Groups, Order 000	-8225.13	Model A.0	2 Groups, Order 00	30141.51
Model B.1	3 Groups, Order 001	-8073.53	Model A.1	2 Groups, Order 01	30452.53
Model B.2	3 Groups, Order 002	-8077.40	Model A.2	2 Groups, Order 02	30532.41
Model B.3	3 Groups, Order 003	-8068.97	Model A.3	2 Groups, Order 03	30677.77
Model B.4	3 Groups, Order 010	-8339.75	Model A.4	2 Groups, Order 10	31458.71
Model B.5	3 Groups, Order 011	-8074.86	Model A.5	2 Groups, Order 11	31725.81
Model B.6	3 Groups, Order 012	-8078.71	Model A.6	2 Groups, Order 12	31791.51
Model B.7	3 Groups, Order 013	-8070.32	Model A.7	2 Groups, Order 13	31915.24
Model B.8	3 Groups, Order 020	-8344.11	Model A.8	2 Groups, Order 20	31829.64
Model B.9	3 Groups, Order 021	-8164.37	Model A.9	2 Groups, Order 21	32087.78
Model B.10	3 Groups, Order 022	-7971.22	Model A.10	2 Groups, Order 22	32142.95
Model B.11	3 Groups, Order 023	-7961.58	Model A.11	2 Groups, Order 23	32263.76
Model B.12	3 Groups, Order 030	-8348.48	Model A.12	2 Groups, Order 30	32656.10
Model B.13	3 Groups, Order 031	-8168.73	Model A.13	2 Groups, Order 31	32906.43
Model B.14	3 Groups, Order 032	-8168.41	Model A.14	2 Groups, Order 32	32959.09
Model B.15	3 Groups, Order 033	-8038.15	Model A.15	2 Groups, Order 33	33064.47
Model B.16	3 Groups, Order 100	-8339.75			
Model B.17	3 Groups, Order 101	-8160.00			
Model B.18	3 Groups, Order 102	-8159.69			
Model B.19	3 Groups, Order 103	-8122.23			
Model B.20	3 Groups, Order 110	-8087.08			
Model B.21	3 Groups, Order 111	-8149.48			
Model B.22	3 Groups, Order 112	-8046.31			
Model B.23	3 Groups, Order 113	-8050.54			
Model B.24	3 Groups, Order 120	-8297.54			
Model B.25	3 Groups, Order 121	-8153.85			
Model B.26	3 Groups, Order 122	-7946.05			
Model B.27	3 Groups, Order 123	-7950.28			
Model B.28	3 Groups, Order 130	-8301.90			
Model B.29	3 Groups, Order 131	-8158.21			
Model B.30	3 Groups, Order 132	-8160.31			
Model B.31	3 Groups, Order 133	-7945.17			
Model B.32	3 Groups, Order 200	-8344.11			
Model B.33	3 Groups, Order 201	-8164.37			
Model B.34	3 Groups, Order 202	-7740.66			
Model B.35	3 Groups, Order 203	-7737.77			
Model B.36	3 Groups, Order 210	-8297.54			
Model B.37	3 Groups, Order 211	-8153.85			
Model B.38	3 Groups, Order 212	-7749.94			
Model B.39	3 Groups, Order 213	-7754.22			
Model B.40	3 Groups, Order 220	-7679.21			
Model B.41	3 Groups, Order 221	-7681.41			
Model B.42	3 Groups, Order 222	-7684.79			

Model B.43	3 Groups, Order 223	-7681.60
Model B.44	3 Groups, Order 230	-7962.83
Model B.45	3 Groups, Order 231	-7900.12
Model B.46	3 Groups, Order 232	-7684.24
Model B.47	3 Groups, Order 233	-7680.63
Model B.48	3 Groups, Order 300	-8348.48
Model B.49	3 Groups, Order 301	-8168.73
Model B.50	3 Groups, Order 302	-8168.41
Model B.51	3 Groups, Order 303	-7764.80
Model B.52	3 Groups, Order 310	-8301.90
Model B.53	3 Groups, Order 311	-8158.21
Model B.54	3 Groups, Order 312	-8160.31
Model B.55	3 Groups, Order 313	-7765.48
Model B.56	3 Groups, Order 320	-9165.44
Model B.57	3 Groups, Order 321	-7680.93
Model B.58	3 Groups, Order 322	-7898.56
Model B.59	3 Groups, Order 323	-7896.91
Model B.60	3 Groups, Order 330	-9169.81
Model B.61	3 Groups, Order 331	-8650.22
Model B.62	3 Groups, Order 332	-7650.65
Model B.63	3 Groups, Order 333	-7652.52

C3 Supplementary Table 4.a - Respective trajectory model statistics for mental illness symptom scores amongst first-time fathers (n = 5573), in the nine years surrounding their child's arrival. *CONSTANCES Cohort. Latent Class Modelling via Proc Traj.*

		Model					
		3 3	3 2	3 1	3 0	2 3	2 2
% Membership (Π)	Trajectory 1	75.1%	76.0%	76.3%	78.1%	74.4%	75.4%
	Trajectory 2	24.9%	24.0%	23.7%	21.9%	25.6%	24.6%
Average Posterior Probability (Avepp)	Trajectory 1	0.979	0.980	0.980	0.982	0.978	0.978
	Trajectory 2	0.947	0.945	0.944	0.943	0.942	0.944
Odds Of Correct Classification (Occ)	Trajectory 1	15.41	15.64	15.51	14.95	15.34	14.84
	Trajectory 2	53.62	54.04	54.53	59.19	47.18	51.89

C3 Supplementary Table 4.b - Respective trajectory model statistics for self-declared mental illness amongst first-time fathers (n = 6156), in the nine years surrounding their first child's arrival. *CONSTANCES Cohort. Latent Class Modelling via Proc Traj.*

		Model								
		3 3 2	3 3 3	3 3 1	2 3 2	2 3 3	3 3 0	3 2 0	2 2 2	2 2 3
% Membership (Π)	Trajectory 1	4.7%	4.8%	1.1%	5.5%	5.6%	32.2%	21.9%	5.5%	5.6%
	Trajectory 2	90.3%	90.3%	81.8%	90.3%	90.3%	49.9%	60.1%	90.3%	90.3%
	Trajectory 3	5.0%	4.9%	17.1%	4.2%	4.1%	17.9%	17.9%	4.2%	4.1%
Average Posterior Probability (Avepp)	Trajectory 1	0.934	0.942	0.999	0.919	0.926	0.972	0.997	0.923	0.929
	Trajectory 2	0.997	0.997	0.991	0.997	0.997	0.605	0.729	0.997	0.997
	Trajectory 3	0.955	0.938	0.993	0.974	0.970	0.997	0.997	0.972	0.974
Odds Of Correct Classification (Occ)	Trajectory 1	286.24	320.29	89123.43	193.79	212.77	73.38	1079.89	205.35	219.62
	Trajectory 2	36.27	37.93	25.47	36.63	37.55	1.54	1.78	34.22	35.09
	Trajectory 3	404.86	293.61	742.97	847.02	765.15	1388.98	1388.95	793.39	852.10

Supplementary Tables - Chapter 4 (C4)

C4 Supplementary Table 1 – Search terms used across all databases (PICO table)

Population	Paternal OR Spouse OR Father* OR Dad* OR Male OR Men AND Child* OR Infant OR Offspring OR Baby OR adol* OR teen* OR youth OR juvenile OR pubescent
Perinatal Status	Pregnan* OR Post-partum OR postpartum OR Post-natal OR postnatal OR Perinatal OR perinatal OR Pre-partum OR prepartum OR Pre-natal OR prenatal OR Gestation OR Antenatal OR Birth*
Exposure	Mental OR Distress OR Psychiatry OR Worry OR Mood OR Irritab* OR Sad* OR Affect* OR Depress* OR Psycho* OR Schizo* OR Anxi* OR GAD OR Panic OR Trauma* OR Post-traum OR Post traumatic stress disorder OR Post-traumatic stress disorder OR Posttraumatic stress disorder OR PTSD OR Stress OR Obsessive Compulsive Disorder OR OCD OR Phobia OR Panic* OR Suicid* OR Emotional wellbeing
Outcome	Development OR Behavioural outcomes OR External* OR Internal* OR Socioemotional OR Psychological OR Cognitive OR Neuro* OR Attention Deficit Hyperactivity Disorder OR ADHD OR Aggressive OR Anxiety OR Mental health OR Withdrawn OR Depress* OR Affective OR Psychopatholog*
Methodology [Title]	Review OR meta-analysis OR metaanalysis OR meta analysis OR synthes*

C4 Supplementary Table 2 - List of excluded studies

Authors	Year	Title	Reason for exclusion
Abdul-Hussein et al.	2021	Early life risk and resiliency factors and their influences on developmental outcomes and disease pathways: a rapid evidence review of systematic reviews and meta-analyses	Unsuitable study design
Ahmadzadeh et al.	2021	Systematic Review and Meta-analysis of Genetically Informed Research: Associations Between Parent Anxiety and Offspring Internalizing Problems	No focus on fathers
Ahun et al.	2021	Sex differences in the association between maternal depression and child and adolescent cognitive development: a systematic review and meta-analysis	No focus on fathers
Ahun & Cote	2019	Maternal depressive symptoms and early childhood cognitive development: a review of putative environmental mediators	No focus on fathers
Araujo et al.	2020	Brazilian cohorts with potential for life-course studies: a scoping review.	No focus on fathers
Banti et al.	2009	Perinatal mood and anxiety disorders. Clinical assessment and management. A review of current literature	No focus on fathers
Barlow et al.	2015	Parent-infant psychotherapy for improving parental and infant mental health	No focus on fathers
Bee et al.	2014	The clinical effectiveness, cost-effectiveness and acceptability of community-based interventions aimed at improving or maintaining quality of life in children of parents with serious mental illness: a systematic review	No focus on fathers
Bendall et al.	2018	Childhood trauma is associated with severity of hallucinations and delusions in psychotic disorders: Results of a meta-analysis and implications for early psychosis treatment	Inadequate/no measures of paternal mental illness
Bennett et al.	2017	A realist synthesis of social connectivity interventions during transition to parenthood: The value of relationships.	Inadequate/no measures of child development
Bernhard et al.	2018	Association of trauma, Posttraumatic Stress Disorder and Conduct Disorder: A systematic review and meta-analysis	No focus on fathers
Billack et al.	2012	Epigenetic changes brought about by perinatal stressors: A brief review of the literature	Unsuitable study design
Bisiacchi & Cainelli	2021	Structural and functional brain asymmetries in the early phases of life: a scoping review	No focus on fathers

Blower et al.	2019	Psychometric Properties of Parent Outcome Measures Used in RCTs of Antenatal and Early Years Parent Programs: A Systematic Review	No focus on child
Bluett-Duncan et al.	2021	A systematic review of the association between perinatal depression and cognitive development in infancy in low and middle-income countries.	No focus on fathers
Borg Cunen et al.	2016	A review of interventions addressing the parental-fetal relationship	Inadequate/no measures of child development
Bradley & Slade	2011	A review of mental health problems in fathers following the birth of a child	Inadequate/no measures of child development
Brassett-Harknett & Butler	2007	Attention-deficit/hyperactivity disorder: an overview of the etiology and a review of the literature relating to the correlates and lifecourse outcomes for men and women.	No focus on fathers
Brown & Lau	2016	A review of the epidemiology of schizophrenia	Inadequate/no measures of paternal mental illness
Bruno et al.	2020	When Fathers Begin to Falter: A Comprehensive Review on Paternal Perinatal Depression	No focus on child
Buist	1998	Childhood abuse, postpartum depression and parenting difficulties: A literature review of associations	Unsuitable study design
Burnett et al.	2011	Prevalence of psychiatric diagnoses in preterm and full-term children, adolescents and young adults: a meta-analysis	No focus on fathers
Caldwell et al.	2021	Shame and guilt in the postnatal period: a systematic review.	Inadequate/no measures of child development
Carlsson et al.	2021	Early environmental risk factors for neurodevelopmental disorders - a systematic review of twin and sibling studies.	Inadequate/no measures of paternal mental illness
Chamberlain et al.	2019	Parenting after a history of childhood maltreatment: A scoping review and map of evidence in the perinatal period	No focus on child
Chartier & Cawthorpe	2016	From 'Big 4' to 'Big 5': A review and epidemiological study on the relationship between psychiatric disorders and World Health Organization preventable diseases	Unsuitable study design
Cheng et al.	2019	Improving autism perinatal risk factors: A systematic review.	Inadequate/no measures of paternal mental illness
Clare & Yeh	2012	Postpartum Depression in Special Populations: A Review	Unsuitable study design

Coles et al.	2021	Children's sleep and fathers' health and wellbeing: A systematic review.	Inadequate/no measures of child development
Correia & Linhares	2007	Maternal anxiety in the pre- and postnatal period: a literature review.	No focus on fathers
Crittenden	2017	Formulating autism systemically: Part 1- A review of the published literature and case assessments	Unsuitable study design
Cuijpers et al.	2015	The effects of psychological treatment of maternal depression on children and parental functioning: A meta-analysis	No focus on fathers
Cunen et al.	2017	A narrative review of interventions addressing the parental-fetal relationship	Inadequate/no measures of child development
Dadi et al.	2020	Postnatal depression and its association with adverse infant health outcomes in low-and middle-income countries: A systematic review and meta-analysis	No focus on fathers
Daniel et al.	2009	Is socioeconomic status in early life associated with drug use? A systematic review of the evidence.	Inadequate/no measures of paternal mental illness
Davies et al.	2020	Prenatal and perinatal risk and protective factors for psychosis: a systematic review and meta-analysis	No focus on child
de Kluiver et al.	2017	Paternal age and psychiatric disorders: A review	Inadequate/no measures of paternal mental illness
Dickson et al.	2018	Academic achievement and schizophrenia: A meta-analysis	No focus on fathers
do Nascimento Gabriel et al.	2020	The effects of parental depression and anxiety on child behavior from 6 to 12 years old: A review	Insufficient data
Dong et al.	2021	Early Life Factors of Schizotypal Personality Disorder in Adolescents: A Systematic Review	Inadequate/no measures of paternal mental illness
Easey & Sharp	2021	The impact of paternal alcohol, tobacco, caffeine use and physical activity on offspring mental health: a systematic review and meta-analysis	Inadequate/no measures of paternal mental illness
Edward et al.	2015	An Integrative Review of Paternal Depression	Inadequate/no measures of child development
Fang et al.	2021	Factors associated with parenting self-efficacy: A systematic review	Inadequate/no measures of child development

Fekadu Dadi et al.	2020	Antenatal depression and its association with adverse birth outcomes in low and middle-income countries: A systematic review and meta-analysis.	No focus on fathers
Field	2011	Prenatal depression effects on early development: a review.	Unsuitable study design
Field	2017	Prenatal Depression Risk Factors, Developmental Effects and Interventions: A Review.	Unsuitable study design
Field	2010	Postpartum depression effects on early interactions, parenting, and safety practices: A review	Unsuitable study design
Field	2018	Postnatal anxiety prevalence, predictors and effects on development: A narrative review	No focus on fathers
Foley & Hughes	2018	Great expectations? Do mothers' and fathers' prenatal thoughts and feelings about the infant predict parent-infant interaction quality? A meta-analytic review	Inadequate/no measures of child development
Frank et al.	2001	Growth, development, and behavior in early childhood following prenatal cocaine exposure: a systematic review.	No focus on fathers
Gao et al.	2019	A review on neuroimaging studies of genetic and environmental influences on early brain development.	No focus on fathers
Gardener et al.	2009	Prenatal risk factors for autism: comprehensive meta-analysis	Inadequate/no measures of paternal mental illness
Geetha et al.	2017	A review on generalized anxiety disorder	Unsuitable study design
Geller et al.	1998	Is juvenile obsessive-compulsive disorder a developmental subtype of the disorder? A review of the pediatric literature.	Unsuitable study design
Gillberg	2003	Deficits in attention, motor control, and perception: a brief review.	Unsuitable study design
Glynn	1984	Adolescent drug use and the family environment: A review	Unsuitable study design
Goli et al.	2021	Intergenerational influence of paternal physical activity on the offspring's brain: A systematic review and meta-analysis.	Inadequate/no measures of paternal mental illness
Grace et al.	2003	The effect of postpartum depression on child cognitive development and behavior: A review and critical analysis of the literature	No focus on fathers

Gray et al.	2018	Determinants of hair cortisol concentration in children: A systematic review	Inadequate/no measures of child development
Gressier et al.	2015	Dépression paternelle du post-partum: revue de la littérature [Paternal postpartum depression: A review]	Unsuitable study design
Gunlicks & Weissman	2008	Change in child psychopathology with improvement in parental depression: A systematic review	No focus on fathers
Hangsleben	1980	Transition to fatherhood: literature review.	Unsuitable study design
Hendricks & Liu	2012	Childbearing depression and childhood aggression: literature review.	Inadequate/no measures of paternal mental illness
Hindelang et al.	2001	Adolescent risk-taking behavior: a review of the role of parental involvement.	Inadequate/no measures of paternal mental illness
Hinshaw et al.	2021	Annual research review: Attention-deficit/hyperactivity disorder in girls and women: Underrepresentation, longitudinal processes, and key directions	No focus on fathers
Howard & Khalifeh	2020	Perinatal mental health: a review of progress and challenges.	Unsuitable study design
Huang et al.	2016	Prenatal, Perinatal and Neonatal Risk Factors for Intellectual Disability: A Systemic Review and Meta-Analysis	Inadequate/no measures of paternal mental illness
Hultman et al.	2011	Advancing paternal age and risk of autism: New evidence from a population-based study and a meta-analysis of epidemiological studies	No focus on fathers
Ilyka et al.	2021	Infant social interactions and brain development: A systematic review	Inadequate/no measures of paternal mental illness
Janeczko et al.	2020	Paternal age is affected by genetic abnormalities, perinatal complications and mental health of the offspring (Review)	Unsuitable study design
Jazayerinezhad et al.	2018	A systematic review of the effective factors in father's adaptation	No focus on child
Kearney	2008	School absenteeism and school refusal behavior in youth: A contemporary review	Unsuitable study design
Khachadourian et al.	2021	Advanced paternal age and risk of schizophrenia in offspring - Review of epidemiological findings and potential mechanisms	Inadequate/no measures of paternal mental illness

Kheir & Yoder	2019	Effects parental depression treatment on their children's mental health outcomes: Systematic review of clinical trials and observational studies	Unsuitable study design
Kim & Swain	2007	Review: Sad dads: Paternal postpartum depression	Unsuitable study design
Kingston et al.	2012	Prenatal and postpartum maternal psychological distress and infant development: a systematic review.	No focus on fathers
Kingston et al.	2015	Association between Prenatal and Postnatal Psychological Distress and Toddler Cognitive Development: A Systematic Review.	No focus on fathers
Kingston & Tough	2014	Prenatal and postnatal maternal mental health and school-age child development: A systematic review	No focus on fathers
Kittel-Schneider et al.	2021	Parental ADHD in pregnancy and the postpartum period – A systematic review	No focus on fathers
Kolevzon et al.	2007	Prenatal and perinatal risk factors for autism - A review and integration of findings	Inadequate/no measures of paternal mental illness
Korja et al.	2017	The Relations Between Maternal Prenatal Anxiety or Stress and Child's Early Negative Reactivity or Self-Regulation: A Systematic Review.	No focus on fathers
Laughlin	1989	Pre- and perinatal anthropology: A selective review	Unsuitable study design
Laurens et al.	2015	Common or distinct pathways to psychosis? A systematic review of evidence from prospective studies for developmental risk factors and antecedents of the schizophrenia spectrum disorders and affective psychoses	Inadequate/no measures of paternal mental illness
Linnet et al.	2003	Maternal Lifestyle Factors in Pregnancy Risk of Attention Deficit Hyperactivity Disorder and Associated Behaviors: Review of the Current Evidence	No focus on fathers
Lynch et al.	2021	A systematic review of transdiagnostic risk and protective factors for general and specific psychopathology in young people	Insufficient data
Mandy & Lai	2016	Annual Research Review: The role of the environment in the developmental psychopathology of autism spectrum condition	Inadequate/no measures of paternal mental illness
Manzari et al.	2019	Prenatal maternal stress and risk of neurodevelopmental disorders in the offspring: a systematic review and meta-analysis.	No focus on fathers
Martucci et al.	2021	The mother-baby bond: a systematic review about perinatal depression and child developmental disorders	No focus on fathers

McIntosh et al.	2021	Exploring Perinatal Indicators of Infant Social-Emotional Development: A Review of the Replicated Evidence	Inadequate/no measures of paternal mental illness
Memon et al.	2021	11.8 Peripartum Depression and Childhood Resilience: A Systemic Review of the Association, Moderators, and Mediators	Unsuitable study design
Mendes et al.	2012	Mothers with depression, school-age children with depression? A systematic review	No focus on fathers
Missler et al.	2021	Universal prevention of distress aimed at pregnant women: a systematic review and meta-analysis of psychological interventions	No focus on child
Montagnoli et al.	2021	Anything new about paternal contribution to reproductive outcomes? A review of the evidence	Inadequate/no measures of child development
Moran et al.	2021	The Paternal Experience of Fear of Childbirth: An Integrative Review	No focus on child
Muhle et al.	2018	The Emerging Clinical Neuroscience of Autism Spectrum Disorder: A Review.	Inadequate/no measures of paternal mental illness
Mytton et al.	2009	Unintentional injuries in school-aged children and adolescents: lessons from a systematic review of cohort studies	No focus on fathers
Nawi et al.	2021	Risk and protective factors of drug abuse among adolescents: a systematic review	Inadequate/no measures of paternal mental illness
Nazzari & Frigerio	2020	The programming role of maternal antenatal inflammation on infants' early neurodevelopment: A review of human studies: Special Section on "Translational and Neuroscience Studies in Affective Disorders"	No focus on fathers
Nettelbladt	1983	Father/son relationship during the preschool years: An integrative review with special reference to recent Swedish findings	Unsuitable study design
Nowland et al.	2021	Experiencing loneliness in parenthood: a scoping review.	Inadequate/no measures of paternal mental illness
Núñez-Regueiro & Núñez-Regueiro	2021	Identifying Salient Stressors of Adolescence: A Systematic Review and Content Analysis.	Inadequate/no measures of paternal mental illness
O'Brien et al.	2017	New fathers' perinatal depression and anxiety treatment options: An integrative review	No focus on child
O'Donoghue et al.	2016	Neighbourhood level social deprivation and the risk of psychotic disorders: a systematic review.	Inadequate/no measures of paternal mental illness

Oh et al.	2018	Systematic review of pediatric health outcomes associated with adverse childhood experiences (ACEs)	No focus on fathers
Orri et al.	2019	In-utero and perinatal influences on suicide risk: A systematic review and meta-analysis	Inadequate/no measures of paternal mental illness
Oyetunji & Chandra	2020	Postpartum stress and infant outcome: A review of current literature.	No focus on fathers
Pierce et al.	2020	Effects of parental mental illness on children's physical health: Systematic review and meta-analysis	Inadequate/no measures of child development
Poh et al.	2014	An integrative review of fathers' experiences during pregnancy and childbirth.	No focus on child
Pomatto	1981	Concerns of fathers throughout the childbearing cycle: a review of the literature.	Unsuitable study design
Prime et al.	2021	The application of positive parenting interventions to academic school readiness: A scoping review	Inadequate/no measures of paternal mental illness
Pulli et al.	2019	Prenatal exposures and infant brain: Review of magnetic resonance imaging studies and a population description analysis.	Inadequate/no measures of paternal mental illness
Ramchandani & Psychogiou	2009	Paternal psychiatric disorders and children's psychosocial development.	Unsuitable study design
Recto & Champion	2020	Psychosocial factors associated with paternal perinatal depression in the united states: A systematic review	No focus on child
Rees et al.	2019	The impact of maternal prenatal and postnatal anxiety on children's emotional problems: a systematic review.	No focus on fathers
Robinson et al.	2019	Fetal programming of neuropsychiatric disorders by maternal pregnancy depression: a systematic mini review.	No focus on fathers
Rolle et al.	2020	Prenatal Attachment and Perinatal Depression: A Systematic Review	Inadequate/no measures of child development
Rudolph	2017	Case History Risk Factors for Specific Language Impairment: A Systematic Review and Meta-Analysis.	Inadequate/no measures of paternal mental illness
Ruiz et al.	2016	Contributions of a Child's Built, Natural, and Social Environments to Their General Cognitive Ability: A Systematic Scoping Review.	Inadequate/no measures of paternal mental illness

Samadaee et al.	2021	Men's psychological and functional changes during parental transition: A review study	No focus on child
Sanger et al.	2015	Associations between postnatal maternal depression and psychological outcomes in adolescent offspring: a systematic review.	No focus on fathers
Shorey et al.	2016	Skin-to-skin contact by fathers and the impact on infant and paternal outcomes: an integrative review.	Inadequate/no measures of paternal mental illness
Shorey & Ang	2019	Experiences, needs, and perceptions of paternal involvement during the first year after their infants' birth: A meta-synthesis.	Inadequate/no measures of child development
Silva et al.	2018	Intimate partner violence during pregnancy and behavioral problems in children and adolescents: a meta-analysis.	Inadequate/no measures of paternal mental illness
Solmi et al.	2021	Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies	No focus on fathers
Su & Liu	2021	Birth cohort changes in chinese primary school students' perceptions of parental rearing patterns: A cross-temporal meta-analysis	Inadequate/no measures of paternal mental illness
Su et al.	2021	Research Review: Developmental origins of depression - a systematic review and meta-analysis	Unsuitable study design
Sui et al.	2016	The Long-Term Effects of Maternal Postnatal Depression on a Child's Intelligence Quotient: A Meta-Analysis of Prospective Cohort Studies Based on 974 Cases.	No focus on fathers
Sutherland & Brunwasser	2018	Sex Differences in Vulnerability to Prenatal Stress: A Review of the Recent Literature	No focus on fathers
Szymanska et al.	2017	Psychophysiological effects of oxytocin on parent-child interactions: A literature review on oxytocin and parent-child interactions	Inadequate/no measures of paternal mental illness
Tarsuslu et al.	2020	Postpartum Depression in Fathers and Associated Risk Factors: A Systematic Review	No focus on child
Tearne	2015	Older maternal age and child behavioral and cognitive outcomes: a review of the literature.	Inadequate/no measures of paternal mental illness
Thompson et al.	2010	What have birth cohort studies asked about genetic, pre- and perinatal exposures and child and adolescent onset mental health outcomes? A systematic review.	Unsuitable study design
Tirumalaraju et al.	2020	Risk of Depression in the Adolescent and Adult Offspring of Mothers With Perinatal Depression: A Systematic Review and Meta-analysis.	No focus on fathers

Tissot et al.	2011	Dépression post-partum maternelle et développement de l'enfant: Revue de littérature et arguments en faveur d'une approche familiale [Post-partum depression and child development: Literature review and evidences toward a family approach]	Unsuitable study design
Trombetta et al.	2021	Pre-natal Attachment and Parent-To-Infant Attachment: A Systematic Review	Inadequate/no measures of paternal mental illness
Tsuchiya et al.	2003	Risk factors in relation to an emergence of bipolar disorder: a systematic review.	Inadequate/no measures of paternal mental illness
Tuszynska-Bogucka & Nawra	2014	Paternal postnatal depression - a review	Unsuitable study design
Twenge & Nolen-Hoeksema	2002	Age, gender, race, socioeconomic status, and birth cohort differences on the Children's Depression Inventory: A meta-analysis	Inadequate/no measures of paternal mental illness
Varley	1984	Attention deficit disorder (the hyperactivity syndrome): A review of selected issues	Unsuitable study design
Wagner et al.	1996	Sex-of-sibling effects: a review. Part II. Personality and mental and physical health.	Unsuitable study design
Walther	1997	Postpartum depression: a review for perinatal social workers.	Unsuitable study design
Wang et al.	2017	Prenatal, perinatal, and postnatal factors associated with autism: A meta-analysis.	Inadequate/no measures of paternal mental illness
Wang et al.	2021	Factors Influencing Paternal Postpartum Depression: A Systematic Review and Meta-Analysis.	No focus on child
Welham et al.	2009	The antecedents of schizophrenia: a review of birth cohort studies.	Inadequate/no measures of paternal mental illness
Williams & Ross	2007	Consequences of prenatal toxin exposure for mental health in children and adolescents: a systematic review.	Inadequate/no measures of paternal mental illness
Wilson & Durbin	2010	Effects of paternal depression on fathers' parenting behaviors: A meta-analytic review	No focus on child
Woolfenden et al.	2014	A systematic review of the prevalence of parental concerns measured by the Parents' Evaluation of Developmental Status (PEDS) indicating developmental risk	No focus on fathers
Xiao & Loke	2021	The effects of co-parenting/intergenerational co-parenting interventions during the postpartum period: A systematic review.	Inadequate/no measures of paternal mental illness

C4 Supplementary Table 3 [pt. 1] - Characteristics of included systematic reviews and meta-analyses.

Study	Country	Included study characteristics	Quality assessment/ RoB tool	Summary measures	Period of PMI diagnosis	PMI diagnoses	% or no. of PMI diagnoses	Mode of PMI assessment
Ayano et al. (2019)	Australia	Observational studies, including case-control or cohort studies. No case reports, reviews, editorials, comments, letters without sufficient data and presentation abstracts	Newcastle-Ottawa quality assessment scale Publication bias: Egger's regression test and funnel plot	Random effects model meta-analyses	Diagnosis at any time (2); Diagnosis before the birth of child (1)	All mood disorders	Mood disorders (3) Unipolar depression (2)	Diagnostic interview, National registries
Cheung and Theule (2019)	Canada	Published and unpublished manuscripts	Publication bias: Egger's regression test and funnel plot	Meta-regression, Pearson's correlation coefficient (r), Fisher's z	ns	Depressive symptoms	100% Depression (52)	Self-report
Connell and Goodman (2002)	USA	No retrospective reports of child symptoms	ns	Weighted least squares regression, simple linear regression, multiple regression, meta-analyses, Fischer's z, ANOVA, chi-square, follow up contrasts	ns	General mental health grouped into: Alcohol or substance abuse, Depression, Anxiety disorders, schizophrenia, ASPD, Bipolar disorder, or "mixed"	Among relevant studies: Alcohol/Substance Abuse (29), Depression (31), Anxiety (8), Schizophrenia (3), ASPD (4), Bipolar disorder (4), Mixed (10)	Self-report (direct interview), spousal report, medical records.
Cui et al. (2020)	China	Prospective cohort studies	Newcastle-Ottawa quality assessment scale Publication bias: Egger's regression test and funnel plot	Random-effects meta-analyses	Among relevant studies: Postnatal (4), prenatal (4) and both (1)	Depression	100% Depression (9)	Self-report
Goodday et al. (2017)	Canada	No single-case studies, case-series, qualitative studies and reviews	Cochrane RoB Assessment Tool: for Non-Randomised Studies of Interventions (ACROBAT-NRSI), GRADE score	Narrative	ns	Psychopathology, defined as any DSM Axis one and two disorders and/or SRT/SRB	Among relevant studies: Suicide/psych administration (1), SRT (1), Suicide attempt (1) Psych (1), Psych/SRB (1), MDD/non-mood disorders (1), Schizophrenia (1)	Self-report, diagnostic interview, National registries
Kane and Garber (2004)	USA	Both published and unpublished studies from peer-reviewed or non-reviewed journals, conference presentations, dissertations, materials direct from authors, and book chapters	ns	Random effects meta-analyses, Pearson's coefficient (r), Fisher's z, non-iterative method of moments	ns	Depression or depressive symptoms	100% Depression (17)	Self-report

Spry et al. (2020)	Australia	Prospective longitudinal design, with PMI assessed prior to offspring outcome; for preconception PMI only, retrospective assessment also included	NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies Publication bias: Egger's regression test and funnel plot	Random effects meta-analyses, Pearson's coefficient (r), Wald tests, prediction intervals, Eigen-decomposition F	Before or during pregnancy, or up to 1 year postpartum. Among relevant studies: Prenatal: T2 - T3 Postnatal: 1.5 – 6 ms	Internalising symptoms, categorised as either depression or anxiety	Among relevant studies: Anxiety and depression (4), Depression (1), Anxiety (1)	Diagnostic interview or validated self-report scale
Stein et al. (2014)	UK	ns	ns	Narrative	Among relevant studies: Antenatal (3), postnatal (2)	Mental health, comprising: Depression, anxiety, bipolar, personality, and eating disorders, other psychoses	Among relevant studies: 100% Depression (5)	Self-report
Sweeney and MacBeth (2016)	UK	Follow-up, cohort designs. No book chapters, case studies, previous meta-analyses /systematic reviews	Agency for Healthcare Research and Quality (AHRQ) Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)	Random effects meta-analyses, Pearson's coefficient (r), Wald tests, prediction intervals, Eigen-decomposition F	18 weeks gestation to 21 years post-partum	Depression or depressive symptoms	100% Depression (21)	Self-report, diagnostic interview
Wickersham et al. (2020)	UK	No systematic reviews, grey literature, or conference abstracts. Also excluded if no primary data, or, if using secondary data, no methodology that was previously published	Newcastle-Ottawa quality assessment scale	Narrative	ns	Any mental health problem	Depression (8), Alcohol abuse (4), Anxiety (2), Non-specific psychopathology or distress (2), PTSD (2), Externalising problems (1), ASPD and ADHD (1)	Self-report, diagnostic interview, or analysis of military service data

C4 Supplementary Table 3 [pt. 2] - Characteristics of included systematic reviews and meta-analyses.

Study	Method of PMI assessment	CD outcomes	Mode of CD assessment	Method of CD assessment	No. of fathers	Child age(s)	Child gender	Total no. of studies (relevant)	Time range of studies
Ayano et al. (2019)	DSM-IV, DSM-V	Autism spectrum disorder	Diagnostic assessment or hospital records	ICD or DSM	ns	N/A but 0 -17 years in studies that reported it	ns	9 (3)	2008 - 2017
Cheung and Theule (2019)	BDI, CES-D, EPDS, SCL-90-R	Externalising behaviours: Overall externalising score or measures of aggression, antisocial behaviours, conduct problems, oppositional behaviour, and/or defiance	Parent reports, self-reports	CBCL, Teacher Rating Form, Conners' Parent and Teacher Rating Scales, and Youth Self-Report	17,854	2.5 - 18.6 years	N/A but % of females in the samples ranged from 0% to 100%	52 (52)	1985 - 2017
Connell and Goodman (2002)	ns	Internalising diagnoses, including: depressed mood, anxiety, or social withdrawal. Externalising diagnoses, including: CD, ODD, ADHD, symptoms of aggression, conduct problems, or delinquency	Self-report, parent or teacher reports, a review of medical records, or a combination of these assessment methods	ns	Internalising: 25,186 Externalising: 14,729	1.70 - 17.50 years, with an overall mean of 9.37 years (SD 3.97)	ns but stratified based on gender	230 (59)	1888–2001 But included studies: 1974- 2000
Cui et al. (2020)	EPDS, SCL-5, BSI, K6	Socioemotional and behavioural development	Self-report (direct interview), spousal report, medical records.	SDQ (8), Infant Toddler Social and Emotional Assessment (ITSEA) (2), CBCL (4)	ns	3 - 6 years	ns	9 (9)	From database inception - 2019 Among relevant studies: 2005-2015
Gooodday et al. (2017)	ICD codes, national survey, COD registry, life events questionnaire, family history screen, SCID, National mortality registry	SRT (any thoughts/ideas pertaining to ending one's life, suicide threats and plans), suicide attempts (any self-inflicted, potentially injurious behaviour with some intent to end one's life). Measures irrespective of suicidal intent were labelled as SRB	Self-report, clinical interview, National registries	National survey, child self-report questionnaire, COD registry, DISC-IV, ICD codes, KSADS	Of relevant studies: 273,299, ranging 352 - 235,395	0 - 25 years	22% - 72% female Average: 49%	54 (7)	1986 - 2017 Among relevant studies: 2002 - 2014

Kane and Garber (2004)	ns	Internalising or externalising symptoms or diagnoses	Observations, psychiatric assessment, self-report. Informant = self, parent, or teacher	Internalising: "standardized measures, such as the CBCL, or psychiatric assessment of depression or anxiety" Externalising: "standardized measures, such as the CBCL, or psychiatric assessment of conduct problems"	Internalising: 1284 Externalising: 1157	N/A but 3 - 15 years in studies that reported it	ns	23 (40 effect sizes), (17 for internal, 17 for external)	1975 - 2000
Spry et al. (2020)	Among relevant studies: STAI (2), CES-D, EPDS (3), BDI-II, BAI, HADS	Negative affectivity (NA): Negative reactivity, mood. Among relevant studies: Frustration/ irritability, fear, sadness, slow recovery from distress	Parent report or observer report	CCTI, IBQ, IBQ-R, IBQ-R VSF, DTS, ITSC, HIBRP, still-face/infant negative expression and vocalisations, maternal separation/ negative vocalisations, ECBQ, STST, EITQ Among relevant studies IBQ-R, IBQ	1235	0-1.5 years. Among relevant studies: 1-12 months	ns	45 (6)	ns but Among relevant studies: 1996 - 2019
Stein et al. (2014)	Among relevant studies: SCL-5, BSI, EPDS, K6	Emotional or behavioural problems, impaired social functioning, depression, "low development and wellbeing", internalising/externalising problems, behavioural or oppositional defiant disorder	Objective assessment / interview, questionnaire (parent or self-report)	Among relevant studies: SDQ, ITSEA, CBCL, CIS-R, DAWBA, DSM-IV	50431	6 months - 18 years Among relevant studies: 3 - 18 years	ns	21 (5)	2009 - 2014 for studies of depression; 1984 - 2014 for other disorders
Sweeney and MacBeth (2016)	ALSPAC, EPDS, BSI, K6, BDI, CES-D, GHQ, HAM-D-17, SCL-90-R	Internalising and externalising behaviours	Reliable and validated parent-report, teacher-report, self-report	ALSPAC, SDQ, CBCL/1½-5, Temperament CTs, ITQ, Rutter's revised preschool scale, DAWBA, Wessel's criteria, GRS, DOIs, SIMS-PR, TRF, MASC, CIS, C-GAS, K-SADS-PL, CDI, Buss and Durkee trait measure of antisocial behaviour, SCL-90-R	21970 ranging 9 - 10927	1 month - 21 years	ns	21 (21)	1806 - 2015 Among relevant studies: 1993-2015
Wickersham et al. (2020)	Among relevant studies: Kessler-6 (2), CES-D (2), BDI (1), Norway Mental Health Index (1), SCL-90-R (1), Harvard Trauma Questionnaire (1), Hopkins Symptom Checklist (1), ns (4)	Anxiety and depression	Parent and child reports, diagnostic interviews	CBCL, Mood and Feelings Questionnaire, Kiddie-Schedule for Affective Disorders and Schizophrenia, CGAS, SDQ, SCL-5, Social Phobia and Anxiety Inventory, SCL-90-R, Depression self-rating scale, CDI, Revised Children's Manifest Anxiety Scale	31271	11-17 years although total studies ranged 4-19 years	49% female	14	2000 - 2019

C4 Supplementary Table 3 [pt. 3] - Characteristics of included systematic reviews and meta-analyses.

Study	Location of studies	Subgroups	Confounders	Synthesis of results	Additional analyses	GRADE Confidence rating	AMSTAR Quality rating
Ayano et al. (2019)	Among relevant studies: Sweden (2), Finland (1)	PMI diagnosis, study design (cohort or case-control study) and source of comparison groups	Parental age, SES, substance use (alcohol, tobacco, or drugs), antidepressant use, and other psychiatric disorders	No apparent association between fathers affective and/or depressive disorders and CD.	None specific to PMI and CD.	VERY LOW ⊕○○○ Due to inconsistency, indirectness and imprecision	CRITICALLY LOW
Cheung and Theule (2019)	USA (42), Canada (3), Germany (2), Sweden (1), UK (4)	Recruitment method, both CD and PMI informant, the country of study, and publication type	Child gender, child age, racial/ethnic background of the child, fathers' relationship status, year of publication	The relationship between PMI and CD was significant.	Samples with higher percentage of boys, vs girls, yielded larger effects. No measurement moderators (e.g. PMI informant) nor child age, fathers' relationship status, ethnicity, when/where the study was conducted, and publication status were significant moderators.	LOW ⊕⊕○○ Due to RoB and inconsistency	CRITICALLY LOW
Connell and Goodman (2002)	ns	Alcohol or substance abuse or dependence, depression, anxiety disorders, schizophrenia, ASPD, bipolar disorder, mixed	Child gender, child age, type of parental diagnoses or child results, clinical vs non-clinically referred children, familial composition and biological status of parent, diagnosis vs symptom rating (both child and parent)	Child externalising problems were equally related to PMI and MMI. Internalising problems were more closely related to MMI than PMI. In the early and middle childhood groups, effects for MMI were larger than those for paternal. For adolescents, the effect of PMI was significantly larger than MMI.	Studies published more recently found smaller effect sizes for child externalising, but not internalising, problems. Direct father interviews yielded larger effects than studies using spousal reports or multiple informants, and spousal reports larger effects than multiple informants. Larger effects were seen among older, vs younger, children.	VERY LOW ⊕○○○ Due to RoB, inconsistency and indirectness	CRITICALLY LOW
Cui et al. (2020)	UK (4), Norway (2), Australia (1), Netherlands (1), UK and Netherlands (1)	CD output (behavioural, emotional or social problems)	Individual studies included: SES, parents' education, alcohol or tobacco use, marital status, somatic health, physical activity, father's age, MMI, birth weight, birth order, ethnicity, no. of children	Prenatal and postnatal PMI significantly associated with a higher risk of child emotional and behavioural problems. No significance seen for child social development.	Emotional and behavioural problems were more closely related to exposure in early childhood. Heterogeneity for PMI was significant for social, but not emotional and behavioural, development.	VERY LOW ⊕○○○ Due to RoB, inconsistency and imprecision	CRITICALLY LOW
Goodday et al. (2017)	Korea (1), UK (1), Denmark (1), USA (2), Sweden (1), Taiwan (1)	None specific to father-only analysis	All studies reporting adjusted results (61%) accounted for age and gender	Exposure to PMI (SA) was not associated with CD (SRT and SA). In one third of relevant studies, PMI was significantly associated with an increased risk of CD (SRT, SA, suicide).	No significant association between paternal SA occurring before age 11 years, and offspring SRT and SA at age 16/17 years.	VERY LOW ⊕○○○ Due to inconsistency, indirectness and imprecision	LOW

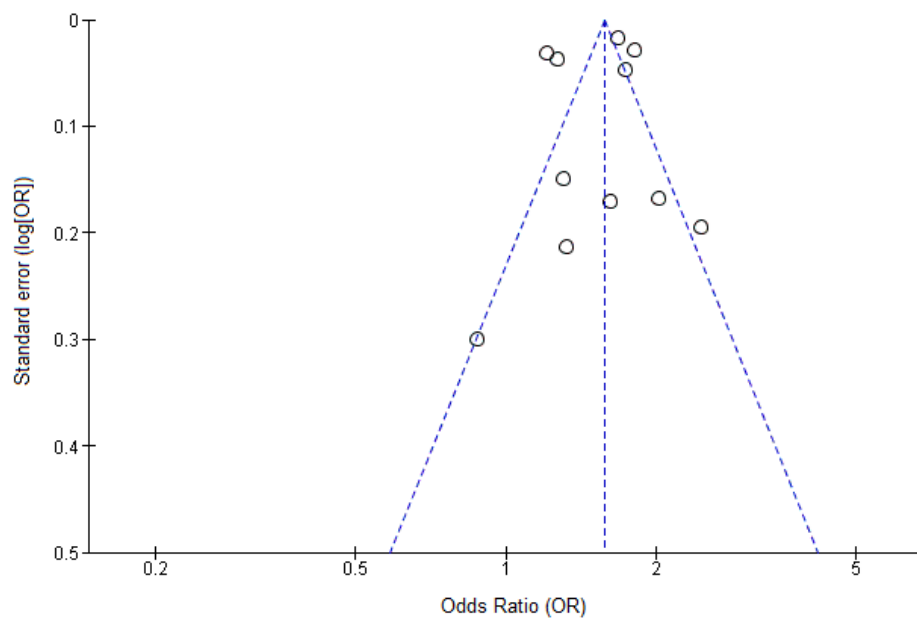
Kane and Garber (2004)	ns	CD output (Internalising or externalising symptoms), father-child conflict, CD sampling method	SES, ethnic composition, or gender composition	PMI was significantly associated to child internalising and externalising behaviours.	Sampling method and CD measure were predictors for internalising behaviours. Larger effect sizes seen for community samples and continuous measures of CD. PMI measure, CD informant, SES, ethnicity, or child gender were not significant moderators.	LOW ⊕⊕○○ Due to RoB and inconsistency	CRITICALLY LOW
Spry et al. (2020)	USA (2) Italy (1) Finland (1) China (1) Netherlands (1)	Dimension of child NA, child age, NA or PMI assessment mode, PMI diagnosis, timing of PMI symptoms	N/A	Paternal internalising symptoms were positively associated with infant NA. Associations were observed for the global NA construct, as well as an effect modification by the facet of infant NA.	Associations between PMI and CD were larger in studies where PMI was assessed postnatally rather than antenatally. No difference in effect size based on PMI diagnosis (anxiety/depression). No difference based on study publication status.	VERY LOW ⊕○○○ Due to inconsistency, indirectness and imprecision	LOW
Stein et al. (2014)	Norway (1) Netherlands (1) UK (2) Australia (1)	Prenatal family functioning, paternal education, child gender	Paternal age, education, marital status, somatic conditions, lifestyle variables, use of alcohol or tobacco, physical activity, SES, maternal education, maternal depression	Postnatal PMI associated with an increased risk of emotional and behavioural disorders for young children, language impairment, and depression at age 18 years. Antenatal PMI associated with socioemotional and behavioural problems at 3 years.	Absence of social support, and persistence of PMI, increased the risk of CD problems. Children from low SES, especially in LMICs, were more likely to be exposed to PMI. Postnatal, but not antenatal, PMI was moderated by paternal education. Postnatal PMI associated more with hyperactivity and pro-social behaviour in boys than girls, and more with emotional, conduct, and overall problems for girls.	VERY LOW ⊕○○○ Due to RoB, inconsistency and imprecision	CRITICALLY LOW
Sweeney and MacBeth (2016)	UK (10) USA (7) Australia (1) Netherlands (2) Netherlands and UK (1)	Internalising behaviour, externalising behaviour, timing of depression	Partially controlled in some studies: SES, parent age, ethnicity, education, MMI, mood, child gender, paternal hostility, anxiety, antisocial behaviour, physical health, inter-parental conflict, time of assessment, number of siblings, living situation with partner, child non-compliance, parental stress, perceived social support, subsequent PMI, birthweight, birth order, maternal prenatal alcohol or tobacco use	CD associated with both antenatal and postnatal PMI. Postnatal PMI associated with both internalising and externalising problems from early to late childhood (2 months to 8 years old). Antenatal PMI associated with emotional and behavioural problems. PMI also associated with an increased risk of adolescent (11–21yr) internalising problems.	The association between PMI and CD in offspring was stronger and more common in early childhood. The strength of this association was strongly reliant upon paternal negative expressiveness, hostility, involvement and marital conflict.	VERY LOW ⊕○○○ Due to RoB, inconsistency and imprecision	CRITICALLY LOW

Wickersham et al. (2020)	USA (5), Norway (2), Croatia (1), Canada (1), UK and Ireland (1), Netherlands (1), Bosnia/Herzegovina (1)	Maternal mental health, paternal diagnosis, child gender	Among respective studies: Child gender, ethnicity, birth weight, parent's relationship, health, child's medical care/insurance, SES, no. of children, biological relationship to child, residential area, MMI (current or past), paternal, maternal and child age, parents' alcohol use, child's depression, parents' education and employment status	Paternal depression associated with adolescent depression and anxiety. Findings relating to other PMI diagnoses were inconclusive.	In five studies child gender had no significant effect on findings. One found a greater impact of PMI among girls. One saw the effect of gender varied based on PMI diagnosis, and one based on if associations were concurrent or longitudinal. Parental rejection and low parental monitoring may mediate the pathway between PMI and adolescent internalising disorders. The effects of ethnicity, family structure and adolescent gender remain unclear.	LOW ⊕⊕○○ Due to inconsistency and indirectness	LOW
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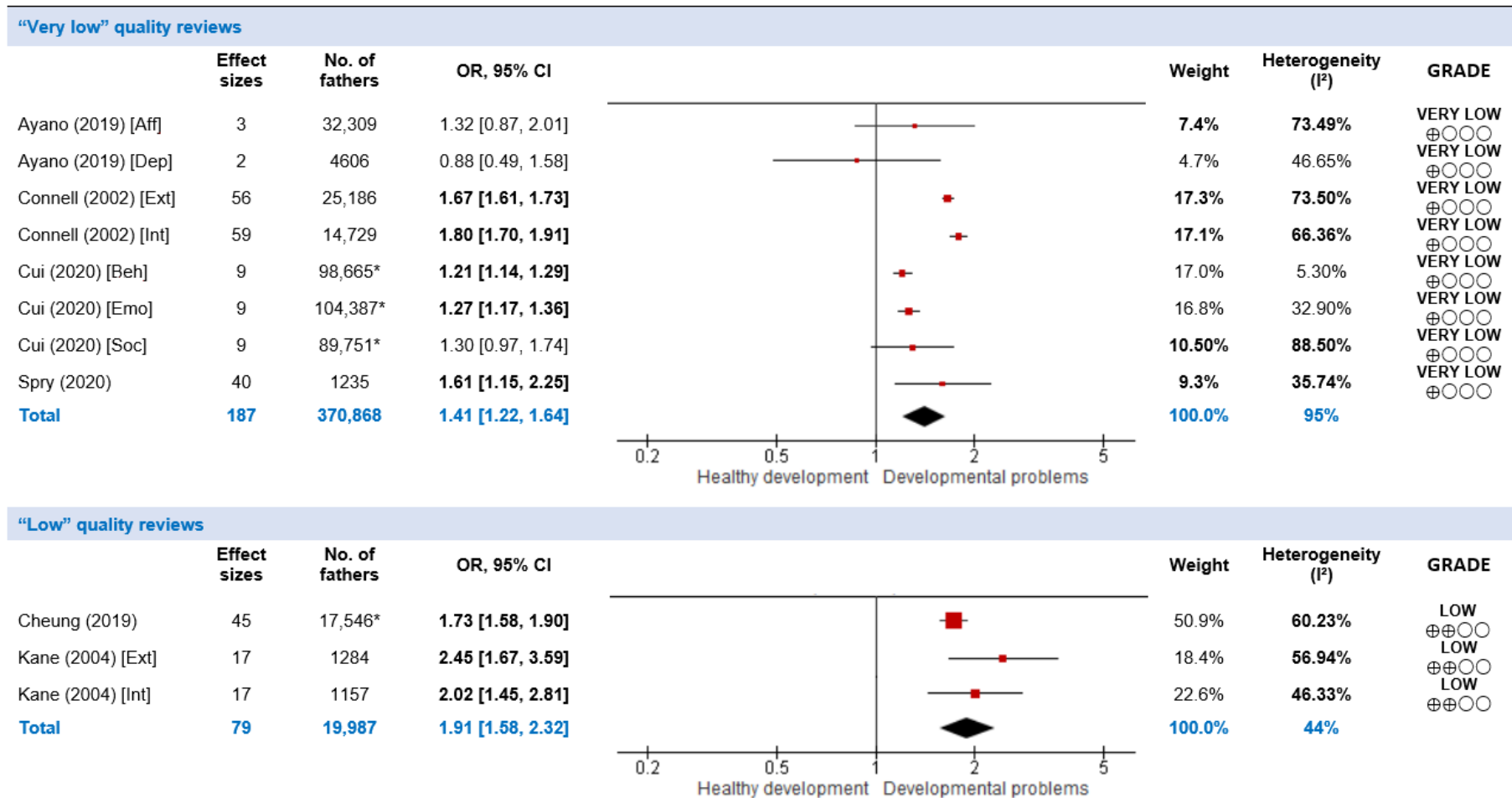
List of acronyms: ns = not specified; N/A = Authors unable to calculate due to individual studies' data; ERIC = Educational Resources Information Center; OR = Odds ratios; ASPD = Antisocial personality disorder; DSM = Diagnostic and Statistical Manual of Mental Disorders; BDI = Beck Depression Inventory; NA = negative affectivity; SES = Socioeconomic status; PPND = Paternal perinatal depression; RoB = Risk of Bias; CBCL = Child behaviour checklist; SCL = Symptom Check List; SRT = Suicide-related thoughts; SRB = Suicide-related behaviours; CGAS = Children's Global Assessment Scale; LMIC = Low to Middle Income countries; MMI = Maternal mental health

C4 Supplementary Table 4 – Results from GRADE assessment

Study	Certainty assessment					Certainty
	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	
Ayano et al. (2019)	Not serious	Serious	Serious	Serious	Considerable heterogeneity for affective disorders, wide confidence intervals for depression, inconsistencies in adjusting for confounders.	VERY LOW
Cheung and Theule (2019)	Serious	Serious	Not serious	Not serious	None	LOW
Connell and Goodman (2002)	Serious	Serious	Serious	Not serious	Focus on comparing fathers and mothers. Substantial variability remained for most groups.	VERY LOW
Cui et al. (2020)	Serious	Serious	Not serious	Serious	Large CI interval for social development, significantly varying heterogeneities. Small sample size. Reported converse findings in relation to moderators e.g. gender.	VERY LOW
Goodday et al. (2017)	Not serious	Serious	Serious	Serious	None	VERY LOW
Kane and Garber (2004)	Serious	Serious	Not serious	Not serious	Larger effect sizes in community samples; individual study variables contributed to heterogeneity in effect sizes	LOW
Spry et al. (2020)	Not serious	Serious	Serious	Serious	Used paternal internalising symptoms as a proxy for PMH. Adjustments for confounders were few and inconsistently implemented, therefore meta-analysed unadjusted results. Residual publication bias.	VERY LOW
Stein et al. (2014)	Serious	Serious	Not serious	Serious	None	VERY LOW
Sweeney and MacBeth (2016)	Serious	Serious	Not serious	Serious	Child age ≤ 21 years. High inflation of heterogeneity, which hindered conclusions.	VERY LOW
Wickersham et al. (2020)	Not serious	Serious	Not serious	Serious	None	LOW



C4 Supplementary Figure 1 - *Funnel plot with pseudo 95% CIs for all included meta-analyses*



C4 Supplementary Figure 2 - Grouped meta-analyses on the effect of paternal mental illness on child development, based on review methodological quality (GRADE score) (Randomised Effect, 95% Confidence Interval). *Calculated estimate, actual value unspecified by authors.

Supplementary Tables - Chapter 5 (C5)

C5 Supplementary Table 1 - Missing variable data within the study population (n=301); *SEPAGES* cohort

Variable	Missing
<i>Child sex at birth</i>	0.0%
<i>Father's age at inclusion, years</i>	1.3%
<i>Father's ethnicity</i>	0.0%
<i>Father's nationality</i>	4.7%
<i>Father's level of education</i>	4.7%
<i>Father employment status - T2</i>	4.7%
<i>Father employment status - 1 Year</i>	20.5%
<i>Father professional skill class</i>	6.3%
<i>Mother relationship status (T1)</i>	2.3%
<i>Father's weight (Kg) - 1 year</i>	19.7%
<i>Mother's age at conception, years</i>	0.0%
<i>Mother's nationality</i>	1.0%
<i>Mother's level of education</i>	7.0%
<i>Mother's ethnicity</i>	0.7%
<i>Mother employment status - First Trimester</i>	2.3%
<i>Mother employment status - 1 year</i>	29.0%
<i>Mother professional skill class</i>	3.3%
<i>Mother's weight (kg) - First trimester</i>	0.0%
<i>Mother's tobacco consumption during pregnancy</i>	6.3%
<i>Mother alcohol during pregnancy</i>	0.7%
<i>Mothers' prenatal mental health score (HAD, T3)</i>	3.0%
<i>Mothers' postnatal mental health score (HAD, 1 year)</i>	18.1%
<i>Diagnosed complications during pregnancy</i>	1.3%
<i>Gestational duration (weeks)*</i>	0.0%
<i>Birth weight (child), g</i>	0.0%
<i>Delivery mode</i>	0.0%
<i>Mother's parity at birth</i>	0.0%
<i>No. Of weeks breastfed before week 48</i>	2.3%
<i>Number of child hospitalisations between birth and 2 months old</i>	0.8%
<i>Number of child hospitalisations between 2 and 12 months Old</i>	2.7%
<i>Main mode of childcare at 6 months</i>	4.2%
<i>Main mode of childcare at 12 months</i>	4.2%
<i>Number of children in household (inc. Part-time) - T1</i>	6.3%
<i>Number of brothers and sisters - 1 year</i>	16.2%

T1/T2/T3= First/Second/Third Trimester.

C5 Supplementary Table 2 - Comparison of father-child demographics, mental health data and developmental outcomes between included and excluded study populations. *SEPAGES cohort. P values = Chi-square and unpaired t-test.*

		Study population (n = 301)		Excluded sample (n = 183)		p value
		n	%	n	%	
Child sex assigned at birth	Female	139	46.2%	83	46.6%	1.000
	Male	162	53.8%	95	53.4%	
Father's age at inclusion, years	Mean (SD)	35.0 (5.1)		35.0 (5.6)		0.984
Father's ethnicity	White	290	96.3%	100	91.7%	0.099
	Other	11	3.7%	9	8.3%	
Father's level of education	Baccalaureate +5 and more	185	64.5%	4	57.1%	NA ¹
	Baccalaureate +3 to 4 years	48	16.7%	1	14.3%	
	Baccalaureate or lower	54	18.8%	2	28.6%	
Father employment status - T2	Employed	269	93.7%	11	100.0%	NA ¹
	Unemployed (inc. paternity or sick leave)	18	6.3%	0	0.0%	
Father employment status - T3	Employed	241	97.9%	2	100.0%	NA ¹
	Unemployed (inc. paternity or sick leave)	13	6.2%	0	0.0%	
Father professional skill class*	Skill level 3-4	242	85.8%	8	80%	NA ¹
	Skill level 2	36	12.8%	1	10.0%	
	Skill level 1	2	0.7%	1	10.0%	
	Armed forces	2	0.7%	0	0.0%	
Father's weight (kg) - 1 year	Mean (SD)	74.0 (10.3)		70.2 (12.3)		0.416
Mother relationship status- T1	In relationship with father	294	100.0%	159	94.6%	NA ¹
	Not in relationship with father	0	0.0%	9	5.4%	
Mother's age at conception, years	Mean (SD)	32.7 (3.7)		32.1 (4.0)		0.135
Mother's ethnicity	White	289	97.0%	156	94.5%	0.295
	Other	9	3.0%	9	5.5%	
Mother's level of education	Baccalaureate +5 and more	181	60.5%	91	49.7%	0.039
	Baccalaureate +3 to 4 years	75	25.1%	52	28.4%	
	Baccalaureate or lower	43	14.4%	40	21.9%	
Mother employment status - T1	Employed	258	87.8%	126	84.0%	0.343

	<i>Unemployed</i>	36	12.2%	24	16.0%	
Mother employment status - 1 year	<i>Employed</i>	200	95.7%	73	94.8%	NA ¹
	<i>Unemployed</i>	9	4.3%	4	5.2%	
Mother professional skill class*	<i>Skill level 3-4</i>	264	90.7%	122	81.9%	0.012
	<i>Skill level 2</i>	27	9.3%	27	18.1%	
	<i>Skill level 1</i>	-	-	-	-	
	<i>Armed forces</i>	-	-	-	-	
Mother's weight (kg) - T1	<i>Mean (SD)</i>	63.7 (10.1)		65.5 (11.9)		0.066
Mother's tobacco consumption during pregnancy	<i>1 or less cigarettes /day</i>	273	96.8%	135	92.5%	0.076
	<i>Over 1 cigarette /day</i>	9	3.2%	11	7.5%	
Mother alcohol during pregnancy	<i>No</i>	91	30.4%	58	35.8%	0.366
	<i>One or less drinks per month</i>	108	36.1%	49	30.2%	
	<i>Over one drink per month</i>	100	33.4%	55	34.0%	
Mothers' prenatal mental health score (HAD, T3)	<i>Mean (SD)</i>	10.6 (4.9)		10.6 (5.2)		0.898
Mothers' postnatal mental health score (HAD, 1 year)	<i>Mean (SD)</i>	11.4 (4.9)		10.5 (4.9)		0.184
Diagnosed complications during pregnancy	<i>No</i>	266	89.6%	155	86.6%	0.404
	<i>Yes</i>	31	10.4%	24	13.4%	
Gestational duration (weeks)**	<i>Mean (SD)</i>	39.7 (1.4)		39.7 (1.8)		0.553
Birth weight (child), g	<i>Mean (SD)</i>	3278.2 (417.1)		3301.0 (512.2)		0.596
Delivery mode	<i>Vaginal</i>	259	86.0%	139	78.1%	0.034
	<i>Caesarean</i>	42	14.0%	39	21.9%	
Mother's parity at birth	<i>0</i>	142	47.2%	80	43.7%	0.759
	<i>1</i>	130	43.2%	84	45.9%	
	<i>2</i>	29	9.6%	19	10.4%	
No. of weeks breastfed before week 48	<i>Mean (SD)</i>	27.0 (15.9)		25.7 (15.9)		0.407
Number of hospitalisations between birth and 2 months old	<i>0</i>	273	91.9%	142	88.2%	NA ¹
	<i>1</i>	23	7.7%	16	9.9%	
	<i>2</i>	1	0.3%	3	1.9%	
Number of hospitalisations between 2 and 12 months old	<i>0</i>	282	96.9%	130	97.7%	NA ¹
	<i>1</i>	9	3.1%	2	1.5%	

	2	0	0.0%	1	0.8%	
Main mode of childcare at 6 months	Collective day care	173	60.9%	80	67.2%	0.279
	Other	111	39.1%	39	32.8%	
Main mode of childcare at 12 months	Collective day care	227	79.9%	99	83.2%	0.534
	Other	57	20.1%	20	16.8%	
Number of children in household (inc. part-time) – T1	Mean (SD)	0.7 (0.7)		0.8 (0.8)		0.155
Number of brothers and sisters - 1 year	Mean (SD)	0.7 (0.7)		0.8 (0.7)		0.391
Paternal mental health						
		n	%	Mean (SD)	n	p value
Prenatal Anxiety***	No	121	72.9%	-	-	-
	Yes	45	27.1%	-	-	-
Prenatal Depression***	No	121	72.9%	-	-	-
	Yes	45	27.1%	-	-	-
Postnatal Anxiety*** - 0-12 months	No	154	74.4%	-	-	-
	Yes	53	25.6%	-	-	-
Postnatal Depression*** - 0-12 months	No	154	74.4%	-	-	-
	Yes	53	25.6%	-	-	-
Postnatal Anxiety*** - 12-24 months	No	154	74.4%	-	-	-
	Yes	53	25.6%	-	-	-
Postnatal Depression*** - 12-24 months	No	154	74.4%	-	-	-
	Yes	53	25.6%	-	-	-
Child developmental outcomes						
		n	Mean (SD)	n	Mean (SD)	p value
Child Behaviour Checklist (CBCL)	Emotional reactivity	286	0.5 (0.3)	131	0.5 (0.3)	0.572
	Anxiety/Depression	286	0.3 (0.3)	131	0.3 (0.3)	0.722
	Somatic complaints	285	0.4 (0.3)	130	0.4 (0.3)	0.116
	Withdrawn behaviour	286	0.2 (0.2)	131	0.2 (0.2)	0.178
	Sleep problems	286	0.5 (0.3)	131	0.5 (0.3)	0.764
	Attention problems	286	0.5 (0.2)	129	0.5 (0.2)	0.526
	Aggressive behaviour	286	1.0 (0.2)	130	1.0 (0.3)	0.035

Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	<i>Other problems</i>	286	0.9 (0.2)	130	0.9 (0.3)	0.088
	<i>Internalising problems</i>	286	0.8 (0.3)	131	0.8 (0.3)	0.361
	<i>Externalising problems</i>	286	1.1 (0.2)	130	1.1 (0.3)	0.048
	<i>Total score</i>	286	32.5 (14.4)	130	30.8 (16.0)	0.284
	<i>Verbal comprehension index</i>	265	112.2 (11.7)	116	112.2 (11.4)	0.990
	<i>Visuospatial index</i>	266	110.4 (10.6)	116	110.7 (11.1)	0.796
	<i>Working memory index</i>	264	105.7 (10.7)	116	107.5 (10.8)	0.132
	<i>Total Intelligence Quotient (IQ)</i>	265	112.9 (11.0)	116	113.6 (11.2)	0.561
	<i>Inhibitory control and impulsivity</i>	279	4.9 (0.5)	126	4.8 (0.6)	0.776
	<i>Shift</i>	284	1.1 (0.1)	130	1.1 (0.1)	0.142
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	<i>Emotional control</i>	284	3.8 (0.5)	130	3.8 (0.4)	0.110
	<i>Working memory</i>	277	1.3 (0.1)	129	1.3 (0.1)	0.306
	<i>Planning/organisation</i>	282	3.7 (0.4)	129	3.7 (0.4)	0.932
	<i>Social Awareness</i>	280	5.8 (2.7)	127	5.3 (2.8)	0.095
Social Responsiveness Scale (SRS)	<i>Social Cognition</i>	280	2.4 (0.7)	127	2.3 (0.7)	0.167
	<i>Social Communication</i>	280	0.9 (0.2)	127	0.9 (0.2)	0.932
	<i>Social Motivation</i>	280	0.8 (0.2)	127	0.8 (0.3)	0.460
	<i>Repetitive Behaviour (RRB)</i>	280	0.6 (0.3)	127	0.6 (0.3)	0.300
	<i>SRS Total</i>	280	1.4 (0.2)	127	1.4 (0.2)	0.349

¹Chi-square not calculated for variables containing groups where n<5. T1/T2/T3= First/Second/Third trimester. *Based on ISCO scoring. Skill level 1: Elementary occupations; Skill level 2: Clerical support workers, service and sales workers, agricultural, forestry and fishery workers, craft and related trade workers, plant and machine operators and assemblers; Skill levels 3-4: Managers, professionals, technicians and associate professionals. **Calculated from mother's last menstrual period ***Hospital Anxiety and Depression Scale (HADS); cut-off score of 8.

C5 Supplementary Table 3a - Moderation effects of mothers' mental health on the relationship between prenatal and postnatal paternal mental health (PMH) and child development (CD). PMH measured using the Hospital Anxiety and Depression Scale (HADS) at three timepoints: prenatally (7.8 +/-5.6 weeks before birth; n = 166) and postnatally at 0-12 months (n = 117) and 12-24 months (n = 207). Linear regression models with an interaction term. P-values of <0.05 = *; 0.01 = **; 0.001 = *** following adjustment for multiple outcomes.

			Mother's mental health (HADS)					
			Pregnancy		0-12 months		12-24 months	
			Anxiety	Depression	Anxiety	Depression	Anxiety	Depression
			<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>
Child Behavioural Checklist (CBCL)	Emotional reactivity	<i>PMH on CD</i>	-0.01 (0.039)	0.01 (0.081)	-0.071 (0.049)	-0.033 (0.047)	-0.025 (0.034)	-0.024 (0.032)
		<i>Moderator on CD</i>	0.004 (0.005)	0.004 (0.005)	0.018 (0.005)	0.018 (0.005)	0.009 (0.004)	0.008 (0.004)
		<i>PMHxModerator on CD</i>	0.006 (0.008)	-0.005 (0.019)	-0.023 (0.011)	-0.022 (0.009)	-0.004 (0.006)	0.001 (0.006)
		<i>R2 / Adjusted R2</i>	0.009 / -0.01	0.006 / -0.014	0.116 / 0.092	0.13 / 0.106	0.025 / 0.01	0.023 / 0.008
	Anxiety/Depression	<i>PMH on CD</i>	0.001 (0.035)	0.002 (0.074)	-0.107 (0.048)	-0.04 (0.046)	-0.026 (0.032)	-0.01 (0.031)
		<i>Moderator on CD</i>	0.004 (0.005)	0.004 (0.005)	0.017 (0.005)	0.017 (0.005)	0.009 (0.004)	0.009 (0.004)
		<i>PMHxModerator on CD</i>	0.003 (0.007)	0.008 (0.018)	-0.019 (0.011)	-0.015 (0.009)	0.003 (0.006)	-0.002 (0.006)
		<i>R2 / Adjusted R2</i>	0.007 / -0.012	0.007 / -0.013	0.125 / 0.101	0.106 / 0.081	0.031 / 0.016	0.028 / 0.013
	Somatic complaints	<i>PMH on CD</i>	0.043 (0.036)	0.098 (0.075)	0.027 (0.046)	-0.036 (0.044)	0.017 (0.031)	-0.0004 (0.03)
		<i>Moderator on CD</i>	-0.003 (0.005)	-0.004 (0.005)	0.018 (0.005)	0.019 (0.005)	0.007 (0.004)	0.008 (0.004)
		<i>PMHxModerator on CD</i>	0.009 (0.007)	0.02 (0.018)	-0.007 (0.011)	-0.004 (0.008)	0.008 (0.006)	0.006 (0.006)
		<i>R2 / Adjusted R2</i>	0.021 / 0.002	0.02 / 0.001	0.116 / 0.091	0.116 / 0.092	0.037 / 0.022	0.031 / 0.016
	Withdrawn behaviour	<i>PMH on CD</i>	0.025 (0.029)	0.058 (0.06)	0.070 (0.034)	0.05 (0.033)	0.029 (0.025)	0.025 (0.024)
		<i>Moderator on CD</i>	0.004 (0.004)	0.004 (0.004)	0.002 (0.004)	0.002 (0.004)	0.006 (0.003)	0.007 (0.003)
		<i>PMHxModerator on CD</i>	-0.003 (0.006)	-0.004 (0.014)	-0.008 (0.008)	-0.005 (0.006)	-0.001 (0.005)	-0.005 (0.005)
		<i>R2 / Adjusted R2</i>	0.016 / -0.004	0.016 / -0.004	0.061 / 0.034	0.031 / 0.004	0.036 / 0.021	0.039 / 0.024
	Sleep problems	<i>PMH on CD</i>	0.015 (0.039)	0.095 (0.08)	-0.083 (0.055)	-0.047 (0.052)	-0.026 (0.034)	-0.033 (0.033)
		<i>Moderator on CD</i>	0.011 (0.005)	0.010 (0.005)	0.019 (0.006)	0.019 (0.006)	0.009 (0.004)	0.010 (0.004)
		<i>PMHxModerator on CD</i>	0.004 (0.008)	0.008 (0.019)	-0.017 (0.013)	-0.017 (0.01)	0.003 (0.007)	0.002 (0.006)
		<i>R2 / Adjusted R2</i>	0.031 / 0.012	0.038 / 0.019	0.099 / 0.074	0.106 / 0.081	0.031 / 0.017	0.033 / 0.018
	Attention problems	<i>PMH on CD</i>	0.008 (0.033)	-0.002 (0.068)	-0.017 (0.041)	-0.01 (0.04)	-0.005 (0.029)	-0.022 (0.027)
		<i>Moderator on CD</i>	0.002 (0.004)	0.002 (0.004)	0.005 (0.004)	0.006 (0.004)	0.002 (0.003)	0.004 (0.003)
		<i>PMHxModerator on CD</i>	0.004 (0.007)	0.022 (0.016)	0.013 (0.01)	0.006 (0.007)	0.006 (0.006)	-0.002 (0.005)
		<i>R2 / Adjusted R2</i>	0.005 / -0.015	0.015 / -0.005	0.038 / 0.011	0.025 / -0.002	0.009 / -0.006	0.008 / -0.007

	Aggressive behaviour	<i>PMH on CD</i>	0.016 (0.029)	0.110 (0.06)	-0.035 (0.04)	-0.023 (0.039)	-0.008 (0.026)	0.008 (0.025)
		<i>Moderator on CD</i>	0.007 (0.004)	0.006 (0.004)	0.014 (0.004)	0.014 (0.004)	0.009 (0.003)	0.009 (0.003)
		<i>PMHxModerator on CD</i>	0.005 (0.006)	0.007 (0.014)	-0.01 (0.009)	-0.01 (0.007)	-0.001 (0.005)	-0.003 (0.005)
		<i>R2 / Adjusted R2</i>	0.027 / 0.008	0.041 / 0.022	0.092 / 0.066	0.098 / 0.073	0.04 / 0.025	0.042 / 0.027
	Other problems	<i>PMH on CD</i>	-0.011 (0.025)	0.061 (0.052)	-0.046 (0.042)	-0.034 (0.04)	-0.036 (0.026)	-0.019 (0.025)
		<i>Moderator on CD</i>	0.005 (0.003)	0.004 (0.003)	0.014 (0.004)	0.014 (0.004)	0.010 (0.003)	0.011 (0.003)
		<i>PMHxModerator on CD</i>	0.003 (0.005)	0.013 (0.012)	-0.011 (0.01)	-0.012 (0.007)	-0.001 (0.005)	-0.006 (0.005)
		<i>R2 / Adjusted R2</i>	0.017 / -0.002	0.028 / 0.009	0.087 / 0.062	0.101 / 0.076	0.056 / 0.041	0.057 / 0.042
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	Verbal comprehension index	<i>PMH on CD</i>	0.821 (1.64)	0.551 (3.388)	1.707 (2.012)	-1.433 (1.975)	0.212 (1.425)	-1.095 (1.343)
		<i>Moderator on CD</i>	-0.475 (0.229)	-0.450 (0.229)	-0.035 (0.232)	0.057 (0.232)	-0.367 (0.179)	-0.365 (0.178)
		<i>PMHxModerator on CD</i>	0.03 (0.355)	-1.147 (0.853)	0.781 (0.432)	0.08 (0.378)	-0.008 (0.283)	-0.008 (0.276)
		<i>R2 / Adjusted R2</i>	0.033 / 0.012	0.042 / 0.021	0.033 / 0.003	0.003 / -0.028	0.029 / 0.013	0.03 / 0.014
	Visuospatial index	<i>PMH on CD</i>	-2.11 (1.607)	-1.478 (3.339)	1.477 (2.044)	-0.385 (2.022)	-0.17 (1.419)	0.19 (1.344)
		<i>Moderator on CD</i>	-0.026 (0.206)	-0.018 (0.208)	0.052 (0.212)	0.123 (0.21)	0.246 (0.17)	0.217 (0.17)
		<i>PMHxModerator on CD</i>	0.156 (0.318)	-0.349 (0.778)	0.267 (0.395)	0.036 (0.341)	-0.225 (0.271)	-0.025 (0.264)
		<i>R2 / Adjusted R2</i>	0.013 / -0.007	0.003 / -0.018	0.012 / -0.018	0.004 / -0.027	0.013 / -0.003	0.01 / -0.007
	Working memory index	<i>PMH on CD</i>	0.821 (1.64)	0.551 (3.388)	1.707 (2.012)	-1.433 (1.975)	0.212 (1.425)	-1.095 (1.343)
		<i>Moderator on CD</i>	-0.192 (0.21)	-0.184 (0.212)	-0.071 (0.208)	0.032 (0.204)	-0.119 (0.172)	-0.096 (0.17)
		<i>PMHxModerator on CD</i>	0.386 (0.326)**	-0.357 (0.792)	-0.05 (0.387)	-0.136 (0.332)	0.107 (0.272)	0.138 (0.264)
		<i>R2 / Adjusted R2</i>	0.018 / -0.003	0.007 / -0.014	0.008 / -0.023	0.009 / -0.021	0.003 / -0.013	0.007 / -0.01
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	Inhibit (inhibitory control and impulsivity)	<i>PMH on CD</i>	-0.084 (0.072)	-0.094 (0.148)	-0.016 (0.103)	0.083 (0.102)	-0.0005 (0.064)	-0.011 (0.062)
		<i>Moderator on CD</i>	0.019 (0.009)	0.018 (0.009)	0.021 (0.011)	0.017 (0.011)	0.020 (0.008)	0.021 (0.008)
		<i>PMHxModerator on CD</i>	0.025 (0.014)	0.039 (0.033)	-0.014 (0.02)	-0.002 (0.017)	0.01 (0.012)	-0.001 (0.012)
		<i>R2 / Adjusted R2</i>	0.054 / 0.035	0.037 / 0.017	0.038 / 0.01	0.039 / 0.012	0.045 / 0.029	0.041 / 0.026
	Shift	<i>PMH on CD</i>	-0.019 (0.012)	0.004 (0.025)	-0.005 (0.017)	0.022 (0.017)	-0.006 (0.011)	-0.013 (0.011)
		<i>Moderator on CD</i>	0.002 (0.001)	0.002 (0.001)	0.005 (0.002)	0.005 (0.002)	0.004 (0.001)	0.004 (0.001)
		<i>PMHxModerator on CD</i>	0.002 (0.002)	0.006 (0.006)	-0.005 (0.003)	-0.004 (0.003)	-0.001 (0.002)	-0.001 (0.002)
		<i>R2 / Adjusted R2</i>	0.035 / 0.016	0.024 / 0.005	0.094 / 0.069	0.095 / 0.069	0.052 / 0.037	0.058 / 0.043
	Emotional control	<i>PMH on CD</i>	-0.016 (0.059)	0.083 (0.12)	-0.108 (0.087)	0.034 (0.087)	0.013 (0.054)	-0.004 (0.052)
		<i>Moderator on CD</i>	0.015 (0.007)	0.014 (0.007)	0.027 (0.009)	0.022 (0.009)	0.017 (0.006)	0.018 (0.006)

		<i>PMHxModerator on CD</i>	0.005 (0.011)	0.006 (0.027)	-0.039 (0.017)	-0.021 (0.015)	-0.002 (0.01)	-0.009 (0.01)
		<i>R2 / Adjusted R2</i>	0.029 / 0.01	0.031 / 0.011	0.102 / 0.077	0.067 / 0.041	0.037 / 0.022	0.042 / 0.027
	Working memory	<i>PMH on CD</i>	-0.016 (0.011)	-0.035 (0.023)	0.007 (0.017)	0.004 (0.017)	0.002 (0.01)	0.001 (0.01)
		<i>Moderator on CD</i>	0.001 (0.001)	0.001 (0.001)	0.001 (0.002)	0.002 (0.002)	0.0002 (0.001)	0.001 (0.001)
		<i>PMHxModerator on CD</i>	0.007 (0.002)	0.011 (0.005)	0.001 (0.003)	-0.001 (0.003)	0.002 (0.002)	-0.002 (0.002)
		<i>R2 / Adjusted R2</i>	0.087 / 0.069	0.044 / 0.025	0.011 / -0.018	0.01 / -0.019	0.007 / -0.009	0.007 / -0.009
	Planning/organisation	<i>PMH on CD</i>	-0.074 (0.053)	-0.061 (0.11)	0.05 (0.067)	0.055 (0.065)	0.004 (0.047)	0.015 (0.045)
		<i>Moderator on CD</i>	0.012 (0.006)	0.011 (0.006)	0.005 (0.007)	0.004 (0.007)	0.010 (0.005)	0.011 (0.005)
		<i>PMHxModerator on CD</i>	0.023 (0.01)	0.012 (0.025)	0.008 (0.013)	0.008 (0.011)	-0.004 (0.009)	-0.01 (0.009)
		<i>R2 / Adjusted R2</i>	0.062 / 0.043	0.02 / 0.001	0.017 / -0.011	0.024 / -0.004	0.02 / 0.004	0.026 / 0.01
Social Responsiveness Scale (SRS)	Social Awareness	<i>PMH on CD</i>	-0.027 (0.373)	0.937 (0.764)	-0.309 (0.504)	0.429 (0.495)	-0.1 (0.335)	0.365 (0.324)
		<i>Moderator on CD</i>	0.074 (0.045)	0.075 (0.044)	0.104 (0.051)	0.091 (0.051)	0.035 (0.039)	0.032 (0.04)
		<i>PMHxModerator on CD</i>	-0.019 (0.071)	0.056 (0.171)	-0.115 (0.098)	-0.133 (0.083)	0.042 (0.064)	-0.03 (0.061)
		<i>R2 / Adjusted R2</i>	0.02 / 0.0002	0.03 / 0.01	0.043 / 0.015	0.054 / 0.026	0.008 / -0.008	0.012 / -0.004
	Social Cognition	<i>PMH on CD</i>	0.031 (0.095)	-0.077 (0.196)	0.054 (0.13)	0.171 (0.128)	0.022 (0.082)	0.081 (0.08)
		<i>Moderator on CD</i>	0.012 (0.011)	0.011 (0.011)	0.017 (0.013)	0.014 (0.013)	0.007 (0.01)	0.007 (0.01)
		<i>PMHxModerator on CD</i>	0.027 (0.018)	0.042 (0.044)	-0.012 (0.025)	-0.018 (0.021)	0.009 (0.016)	-0.007 (0.015)
		<i>R2 / Adjusted R2</i>	0.021 / 0.001	0.012 / -0.007	0.021 / -0.007	0.036 / 0.008	0.006 / -0.01	0.01 / -0.006
	Social Communication	<i>PMH on CD</i>	-0.009 (0.031)	-0.001 (0.064)	-0.07 (0.049)	0.004 (0.048)	-0.03 (0.029)	0.004 (0.028)
		<i>Moderator on CD</i>	0.007 (0.004)	0.008 (0.004)	0.011 (0.005)	0.011 (0.005)	0.009 (0.003)	0.008 (0.003)
		<i>PMHxModerator on CD</i>	-0.0002 (0.006)	0.021 (0.014)	-0.009 (0.009)	-0.014 (0.008)	-0.003 (0.006)	0.0005 (0.005)
		<i>R2 / Adjusted R2</i>	0.027 / 0.007	0.04 / 0.021	0.054 / 0.027	0.058 / 0.031	0.039 / 0.024	0.032 / 0.017
	Social Motivation	<i>PMH on CD</i>	-0.022 (0.033)	0.055 (0.069)	0.035 (0.043)	0.019 (0.043)	-0.009 (0.029)	0.011 (0.028)
		<i>Moderator on CD</i>	0.005 (0.004)	0.005 (0.004)	0.009 (0.004)	0.010 (0.004)	0.011 (0.003)	0.010 (0.003)
		<i>PMHxModerator on CD</i>	0.007 (0.006)	0.016 (0.015)	-0.003 (0.008)	-0.004 (0.007)	-0.006 (0.006)	-0.002 (0.005)
		<i>R2 / Adjusted R2</i>	0.019 / -0.001	0.02 / -0.0001	0.055 / 0.028	0.051 / 0.023	0.055 / 0.04	0.049 / 0.034
	Repetitive Behavior (RRB)	<i>PMH on CD</i>	0.019 (0.039)	0.096 (0.079)	-0.045 (0.059)	-0.044 (0.058)	-0.021 (0.037)	0.018 (0.036)
		<i>Moderator on CD</i>	0.009 (0.005)	0.009 (0.005)	0.006 (0.006)	0.006 (0.006)	0.005 (0.004)	0.004 (0.004)
		<i>PMHxModerator on CD</i>	0.008 (0.007)	0.025 (0.018)	-0.002 (0.011)	0.002 (0.01)	0.012 (0.007)	0.005 (0.007)
		<i>R2 / Adjusted R2</i>	0.032 / 0.013	0.044 / 0.025	0.013 / -0.015	0.013 / -0.015	0.026 / 0.011	0.013 / -0.002

C5 Supplementary Table 3b - Moderation effects of child sex assigned at birth on the relationship between prenatal and postnatal paternal mental health (PMH) and child development (CD). PMH measured using the Hospital Anxiety and Depression Scale (HADS) at three timepoints: prenatally (7.8 +/-5.6 weeks before birth; n = 166) and postnatally at 0-12 months (n = 117) and 12-24 months (n = 207). Linear regression models with an interaction term. P-values of <0.05 = *, 0.01 = **, 0.001 = *** following adjustment for multiple outcomes.

			Child sex					
			Pregnancy		0-12 months		12-24 months	
			Anxiety	Depression	Anxiety	Depression	Anxiety	Depression
			<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>
Child Behavioural Checklist (CBCL)	Emotional reactivity	<i>PMH on CD</i>	-0.019 (0.06)	0.029 (0.126)	-0.096 (0.067)	-0.019 (0.067)	-0.021 (0.046)	-0.048 (0.049)
		<i>Moderator on CD</i>	0.02 (0.047)	0.022 (0.046)	-0.07 (0.053)	-0.068 (0.053)	-0.006 (0.04)	-0.003 (0.039)
		<i>PMHxModerator on CD</i>	0.022 (0.08)	-0.018 (0.164)	0.133 (0.101)	-0.002 (0.097)	0.017 (0.067)	0.065 (0.064)
		<i>R2 / Adjusted R2</i>	0.002 / -0.017	0.002 / -0.018	0.035 / 0.008	0.016 / -0.011	0.001 / -0.014	0.006 / -0.009
	Anxiety/Depression	<i>PMH on CD</i>	0.032 (0.055)	0.046 (0.115)	-0.120 (0.065)	-0.051 (0.066)	-0.028 (0.044)	-0.037 (0.047)
		<i>Moderator on CD</i>	0.036 (0.043)	0.034 (0.042)	-0.046 (0.051)	-0.04 (0.052)	0.025 (0.038)	0.027 (0.038)
		<i>PMHxModerator on CD</i>	-0.045 (0.073)	-0.067 (0.15)	0.102 (0.098)	0.056 (0.095)	0.038 (0.064)	0.066 (0.062)
		<i>R2 / Adjusted R2</i>	0.007 / -0.013	0.006 / -0.014	0.036 / 0.009	0.011 / -0.017	0.005 / -0.011	0.008 / -0.007
	Somatic complaints	<i>PMH on CD</i>	0.041 (0.055)	-0.042 (0.116)	0.072 (0.063)	-0.012 (0.063)	0.001 (0.043)	0.016 (0.046)
		<i>Moderator on CD</i>	-0.051 (0.043)	-0.058 (0.042)	0.036 (0.05)	0.03 (0.05)	0.01 (0.037)	0.006 (0.037)
		<i>PMHxModerator on CD</i>	-0.015 (0.074)	0.21 (0.15)	-0.033 (0.095)	0.003 (0.092)	0.061 (0.063)	-0.004 (0.061)
		<i>R2 / Adjusted R2</i>	0.018 / -0.002	0.033 / 0.014	0.018 / -0.009	0.004 / -0.024	0.009 / -0.006	0.001 / -0.014
	Withdrawn behaviour	<i>PMH on CD</i>	0.028 (0.06)	0.087 (0.127)	-0.058 (0.074)	-0.006 (0.074)	-0.017 (0.047)	-0.039 (0.05)
		<i>Moderator on CD</i>	0.011 (0.047)	0.009 (0.046)	-0.102 (0.058)	-0.098 (0.058)	-0.011 (0.04)	-0.008 (0.04)
		<i>PMHxModerator on CD</i>	-0.016 (0.081)	0.029 (0.165)	0.006 (0.111)	-0.05 (0.106)	0.01 (0.069)	0.039 (0.066)
		<i>R2 / Adjusted R2</i>	0.002 / -0.018	0.011 / -0.008	0.034 / 0.007	0.03 / 0.003	0.001 / -0.014	0.003 / -0.012
	Sleep problems	<i>PMH on CD</i>	0.028 (0.06)	0.087 (0.127)	-0.058 (0.074)	-0.006 (0.074)	-0.017 (0.047)	-0.039 (0.05)
		<i>Moderator on CD</i>	0.011 (0.047)	0.009 (0.046)	-0.102 (0.058)	-0.098 (0.058)	-0.011 (0.04)	-0.008 (0.04)
		<i>PMHxModerator on CD</i>	-0.016 (0.081)	0.029 (0.165)	0.006 (0.111)	-0.05 (0.106)	0.01 (0.069)	0.039 (0.066)
		<i>R2 / Adjusted R2</i>	0.002 / -0.018	0.011 / -0.008	0.034 / 0.007	0.03 / 0.003	0.001 / -0.014	0.003 / -0.012
	Attention problems	<i>PMH on CD</i>	0.051 (0.05)	0.052 (0.106)	0.017 (0.054)	0.045 (0.054)	0.014 (0.039)	-0.00001 (0.041)
		<i>Moderator on CD</i>	-0.004 (0.039)	-0.007 (0.039)	0.007 (0.043)	0.01 (0.042)	-0.012 (0.033)	-0.011 (0.033)
		<i>PMHxModerator on CD</i>	-0.079 (0.067)	-0.101 (0.138)	-0.078 (0.082)	-0.083 (0.078)	-0.033 (0.057)	-0.031 (0.054)
		<i>R2 / Adjusted R2</i>	0.009 / -0.01	0.004 / -0.016	0.011 / -0.017	0.011 / -0.016	0.002 / -0.013	0.004 / -0.011

	Aggressive behaviour	<i>PMH on CD</i>	0.052 (0.045)	0.134 (0.095)	0.005 (0.055)	0.015 (0.055)	0.017 (0.036)	-0.007 (0.038)
		<i>Moderator on CD</i>	0.025 (0.036)	0.022 (0.035)	0.003 (0.043)	0.003 (0.043)	-0.017 (0.031)	-0.018 (0.031)
		<i>PMHxModerator on CD</i>	-0.056 (0.06)	-0.031 (0.123)	-0.03 (0.083)	-0.046 (0.079)	-0.027 (0.052)	0.048 (0.05)
		<i>R2 / Adjusted R2</i>	0.011 / -0.009	0.026 / 0.006	0.002 / -0.026	0.003 / -0.024	0.003 / -0.012	0.009 / -0.006
	Other problems	<i>PMH on CD</i>	0.004 (0.039)	0.042 (0.081)	0.008 (0.057)	-0.013 (0.057)	0.009 (0.037)	0.006 (0.039)
		<i>Moderator on CD</i>	0.036 (0.03)	0.038 (0.029)	-0.015 (0.045)	-0.013 (0.045)	-0.008 (0.031)	-0.005 (0.031)
		<i>PMHxModerator on CD</i>	-0.015 (0.051)	0.036 (0.105)	-0.066 (0.086)	-0.011 (0.083)	-0.061 (0.053)	-0.021 (0.051)
		<i>R2 / Adjusted R2</i>	0.01 / -0.009	0.02 / 0.001	0.008 / -0.019	0.003 / -0.025	0.01 / -0.005	0.001 / -0.014
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	Verbal comprehension index	<i>PMH on CD</i>	2.431 (2.686)	6.869 (5.677)	2.535 (2.883)	1.001 (2.756)	0.77 (1.979)	1.439 (2.115)
		<i>Moderator on CD</i>	-1.972 (2.151)	-2.146 (2.098)	-4.455 (2.223)	-4.271 (2.212)	-2.093 (1.717)	-1.894 (1.718)
		<i>PMHxModerator on CD</i>	-2.842 (3.673)	-12.359 (7.43)	-6.509 (4.272)	-4.485 (4.138)	-5.182 (2.929)	-5.080 (2.793)
		<i>R2 / Adjusted R2</i>	0.014 / -0.007	0.027 / 0.006	0.056 / 0.027	0.047 / 0.017	0.029 / 0.013	0.03 / 0.014
	Visuospatial index	<i>PMH on CD</i>	-1.37 (2.41)	2.942 (5.13)	-0.878 (2.646)	-1.478 (2.541)	0.068 (1.906)	1.587 (2.035)
		<i>Moderator on CD</i>	0.942 (1.926)	1.386 (1.891)	0.546 (2.041)	0.158 (2.039)	0.521 (1.65)	0.406 (1.649)
		<i>PMHxModerator on CD</i>	-1.041 (3.281)	-7.349 (6.705)	5.411 (3.921)	3.277 (3.815)	0.303 (2.819)	-1.993 (2.685)
		<i>R2 / Adjusted R2</i>	0.014 / -0.007	0.013 / -0.008	0.025 / -0.004	0.007 / -0.023	0.001 / -0.016	0.004 / -0.012
	Working memory index	<i>PMH on CD</i>	2.431 (2.686)	6.869 (5.677)	2.535 (2.883)	1.001 (2.756)	0.77 (1.979)	1.439 (2.115)
		<i>Moderator on CD</i>	-1.972 (2.151)	-2.146 (2.098)	-4.455 (2.223)	-4.271 (2.212)	-2.093 (1.717)	-1.894 (1.718)
		<i>PMHxModerator on CD</i>	-2.842 (3.673)	-12.359 (7.43)	-6.509 (4.272)	-4.485 (4.138)	-5.182 (2.929)	-5.080 (2.793)
		<i>R2 / Adjusted R2</i>	0.006 / -0.015	0.006 / -0.015	0.049 / 0.02	0.053 / 0.024	0.028 / 0.012	0.045 / 0.029
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	Inhibit (inhibitory control and impulsivity)	<i>PMH on CD</i>	0.01 (0.112)	0.108 (0.23)	0.181 (0.136)	0.283 (0.129)	0.098 (0.087)	0.091 (0.094)
		<i>Moderator on CD</i>	0.152 (0.088)	0.163 (0.086)	0.048 (0.106)	0.061 (0.104)	0.152 (0.076)	0.147 (0.076)
		<i>PMHxModerator on CD</i>	-0.108 (0.15)	-0.299 (0.3)	-0.296 (0.203)	-0.335 (0.193)	-0.112 (0.128)	-0.133 (0.124)
		<i>R2 / Adjusted R2</i>	0.03 / 0.011	0.032 / 0.012	0.024 / -0.004	0.047 / 0.02	0.027 / 0.012	0.027 / 0.011
	Shift	<i>PMH on CD</i>	1.022 (2.55)	4.943 (5.399)	1.297 (2.691)	-0.556 (2.56)	0.39 (1.925)	1.559 (2.054)
		<i>Moderator on CD</i>	-0.54 (2.042)	-0.575 (1.996)	-3.009 (2.076)	-3.109 (2.054)	-1.643 (1.67)	-1.645 (1.668)
		<i>PMHxModerator on CD</i>	-1.304 (3.488)	-8.995 (7.067)	-1.415 (3.988)	-0.826 (3.843)	-1.765 (2.849)	-3.091 (2.712)
		<i>R2 / Adjusted R2</i>	0.029 / 0.01	0.011 / -0.009	0.004 / -0.024	0.032 / 0.005	0.025 / 0.01	0.024 / 0.008
	Emotional control	<i>PMH on CD</i>	0.109 (0.091)	0.198 (0.189)	0.095 (0.118)	0.182 (0.112)	0.141 (0.074)	0.066 (0.081)
		<i>Moderator on CD</i>	0.02 (0.07)	0.024 (0.07)	-0.061 (0.091)	-0.046 (0.091)	0.021 (0.063)	0.02 (0.064)

		<i>PMHxModerator on CD</i>	-0.213 (0.121)	-0.17 (0.246)	-0.286 (0.176)	-0.279 (0.168)	-0.215 (0.108)	-0.089 (0.105)
		<i>R2 / Adjusted R2</i>	0.021 / 0.001	0.008 / -0.012	0.028 / 0.0004	0.031 / 0.004	0.024 / 0.008	0.005 / -0.011
	Working memory	<i>PMH on CD</i>	-0.014 (0.017)	-0.041 (0.036)	0.043 (0.022)	0.043 (0.021)	0.002 (0.014)	-0.004 (0.015)
		<i>Moderator on CD</i>	-0.014 (0.014)	-0.012 (0.013)	-0.001 (0.017)	-0.0003 (0.017)	-0.013 (0.012)	-0.013 (0.012)
		<i>PMHxModerator on CD</i>	-0.005 (0.023)	0.008 (0.047)	-0.072 (0.032)	-0.080 (0.031)	-0.001 (0.02)	0.009 (0.019)
		<i>R2 / Adjusted R2</i>	0.019 / -0.0004	0.02 / 0.001	0.05 / 0.023	0.063 / 0.036	0.007 / -0.009	0.008 / -0.008
	Planning/organisation	<i>PMH on CD</i>	0.002 (0.083)	-0.086 (0.173)	0.162 (0.086)	0.168 (0.082)	0.065 (0.063)	0.008 (0.069)
		<i>Moderator on CD</i>	0.015 (0.065)	0.027 (0.064)	-0.036 (0.067)	-0.031 (0.066)	0.008 (0.055)	0.007 (0.055)
		<i>PMHxModerator on CD</i>	-0.125 (0.111)	0.063 (0.226)	-0.238 (0.129)	-0.208 (0.123)	-0.095 (0.093)	0.025 (0.09)
		<i>R2 / Adjusted R2</i>	0.02 / 0.0004	0.003 / -0.017	0.04 / 0.013	0.042 / 0.015	0.007 / -0.009	0.002 / -0.014
Social Responsiveness Scale (SRS)	Social Awareness	<i>PMH on CD</i>	-0.281 (0.557)	-0.265 (1.149)	0.462 (0.672)	0.677 (0.639)	-0.318 (0.447)	-0.193 (0.481)
		<i>Moderator on CD</i>	1.279 (0.44)	1.281 (0.426)	-0.209 (0.52)	-0.131 (0.517)	0.466 (0.389)	0.443 (0.386)
		<i>PMHxModerator on CD</i>	0.899 (0.749)	2.426 (1.506)	-1.081 (0.997)	-0.475 (0.955)	0.701 (0.659)	0.981 (0.633)
		<i>R2 / Adjusted R2</i>	0.063 / 0.044	0.082 / 0.064	0.012 / -0.016	0.012 / -0.016	0.013 / -0.003	0.027 / 0.011
	Social Cognition	<i>PMH on CD</i>	0.086 (0.146)	-0.035 (0.304)	0.119 (0.171)	0.217 (0.161)	0.046 (0.111)	0.065 (0.119)
		<i>Moderator on CD</i>	0.007 (0.115)	-0.006 (0.113)	-0.164 (0.132)	-0.158 (0.13)	-0.025 (0.096)	-0.032 (0.096)
		<i>PMHxModerator on CD</i>	-0.086 (0.196)	-0.066 (0.399)	-0.085 (0.253)	-0.105 (0.241)	-0.024 (0.163)	0.039 (0.157)
		<i>R2 / Adjusted R2</i>	0.002 / -0.018	0.001 / -0.019	0.021 / -0.007	0.036 / 0.008	0.002 / -0.014	0.007 / -0.008
	Social Communication	<i>PMH on CD</i>	0.046 (0.048)	0.086 (0.1)	0.041 (0.064)	0.053 (0.062)	0.036 (0.04)	0.066 (0.043)
		<i>Moderator on CD</i>	0.051 (0.038)	0.05 (0.037)	-0.048 (0.049)	-0.036 (0.05)	-0.016 (0.034)	-0.014 (0.034)
		<i>PMHxModerator on CD</i>	-0.081 (0.064)	-0.133 (0.131)	-0.186 (0.095)	-0.097 (0.092)	-0.112 (0.058)	-0.082 (0.057)
		<i>R2 / Adjusted R2</i>	0.022 / 0.003	0.019 / -0.001	0.047 / 0.02	0.015 / -0.013	0.021 / 0.006	0.014 / -0.002
	Social Motivation	<i>PMH on CD</i>	0.052 (0.051)	0.177 (0.106)	0.130 (0.057)	0.054 (0.055)	0.06 (0.04)	0.117 (0.043)
		<i>Moderator on CD</i>	0.034 (0.04)	0.038 (0.039)	-0.009 (0.044)	-0.007 (0.045)	0.003 (0.035)	0.0005 (0.034)
		<i>PMHxModerator on CD</i>	-0.119 (0.068)	-0.199 (0.139)	-0.160 (0.085)	-0.033 (0.083)	-0.112 (0.059)	-0.157 (0.056)
		<i>R2 / Adjusted R2</i>	0.026 / 0.007	0.024 / 0.004	0.05 / 0.022	0.01 / -0.018	0.019 / 0.004	0.044 / 0.029
	Repetitive Behavior (RRB)	<i>PMH on CD</i>	0.006 (0.06)	0.063 (0.124)	0.024 (0.077)	-0.002 (0.074)	-0.041 (0.05)	-0.0005 (0.054)
		<i>Moderator on CD</i>	0.001 (0.047)	-0.001 (0.046)	-0.034 (0.06)	-0.028 (0.06)	0.056 (0.043)	0.054 (0.043)
		<i>PMHxModerator on CD</i>	0.03 (0.08)	0.063 (0.163)	-0.122 (0.115)	-0.054 (0.111)	0.077 (0.073)	0.048 (0.071)
		<i>R2 / Adjusted R2</i>	0.003 / -0.017	0.011 / -0.009	0.015 / -0.013	0.006 / -0.022	0.015 / -0.001	0.014 / -0.002

C5 Supplementary Table 3c - Moderation effects of mother's professional class (ISCO scores) on the relationship between prenatal and postnatal paternal mental health (PMH) and child development (CD). PMH measured using the Hospital Anxiety and Depression Scale (HADS) at three timepoints: prenatally (7.8 +/-5.6 weeks before birth; n = 166) and postnatally at 0-12 months (n = 117) and 12-24 months (n = 207). Linear regression models with an interaction term. P-values of <0.05 = *; 0.01 = **; 0.001 = *** following adjustment for multiple outcomes.

			Mother's professional class					
			Pregnancy		0-12 months		12-24 months	
			Anxiety	Depression	Anxiety	Depression	Anxiety	Depression
			<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>
Child Behavioural Checklist (CBCL)	Emotional reactivity	<i>PMH on CD</i>	-0.085 (0.171)	-0.046 (0.32)	-0.414 (0.286)	0.982 (0.665)	-0.061 (0.148)	-0.099 (0.186)
		<i>Moderator on CD</i>	0.033 (0.072)	0.031 (0.071)	-0.240 (0.115)	-0.429 (0.169)	-0.032 (0.071)	-0.02 (0.074)
		<i>PMHxModerator on CD</i>	0.071 (0.156)	0.057 (0.284)	0.371 (0.273)	-1.003 (0.135)	0.046 (0.135)	0.084 (0.178)
		<i>R2 / Adjusted R2</i>	0.003 / -0.017	0.002 / -0.018	0.056 / 0.03	0.059 / 0.033	0.002 / -0.013	0.003 / -0.013
	Anxiety/Depression	<i>PMH on CD</i>	0.182 (0.155)	0.648 (0.286)	0.283 (0.283)	-0.32 (0.667)	0.074 (0.141)	0.036 (0.178)
		<i>Moderator on CD</i>	-0.109 (0.065)	-0.105 (0.064)	0.016 (0.113)	0.06 (0.17)	-0.035 (0.068)	-0.048 (0.07)
		<i>PMHxModerator on CD</i>	-0.171 (0.141)	-0.593 (0.254)	-0.341 (0.27)	0.296 (0.129)	-0.08 (0.129)	-0.034 (0.17)
		<i>R2 / Adjusted R2</i>	0.025 / 0.006	0.049 / 0.031	0.033 / 0.006	0.004 / -0.024	0.005 / -0.011	0.002 / -0.013
	Somatic complaints	<i>PMH on CD</i>	-0.276 (0.156)	-0.239 (0.294)	0.493 (0.269)	0.449 (0.634)	0.251 (0.138)	-0.015 (0.176)
		<i>Moderator on CD</i>	-0.063 (0.065)	-0.075 (0.065)	-0.106 (0.108)	-0.201 (0.161)	0.017 (0.067)	0.008 (0.069)
		<i>PMHxModerator on CD</i>	0.296 (0.142)	0.299 (0.261)	-0.425 (0.256)	-0.461 (0.126)	-0.208 (0.126)	0.028 (0.168)
		<i>R2 / Adjusted R2</i>	0.044 / 0.025	0.026 / 0.007	0.046 / 0.02	0.016 / -0.012	0.018 / 0.003	0.001 / -0.014
	Withdrawn behaviour	<i>PMH on CD</i>	0.038 (0.127)	0.443 (0.235)	-0.104 (0.192)	0.071 (0.454)	0.078 (0.108)	0.029 (0.137)
		<i>Moderator on CD</i>	-0.043 (0.053)	-0.045 (0.052)	-0.045 (0.077)	-0.034 (0.116)	-0.061 (0.052)	-0.055 (0.054)
		<i>PMHxModerator on CD</i>	-0.012 (0.116)	-0.349 (0.209)	0.177 (0.183)	-0.021 (0.099)	-0.035 (0.099)	0.002 (0.131)
		<i>R2 / Adjusted R2</i>	0.009 / -0.01	0.029 / 0.01	0.06 / 0.034	0.024 / -0.003	0.021 / 0.006	0.015 / 0.0001
	Sleep problems	<i>PMH on CD</i>	-0.085 (0.172)	-0.006 (0.321)	-0.284 (0.323)	-1.056 (0.747)	-0.119 (0.151)	-0.272 (0.19)
		<i>Moderator on CD</i>	0.016 (0.072)	0.013 (0.072)	-0.043 (0.13)	0.147 (0.19)	-0.039 (0.073)	-0.003 (0.075)
		<i>PMHxModerator on CD</i>	0.095 (0.157)	0.101 (0.286)	0.231 (0.308)	1.022 (0.138)	0.102 (0.138)	0.246 (0.181)
		<i>R2 / Adjusted R2</i>	0.004 / -0.016	0.011 / -0.008	0.012 / -0.015	0.021 / -0.006	0.004 / -0.011	0.012 / -0.003
	Attention problems	<i>PMH on CD</i>	-0.389 (0.139)	-0.014 (0.267)	0.143 (0.236)	0.005 (0.549)	-0.027 (0.124)	0.147 (0.156)
		<i>Moderator on CD</i>	-0.077 (0.058)	-0.094 (0.059)	0.022 (0.094)	0.02 (0.14)	-0.098 (0.06)	-0.119 (0.062)

		<i>PMHxModerator on CD</i>	0.372 (0.127)*	0.005 (0.237)	-0.156 (0.225)	-0.001 (0.114)	0.027 (0.114)	-0.163 (0.149)
		<i>R2 / Adjusted R2</i>	0.069 / 0.05	0.016 / -0.003	0.007 / -0.021	0.001 / -0.027	0.014 / -0.001	0.022 / 0.007
	Aggressive behaviour	<i>PMH on CD</i>	-0.004 (0.13)	0.355 (0.239)	0.231 (0.232)	-0.295 (0.541)	-0.027 (0.114)	-0.08 (0.144)
		<i>Moderator on CD</i>	-0.031 (0.054)	-0.034 (0.053)	-0.224 (0.093)	-0.178 (0.138)	-0.113 (0.055)	-0.096 (0.057)
		<i>PMHxModerator on CD</i>	0.019 (0.119)	-0.221 (0.213)	-0.231 (0.221)	0.279 (0.104)	0.033 (0.104)	0.093 (0.137)
		<i>R2 / Adjusted R2</i>	0.005 / -0.015	0.032 / 0.013	0.062 / 0.036	0.056 / 0.03	0.022 / 0.007	0.025 / 0.01
	Other problems	<i>PMH on CD</i>	-0.028 (0.11)	0.103 (0.206)	0.121 (0.247)	-0.241 (0.573)	0.064 (0.117)	-0.189 (0.147)
		<i>Moderator on CD</i>	-0.025 (0.046)	-0.025 (0.046)	-0.126 (0.099)	-0.093 (0.146)	-0.072 (0.056)	-0.061 (0.058)
		<i>PMHxModerator on CD</i>	0.016 (0.101)	-0.039 (0.183)	-0.136 (0.235)	0.218 (0.107)	-0.077 (0.107)	0.175 (0.14)
		<i>R2 / Adjusted R2</i>	0.003 / -0.016	0.011 / -0.008	0.02 / -0.007	0.02 / -0.008	0.016 / 0.001	0.019 / 0.004
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	Verbal comprehension index	<i>PMH on CD</i>	-0.96 (7.904)	-13.286 (14.896)	34.103 (11.374)	67.920 (26.587)	2.581 (6.381)	-2.659 (8.073)
		<i>Moderator on CD</i>	-4.87 (3.356)	-4.853 (3.35)	7.335 (4.542)	-6.097 (6.772)	-2.406 (3.208)	-3.002 (3.359)
		<i>PMHxModerator on CD</i>	2.008 (7.219)	11.922 (13.332)	-32.868 (10.78)*	-68.072 (5.808)	-3.758 (5.808)	0.972 (7.69)
		<i>R2 / Adjusted R2</i>	0.019 / -0.002	0.021 / 0.0001	0.105 / 0.078	0.084 / 0.056	0.012 / -0.004	0.012 / -0.004
	Visuospatial index	<i>PMH on CD</i>	12.308 (6.934)	-4.135 (13.371)	18.598 (10.686)	59.612 (24.352)	3.984 (6.08)	-10.176 (7.659)
		<i>Moderator on CD</i>	-5.157 (2.947)	-4.737 (3.008)	1.227 (4.267)	-10.089 (6.203)	-1.652 (3.057)	-0.382 (3.186)
		<i>PMHxModerator on CD</i>	-13.546 (6.34)	2.408 (11.972)	-16.439 (10.129)	-59.255 (5.534)	-3.504 (5.534)	10.244 (7.296)
		<i>R2 / Adjusted R2</i>	0.059 / 0.039	0.019 / -0.002	0.033 / 0.003	0.059 / 0.03	0.005 / -0.012	0.013 / -0.003
	Working memory index	<i>PMH on CD</i>	1.478 (7.259)	3.308 (13.707)	16.138 (10.443)	17.406 (24.252)	5.318 (6.065)	-1.589 (7.672)
		<i>Moderator on CD</i>	-1.372 (3.082)	-1.413 (3.083)	-1.74 (4.168)	-5.682 (6.178)	-0.728 (3.049)	-1.241 (3.193)
		<i>PMHxModerator on CD</i>	-0.536 (6.63)	-2.735 (12.267)	-14.059 (9.891)	-18.94 (5.519)	-4.904 (5.519)	0.394 (7.308)
		<i>R2 / Adjusted R2</i>	0.004 / -0.017	0.002 / -0.019	0.029 / -0.001	0.016 / -0.014	0.005 / -0.011	0.005 / -0.011
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	Inhibit (inhibitory control and impulsivity)	<i>PMH on CD</i>	-0.377 (0.33)	-0.689 (0.604)	-0.03 (0.58)	-0.922 (1.334)	-0.197 (0.286)	0.099 (0.372)
		<i>Moderator on CD</i>	-0.091 (0.139)	-0.093 (0.14)	-0.195 (0.232)	0.026 (0.34)	-0.213 (0.143)	-0.196 (0.152)
		<i>PMHxModerator on CD</i>	0.283 (0.303)	0.561 (0.54)	0.07 (0.552)	1.037 (0.262)	0.223 (0.262)	-0.082 (0.356)
		<i>R2 / Adjusted R2</i>	0.016 / -0.004	0.012 / -0.008	0.008 / -0.02	0.026 / -0.001	0.015 / -0.001	0.01 / -0.006
	Shift	<i>PMH on CD</i>	-0.107 (0.055)	-0.13 (0.101)	-0.059 (0.097)	0.244 (0.223)	0.001 (0.05)	-0.001 (0.063)
		<i>Moderator on CD</i>	0.01 (0.023)	0.008 (0.023)	-0.047 (0.039)	-0.081 (0.057)	-0.003 (0.024)	-0.004 (0.025)
		<i>PMHxModerator on CD</i>	0.083 (0.05)	0.125 (0.091)	0.067 (0.093)	-0.215 (0.046)	0.0002 (0.046)	-0.006 (0.06)
		<i>R2 / Adjusted R2</i>	0.033 / 0.014	0.014 / -0.006	0.02 / -0.007	0.046 / 0.019	0.0001 / -0.016	0.003 / -0.013

	Emotional control	<i>PMH on CD</i>	-0.313 (0.266)	-0.587 (0.487)	-0.49 (0.498)	0.35 (1.159)	-0.241 (0.237)	-0.062 (0.299)
		<i>Moderator on CD</i>	0.017 (0.11)	0.009 (0.11)	-0.323 (0.2)	-0.364 (0.295)	-0.175 (0.116)	-0.14 (0.121)
		<i>PMHxModerator on CD</i>	0.28 (0.244)	0.631 (0.436)	0.449 (0.474)	-0.297 (0.217)	0.266 (0.217)	0.07 (0.285)
		<i>R2 / Adjusted R2</i>	0.009 / -0.01	0.018 / -0.002	0.032 / 0.005	0.027 / -0.0003	0.02 / 0.004	0.009 / -0.006
	Working memory	<i>PMH on CD</i>	-0.157 (0.049)	-0.103 (0.093)	0.043 (0.091)	-0.12 (0.211)	-0.028 (0.044)	0.029 (0.055)
		<i>Moderator on CD</i>	-0.004 (0.021)	-0.007 (0.021)	-0.047 (0.036)	-0.023 (0.054)	-0.022 (0.021)	-0.023 (0.022)
		<i>PMHxModerator on CD</i>	0.133 (0.045)*	0.062 (0.083)	-0.032 (0.087)	0.124 (0.04)	0.029 (0.04)	-0.027 (0.052)
		<i>R2 / Adjusted R2</i>	0.066 / 0.047	0.02 / 0.00004	0.021 / -0.008	0.02 / -0.009	0.008 / -0.008	0.006 / -0.01
	Planning/organisation	<i>PMH on CD</i>	-0.28 (0.242)	-0.004 (0.449)	0.21 (0.366)	-0.665 (0.845)	-0.203 (0.202)	-0.239 (0.254)
		<i>Moderator on CD</i>	-0.045 (0.101)	-0.048 (0.101)	-0.219 (0.147)	-0.067 (0.215)	-0.157 (0.099)	-0.105 (0.103)
		<i>PMHxModerator on CD</i>	0.197 (0.222)	-0.043 (0.402)	-0.145 (0.348)	0.732 (0.184)	0.213 (0.184)	0.25 (0.242)
		<i>R2 / Adjusted R2</i>	0.018 / -0.002	0.003 / -0.017	0.03 / 0.003	0.04 / 0.012	0.019 / 0.003	0.017 / 0.001
Social Responsiveness Scale (SRS)	Social Awareness	<i>PMH on CD</i>	-0.491 (1.672)	-0.041 (3.064)	1.545 (2.751)	1.069 (6.369)	1.264 (1.445)	-1.9 (1.805)
		<i>Moderator on CD</i>	1.316 (0.695)	1.294 (0.691)	-2.793 (1.102)	-2.874 (1.622)	-0.301 (0.709)	-0.063 (0.731)
		<i>PMHxModerator on CD</i>	0.453 (1.534)	0.946 (2.738)	-1.473 (2.617)	-0.679 (1.319)	-1.202 (1.319)	2.206 (1.718)
		<i>R2 / Adjusted R2</i>	0.024 / 0.004	0.035 / 0.015	0.061 / 0.035	0.065 / 0.038	0.006 / -0.01	0.018 / 0.002
	Social Cognition	<i>PMH on CD</i>	-1.276 (0.413)	-0.527 (0.787)	-0.139 (0.705)	-1.869 (1.616)	0.635 (0.353)	0.658 (0.445)
		<i>Moderator on CD</i>	0.224 (0.172)	0.2 (0.177)	-0.644 (0.282)	-0.224 (0.412)	-0.046 (0.173)	-0.141 (0.18)
		<i>PMHxModerator on CD</i>	1.236 (0.379)*	0.416 (0.703)	0.237 (0.671)	2.021 (0.323)	-0.559 (0.323)	-0.555 (0.423)
		<i>R2 / Adjusted R2</i>	0.075 / 0.057	0.012 / -0.008	0.053 / 0.026	0.076 / 0.05	0.018 / 0.002	0.016 / 0.001
	Social Communication	<i>PMH on CD</i>	-0.194 (0.141)	-0.229 (0.26)	0.218 (0.256)	0.938 (0.592)	0.255 (0.126)	0.139 (0.16)
		<i>Moderator on CD</i>	0.068 (0.058)	0.064 (0.059)	-0.381 (0.103)	-0.563 (0.151)	-0.083 (0.062)	-0.116 (0.065)
		<i>PMHxModerator on CD</i>	0.175 (0.129)	0.214 (0.232)	-0.245 (0.244)	-0.933 (0.115)	-0.251 (0.115)	-0.12 (0.152)
		<i>R2 / Adjusted R2</i>	0.021 / 0.001	0.014 / -0.006	0.131 / 0.106	0.139 / 0.114	0.04 / 0.024	0.019 / 0.004
	Social Motivation	<i>PMH on CD</i>	-0.222 (0.15)	-0.245 (0.277)	-0.33 (0.239)	0.294 (0.563)	0.076 (0.13)	0.034 (0.163)
		<i>Moderator on CD</i>	-0.001 (0.062)	-0.006 (0.062)	-0.142 (0.096)	-0.175 (0.144)	0.03 (0.064)	0.029 (0.066)
		<i>PMHxModerator on CD</i>	0.19 (0.138)	0.279 (0.247)	0.377 (0.227)	-0.257 (0.118)	-0.065 (0.118)	-0.007 (0.155)
		<i>R2 / Adjusted R2</i>	0.015 / -0.005	0.013 / -0.007	0.06 / 0.033	0.026 / -0.002	0.003 / -0.013	0.006 / -0.01
	Repetitive Behavior (RRB)	<i>PMH on CD</i>	-0.325 (0.174)	-0.730 (0.315)	-0.218 (0.326)	0.407 (0.756)	-0.16 (0.16)	0.216 (0.201)
		<i>Moderator on CD</i>	-0.02 (0.072)	-0.03 (0.071)	0.108 (0.13)	0.025 (0.193)	-0.012 (0.079)	-0.022 (0.081)

		<i>PMHxModerator on CD</i>	0.326 (0.159)	0.766 (0.282)	0.182 (0.31)	-0.426 (0.146)	0.141 (0.146)	-0.181 (0.191)
		<i>R2 / Adjusted R2</i>	0.03 / 0.011	0.058 / 0.039	0.012 / -0.016	0.011 / -0.017	0.005 / -0.011	0.008 / -0.007

C5 Supplementary Table 3d - Moderation effects of father's professional class (ISCO scores) on the relationship between prenatal and postnatal paternal mental health (PMH) and child development (CD). PMH measured using the Hospital Anxiety and Depression Scale (HADS) at three timepoints: prenatally (7.8 +/-5.6 weeks before birth; n = 166) and postnatally at 0-12 months (n = 117) and 12-24 months (n = 207). Linear regression models with an interaction term. P-values of <0.05 = *, 0.01 = **, 0.001 = *** following adjustment for multiple outcomes.

			Father's professional class					
			Pregnancy		0-12 months		12-24 months	
			Anxiety	Depression	Anxiety	Depression	Anxiety	Depression
			<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>	<i>Coefficient (SE)</i>
Child Behavioural Checklist (CBCL)	Emotional reactivity	<i>PMH on CD</i>	0.136 (0.133)	0.353 (0.268)	-0.077 (0.179)	0.035 (0.173)	0.038 (0.129)	-0.05 (0.12)
		<i>Moderator on CD</i>	-0.085 (0.067)	-0.102 (0.068)	0.078 (0.076)	0.074 (0.076)	-0.016 (0.067)	-0.02 (0.067)
		<i>PMHxModerator on CD</i>	-0.127 (0.113)	-0.299 (0.222)	0.04 (0.153)	-0.045 (0.114)	-0.046 (0.114)	0.035 (0.105)
		<i>R2 / Adjusted R2</i>	0.019 / 0.0001	0.023 / 0.003	0.014 / -0.014	0.011 / -0.016	0.002 / -0.013	0.002 / -0.014
	Anxiety/Depression	<i>PMH on CD</i>	0.067 (0.123)	0.039 (0.248)	0.097 (0.172)	-0.026 (0.168)	-0.149 (0.123)	-0.292 (0.113)
		<i>Moderator on CD</i>	0.022 (0.062)	0.02 (0.063)	0.102 (0.073)	0.097 (0.074)	0.043 (0.064)	0.057 (0.063)
		<i>PMHxModerator on CD</i>	-0.059 (0.104)	-0.029 (0.205)	-0.15 (0.147)	0.006 (0.109)	0.124 (0.109)	0.267 (0.099)
		<i>R2 / Adjusted R2</i>	0.003 / -0.017	0.001 / -0.019	0.045 / 0.018	0.018 / -0.009	0.011 / -0.004	0.039 / 0.024
	Somatic complaints	<i>PMH on CD</i>	0.06 (0.125)	-0.008 (0.251)	0.320 (0.16)	0.05 (0.158)	0.101 (0.121)	0.008 (0.113)
		<i>Moderator on CD</i>	-0.009 (0.063)	0.002 (0.064)	0.183 (0.067)	0.179 (0.069)	0.104 (0.063)	0.102 (0.063)
		<i>PMHxModerator on CD</i>	-0.016 (0.105)	0.082 (0.208)	-0.238 (0.136)	-0.051 (0.107)	-0.069 (0.107)	0.006 (0.099)
		<i>R2 / Adjusted R2</i>	0.009 / -0.011	0.01 / -0.01	0.098 / 0.073	0.063 / 0.037	0.019 / 0.004	0.015 / -0.001
	Withdrawn behaviour	<i>PMH on CD</i>	0.05 (0.1)	0.194 (0.201)	0.031 (0.117)	-0.087 (0.114)	-0.015 (0.095)	-0.025 (0.088)
		<i>Moderator on CD</i>	0.009 (0.051)	0.009 (0.051)	-0.063 (0.049)	-0.051 (0.05)	-0.027 (0.049)	-0.018 (0.049)
		<i>PMHxModerator on CD</i>	-0.022 (0.084)	-0.112 (0.166)	0.043 (0.1)	0.121 (0.084)	0.049 (0.084)	0.052 (0.077)
		<i>R2 / Adjusted R2</i>	0.006 / -0.014	0.011 / -0.009	0.065 / 0.039	0.048 / 0.021	0.015 / 0.0001	0.013 / -0.003
	Sleep problems	<i>PMH on CD</i>	0.193 (0.135)	0.602 (0.269)	-0.006 (0.196)	0.125 (0.189)	-0.133 (0.131)	0.006 (0.122)
		<i>Moderator on CD</i>	0.02 (0.068)	0.004 (0.069)	0.137 (0.082)	0.127 (0.083)	0.124 (0.068)	0.129 (0.068)
		<i>PMHxModerator on CD</i>	-0.155 (0.114)	-0.431 (0.223)	-0.037 (0.167)	-0.133 (0.115)	0.108 (0.115)	-0.02 (0.107)
		<i>R2 / Adjusted R2</i>	0.014 / -0.006	0.035 / 0.016	0.031 / 0.004	0.032 / 0.005	0.024 / 0.009	0.02 / 0.005
	Attention problems	<i>PMH on CD</i>	0.017 (0.113)	0.013 (0.227)	0.047 (0.144)	0.017 (0.139)	-0.04 (0.109)	-0.052 (0.102)
		<i>Moderator on CD</i>	-0.073 (0.057)	-0.074 (0.058)	0.052 (0.061)	0.051 (0.061)	-0.01 (0.057)	-0.007 (0.056)
		<i>PMHxModerator on CD</i>	-0.007 (0.095)	-0.024 (0.188)	-0.058 (0.123)	-0.01 (0.096)	0.036 (0.096)	0.03 (0.089)
		<i>R2 / Adjusted R2</i>	0.011 / -0.008	0.011 / -0.009	0.01 / -0.017	0.007 / -0.021	0.001 / -0.015	0.003 / -0.012

	Aggressive behaviour	<i>PMH on CD</i>	0.218 (0.101)	0.472 (0.201)	-0.078 (0.144)	-0.178 (0.138)	0.114 (0.1)	0.003 (0.094)
		<i>Moderator on CD</i>	0.021 (0.051)	0.011 (0.051)	0.104 (0.061)	0.112 (0.061)	0.043 (0.052)	0.036 (0.052)
		<i>PMHxModerator on CD</i>	-0.177 (0.085)	-0.309 (0.167)	0.061 (0.123)	0.155 (0.089)	-0.1 (0.089)	0.015 (0.082)
		<i>R2 / Adjusted R2</i>	0.03 / 0.011	0.046 / 0.027	0.029 / 0.002	0.042 / 0.015	0.009 / -0.006	0.006 / -0.01
	Other problems	<i>PMH on CD</i>	0.018 (0.087)	0.075 (0.175)	-0.062 (0.149)	-0.145 (0.143)	-0.084 (0.102)	-0.083 (0.095)
		<i>Moderator on CD</i>	-0.01 (0.044)	-0.008 (0.045)	0.138 (0.063)	0.143 (0.063)	0.061 (0.053)	0.064 (0.053)
		<i>PMHxModerator on CD</i>	-0.025 (0.073)	-0.013 (0.144)	0.036 (0.127)	0.116 (0.09)	0.056 (0.09)	0.07 (0.083)
		<i>R2 / Adjusted R2</i>	0.002 / -0.017	0.009 / -0.01	0.045 / 0.019	0.051 / 0.025	0.012 / -0.003	0.011 / -0.004
Wechsler Primary and Preschool Scales of Intelligence (WPPSI)	Verbal comprehension index	<i>PMH on CD</i>	3.864 (6.133)	-1.992 (12.343)	-0.551 (7.249)	-11.097 (6.754)	-4.04 (5.568)	0.762 (5.169)
		<i>Moderator on CD</i>	-2.304 (3.129)	-2.303 (3.168)	2.75 (3.254)	2.82 (3.133)	-1.896 (2.876)	-1.955 (2.849)
		<i>PMHxModerator on CD</i>	-2.277 (5.116)	1.315 (10.154)	0.328 (5.961)	8.782 (4.871)	2.344 (4.871)	-2.106 (4.495)
		<i>R2 / Adjusted R2</i>	0.009 / -0.012	0.004 / -0.017	0.008 / -0.023	0.034 / 0.005	0.009 / -0.007	0.011 / -0.006
	Visuospatial index	<i>PMH on CD</i>	-0.543 (5.476)	-7.014 (11.065)	2.074 (6.497)	-1.855 (6.145)	6.044 (5.288)	0.609 (4.93)
		<i>Moderator on CD</i>	-0.493 (2.801)	-0.492 (2.842)	3.846 (2.917)	4.028 (2.85)	-0.316 (2.732)	-0.67 (2.717)
		<i>PMHxModerator on CD</i>	-1.34 (4.577)	4.775 (9.109)	-0.756 (5.343)	1.506 (4.628)	-5.298 (4.628)	-0.13 (4.288)
		<i>R2 / Adjusted R2</i>	0.012 / -0.008	0.004 / -0.017	0.024 / -0.006	0.021 / -0.009	0.008 / -0.009	0.001 / -0.015
	Working memory index	<i>PMH on CD</i>	3.87 (5.586)	-3.5 (11.237)	5.554 (6.381)	-2.406 (6.017)	5.433 (5.278)	-2.808 (4.906)
		<i>Moderator on CD</i>	-2.516 (2.85)	-2.418 (2.884)	2.05 (2.857)	2.065 (2.79)	-0.962 (2.727)	-1.267 (2.705)
		<i>PMHxModerator on CD</i>	-2.555 (4.66)	3.15 (9.244)	-3.624 (5.236)	0.675 (4.617)	-4.852 (4.617)	1.5 (4.266)
		<i>R2 / Adjusted R2</i>	0.01 / -0.011	0.006 / -0.015	0.015 / -0.015	0.013 / -0.017	0.007 / -0.009	0.006 / -0.01
Behaviour Rating Inventory of Executive Function, Preschool version (BRIEF-P)	Inhibit (inhibitory control and impulsivity)	<i>PMH on CD</i>	0.129 (0.252)	0.428 (0.505)	-0.123 (0.334)	-0.415 (0.318)	-0.138 (0.249)	0.129 (0.244)
		<i>Moderator on CD</i>	0.064 (0.13)	0.033 (0.131)	-0.092 (0.15)	-0.104 (0.147)	-0.091 (0.132)	-0.069 (0.131)
		<i>PMHxModerator on CD</i>	-0.182 (0.212)	-0.439 (0.419)	0.143 (0.273)	0.470 (0.22)	0.16 (0.22)	-0.099 (0.217)
		<i>R2 / Adjusted R2</i>	0.014 / -0.006	0.01 / -0.01	0.007 / -0.021	0.048 / 0.021	0.006 / -0.01	0.003 / -0.013
	Shift	<i>PMH on CD</i>	-0.056 (0.042)	0.057 (0.084)	-0.021 (0.056)	0.023 (0.053)	-0.023 (0.044)	-0.041 (0.043)
		<i>Moderator on CD</i>	-0.041 (0.021)	-0.043 (0.022)	-0.002 (0.025)	-0.002 (0.024)	-0.03 (0.023)	-0.028 (0.023)
		<i>PMHxModerator on CD</i>	0.033 (0.035)	-0.047 (0.07)	0.027 (0.046)	0.005 (0.039)	0.022 (0.039)	0.031 (0.038)
		<i>R2 / Adjusted R2</i>	0.042 / 0.023	0.026 / 0.007	0.006 / -0.022	0.028 / 0.001	0.009 / -0.006	0.013 / -0.002
	Emotional control	<i>PMH on CD</i>	-0.051 (0.205)	0.221 (0.41)	-0.108 (0.288)	-0.227 (0.276)	-0.137 (0.209)	0.068 (0.206)
		<i>Moderator on CD</i>	-0.031 (0.106)	-0.031 (0.106)	-0.119 (0.127)	-0.122 (0.126)	-0.129 (0.111)	-0.107 (0.11)

		<i>PMHxModerator on CD</i>	0.032 (0.173)	-0.11 (0.341)	0.072 (0.236)	0.249 (0.185)	0.164 (0.185)	-0.048 (0.183)
		<i>R2 / Adjusted R2</i>	0.001 / -0.019	0.005 / -0.014	0.01 / -0.018	0.024 / -0.003	0.012 / -0.003	0.006 / -0.01
	Working memory	<i>PMH on CD</i>	0.008 (0.039)	0.026 (0.078)	-0.03 (0.054)	-0.085 (0.054)	0.006 (0.038)	-0.003 (0.038)
		<i>Moderator on CD</i>	-0.006 (0.02)	-0.011 (0.02)	-0.014 (0.025)	-0.018 (0.024)	0.001 (0.021)	0.001 (0.021)
		<i>PMHxModerator on CD</i>	-0.02 (0.033)	-0.054 (0.065)	0.035 (0.044)	0.081 (0.034)	-0.003 (0.034)	0.003 (0.034)
		<i>R2 / Adjusted R2</i>	0.015 / -0.005	0.021 / 0.002	0.011 / -0.017	0.033 / 0.005	0.0004 / -0.016	0.0001 / -0.016
	Planning/organisation	<i>PMH on CD</i>	0.15 (0.185)	0.625 (0.369)	-0.037 (0.211)	-0.216 (0.2)	0.119 (0.177)	0.034 (0.174)
		<i>Moderator on CD</i>	-0.118 (0.095)	-0.154 (0.096)	0.073 (0.093)	0.076 (0.091)	-0.164 (0.094)	-0.169 (0.093)
		<i>PMHxModerator on CD</i>	-0.193 (0.155)	-0.597 (0.307)	0.079 (0.172)	0.251 (0.156)	-0.085 (0.156)	-0.009 (0.154)
		<i>R2 / Adjusted R2</i>	0.032 / 0.012	0.037 / 0.018	0.015 / -0.012	0.042 / 0.015	0.02 / 0.005	0.019 / 0.003
Social Responsiveness Scale (SRS)	Social Awareness	<i>PMH on CD</i>	(1.293)	-3.055 (2.567)	-2.01 (1.627)	0.685 (1.572)	-1.779 (1.264)	-2.472 (1.241)
		<i>Moderator on CD</i>	0.446 (0.666)	0.675 (0.666)	0.848 (0.722)	0.837 (0.725)	0.609 (0.687)	0.727 (0.669)
		<i>PMHxModerator on CD</i>	1.261 (1.088)	3.557 (2.131)	1.709 (1.339)	-0.181 (1.115)	1.576 (1.115)	2.635 (1.108)
		<i>R2 / Adjusted R2</i>	0.012 / -0.008	0.033 / 0.014	0.028 / -0.0002	0.022 / -0.006	0.017 / 0.001	0.043 / 0.028
	Social Cognition	<i>PMH on CD</i>	0.174 (0.33)	-0.054 (0.662)	0.071 (0.418)	0.437 (0.399)	0.146 (0.313)	0.314 (0.31)
		<i>Moderator on CD</i>	-0.076 (0.17)	-0.082 (0.172)	0.178 (0.186)	0.178 (0.184)	0.14 (0.17)	0.134 (0.167)
		<i>PMHxModerator on CD</i>	-0.119 (0.277)	-0.022 (0.55)	0.021 (0.344)	-0.22 (0.276)	-0.104 (0.276)	-0.211 (0.277)
		<i>R2 / Adjusted R2</i>	0.004 / -0.016	0.002 / -0.017	0.014 / -0.014	0.034 / 0.007	0.005 / -0.011	0.013 / -0.003
	Social Communication	<i>PMH on CD</i>	0.057 (0.109)	-0.0005 (0.218)	-0.248 (0.158)	-0.144 (0.153)	-0.03 (0.113)	0.015 (0.113)
		<i>Moderator on CD</i>	-0.065 (0.056)	-0.067 (0.057)	0.039 (0.07)	0.04 (0.07)	0.012 (0.061)	0.011 (0.061)
		<i>PMHxModerator on CD</i>	-0.056 (0.091)	-0.001 (0.181)	0.179 (0.13)	0.134 (0.1)	0.014 (0.1)	0.002 (0.1)
		<i>R2 / Adjusted R2</i>	0.012 / -0.008	0.009 / -0.01	0.027 / -0.001	0.014 / -0.014	0.002 / -0.014	0.002 / -0.014
	Social Motivation	<i>PMH on CD</i>	0.012 (0.115)	0.216 (0.229)	-0.106 (0.14)	-0.072 (0.136)	0.101 (0.113)	-0.078 (0.112)
		<i>Moderator on CD</i>	-0.117 (0.059)	-0.122 (0.059)	-0.061 (0.062)	-0.056 (0.063)	-0.097 (0.062)	-0.104 (0.061)
		<i>PMHxModerator on CD</i>	-0.027 (0.096)	-0.145 (0.19)	0.143 (0.115)	0.095 (0.1)	-0.082 (0.1)	0.097 (0.1)
		<i>R2 / Adjusted R2</i>	0.029 / 0.009	0.033 / 0.014	0.04 / 0.013	0.023 / -0.005	0.019 / 0.004	0.025 / 0.009
	Repetitive Behavior (RRB)	<i>PMH on CD</i>	-0.166 (0.134)	-0.156 (0.27)	-0.094 (0.19)	-0.163 (0.182)	-0.297 (0.14)	-0.001 (0.14)
		<i>Moderator on CD</i>	-0.001 (0.069)	0.018 (0.07)	-0.059 (0.084)	-0.058 (0.084)	0.02 (0.076)	0.042 (0.076)
		<i>PMHxModerator on CD</i>	0.165 (0.113)	0.223 (0.224)	0.058 (0.156)	0.119 (0.123)	0.261 (0.123)	0.028 (0.125)
		<i>R2 / Adjusted R2</i>	0.016 / -0.004	0.017 / -0.003	0.008 / -0.02	0.013 / -0.015	0.026 / 0.01	0.006 / -0.01

C5 Supplementary Table 4a: Multiple correction using four different methodological approaches, using the p values of linear regression models* on the effect of paternal mental health at pregnancy on child development. *P values corrected based on year of child developmental outcome; Paternal mental health measured via the hospital anxiety and depression scale (HADS).*

	Pregnancy (n = 166)											
				Paternal anxiety					Paternal depression			
Child age	Measure	Subscale	<i>p</i>	<i>p</i> ₁	<i>p</i> ₂	<i>p</i> ₃	<i>p</i> ₄	<i>p</i>	<i>p</i> ₁	<i>p</i> ₂	<i>p</i> ₃	<i>p</i> ₄
2 years	CBCL	<i>Emotional reactivity</i>	0.82	0.82	1.00	1.00	1.00	0.95	0.95	1.00	1.00	1.00
		<i>Anxiety/Depression</i>	0.44	0.82	1.00	1.00	0.99	0.34	0.95	1.00	1.00	0.96
		<i>Somatic complaints</i>	0.02	0.16	0.15	0.16	0.15	0.16	0.95	1.00	0.96	0.75
		<i>Withdrawn behaviour</i>	0.29	0.82	1.00	1.00	0.94	0.22	0.95	1.00	1.00	0.86
		<i>Sleep problems</i>	0.30	0.82	1.00	1.00	0.94	0.13	0.91	1.00	0.91	0.67
		<i>Attention problems</i>	0.62	0.82	1.00	1.00	1.00	0.80	0.95	1.00	1.00	1.00
		<i>Aggressive behaviour</i>	0.70	0.82	1.00	1.00	1.00	0.08	0.64	0.65	0.64	0.49
		<i>Other problems</i>	0.78	0.82	1.00	1.00	1.00	0.27	0.95	1.00	1.00	0.92
3 years	WPPSI	<i>Verbal comprehension index</i>	0.40	0.91	1.00	1.00	1.00	0.63	0.95	1.00	1.00	1.00
		<i>Visuospatial index</i>	0.14	0.91	1.00	1.00	0.86	0.50	0.95	1.00	1.00	1.00
		<i>Working memory index</i>	0.49	0.91	1.00	1.00	1.00	0.84	0.95	1.00	1.00	1.00
	BRIEF-P	<i>Inhibitory control and impulsivity</i>	0.40	0.91	1.00	1.00	1.00	0.95	0.95	1.00	1.00	1.00
		<i>Shift</i>	0.45	0.91	1.00	1.00	1.00	0.81	0.95	1.00	1.00	1.00
		<i>Emotional control</i>	0.63	0.91	1.00	1.00	1.00	0.23	0.95	1.00	1.00	0.97
		<i>Working memory</i>	0.31	0.91	1.00	1.00	0.99	0.27	0.95	1.00	1.00	0.98
		<i>Planning/organisation</i>	0.27	0.91	1.00	1.00	0.98	0.45	0.95	1.00	1.00	1.00
	SRS	<i>Social Awareness</i>	0.46	0.91	1.00	1.00	1.00	0.09	0.95	1.00	1.00	0.71
		<i>Social Cognition</i>	0.91	0.91	1.00	1.00	1.00	0.67	0.95	1.00	1.00	1.00
		<i>Social Communication</i>	0.83	0.91	1.00	1.00	1.00	0.62	0.95	1.00	1.00	1.00
		<i>Social Motivation</i>	0.57	0.91	1.00	1.00	1.00	0.65	0.95	1.00	1.00	1.00
		<i>Repetitive Behaviour (RRB)</i>	0.45	0.91	1.00	1.00	1.00	0.02	0.26	0.30	0.26	0.23

*Adjusted For Confounding Variables. P₁ = Hochberg Sequential Procedure P₂ = Bonferroni Correction P₃ = Holm's Sequential Bonferroni Procedure P₄ = Dunn-Šidák Correction. CBCL = *Child Behaviour Checklist*; WPPSI = *Wechsler Primary and Preschool Scales of Intelligence*; BRIEF-P = *Behaviour Rating Inventory Of Executive Function, Preschool Version*; SRS = *Social Responsiveness Scale*.

C5 Supplementary Table 4b: Multiple correction using four different methodological approaches, using the p values of linear regression models* on the effect of paternal mental health at 0-12 months postpartum on child development. *P values corrected based on year of child developmental outcome; Paternal mental health measured via the hospital anxiety and depression scale (HADS).*

		0-12 months postpartum (n = 117)										
		Paternal anxiety					Paternal depression					
Child age	Measure	Subscale	p	p ₁	p ₂	p ₃	p ₄	p	p ₁	p ₂	p ₃	p ₄
2 years	CBCL	Emotional reactivity	0.33	0.98	1.00	1.00	0.96	0.81	0.99	1.00	1.00	1.00
		Anxiety/Depression	0.65	0.98	1.00	1.00	1.00	0.67	0.99	1.00	1.00	1.00
		Somatic complaints	0.27	0.98	1.00	1.00	0.92	0.42	0.99	1.00	1.00	0.99
		Withdrawn behaviour	0.16	0.98	1.00	1.00	0.75	0.13	0.99	1.00	1.00	0.67
		Sleep problems	0.75	0.98	1.00	1.00	1.00	0.57	0.99	1.00	1.00	1.00
		Attention problems	0.98	0.98	1.00	1.00	1.00	0.57	0.99	1.00	1.00	1.00
		Aggressive behaviour	0.71	0.98	1.00	1.00	1.00	0.46	0.99	1.00	1.00	0.99
		Other problems	0.21	0.98	1.00	1.00	0.85	0.99	0.99	1.00	1.00	1.00
3 years	WPPSI	Verbal comprehension index	0.88	0.88	1.00	1.00	1.00	0.33	0.88	1.00	1.00	0.99
		Visuospatial index	0.53	0.88	1.00	1.00	1.00	0.88	0.88	1.00	1.00	1.00
		Working memory index	0.55	0.88	1.00	1.00	1.00	0.48	0.88	1.00	1.00	1.00
	BRIEF-P	Inhibitory control and impulsivity	0.45	0.88	1.00	1.00	1.00	0.39	0.88	1.00	1.00	1.00
		Shift	0.82	0.88	1.00	1.00	1.00	0.86	0.88	1.00	1.00	1.00
		Emotional control	0.54	0.88	1.00	1.00	1.00	0.72	0.88	1.00	1.00	1.00
		Working memory	0.27	0.88	1.00	1.00	0.98	0.44	0.88	1.00	1.00	1.00
		Planning/organisation	0.44	0.88	1.00	1.00	1.00	0.45	0.88	1.00	1.00	1.00
	SRS	Social Awareness	0.84	0.88	1.00	1.00	1.00	0.12	0.88	1.00	1.00	0.81
		Social Cognition	0.48	0.88	1.00	1.00	1.00	0.02	0.24	0.30	0.26	0.23
		Social Communication	0.82	0.88	1.00	1.00	1.00	0.08	0.88	1.00	0.88	0.66
		Social Motivation	0.35	0.88	1.00	1.00	1.00	0.11	0.88	1.00	1.00	0.78
		Repetitive Behaviour (RRB)	0.36	0.88	1.00	1.00	1.00	0.02	0.24	0.20	0.26	0.23

*Adjusted For Confounding Variables. P₁ = Hochberg Sequential Procedure P₂ = Bonferroni Correction P₃ = Holm's Sequential Bonferroni Procedure P₄ = Dunn-Šidák Correction. CBCL = Child Behaviour Checklist; WPPSI = Wechsler Primary and Preschool Scales Of Intelligence; BRIEF-P = Behaviour Rating Inventory Of Executive Function, Preschool Version; SRS = Social Responsiveness Scale.

C5 Supplementary Table 4c: Multiple correction using four different methodological approaches, using the p values of linear regression models* on the effect of paternal mental health at 12-24 months postpartum on child development. *P values corrected based on year of child developmental outcome; Paternal mental health measured via the hospital anxiety and depression scale (HADS).*

		12-24 months postpartum (n = 207)										
		Paternal anxiety					Paternal depression					
Child age	Measure	Subscale	<i>p</i>	<i>p</i> ₁	<i>p</i> ₂	<i>p</i> ₃	<i>p</i> ₄	<i>p</i>	<i>p</i> ₁	<i>p</i> ₂	<i>p</i> ₃	<i>p</i> ₄
2 years	CBCL	<i>Emotional reactivity</i>	0.74	0.80	1.00	1.00	1.00	0.98	0.98	1.00	1.00	1.00
		<i>Anxiety/Depression</i>	0.30	0.80	1.00	1.00	0.94	0.56	0.98	1.00	1.00	1.00
		<i>Somatic complaints</i>	0.44	0.80	1.00	1.00	0.99	0.91	0.98	1.00	1.00	1.00
		<i>Withdrawn behaviour</i>	0.01	0.08	0.10	0.08	0.08	0.18	0.98	1.00	1.00	0.80
		<i>Sleep problems</i>	0.19	0.80	1.00	1.00	0.81	0.92	0.98	1.00	1.00	1.00
		<i>Attention problems</i>	0.56	0.80	1.00	1.00	1.00	0.58	0.98	1.00	1.00	1.00
		<i>Aggressive behaviour</i>	0.80	0.80	1.00	1.00	1.00	0.97	0.98	1.00	1.00	1.00
		<i>Other problems</i>	0.55	0.80	1.00	1.00	1.00	0.90	0.98	1.00	1.00	1.00
3 years	WPPSI	<i>Verbal comprehension index</i>	0.12	0.96	1.00	1.00	0.81	0.30	0.74	1.00	1.00	0.99
		<i>Visuospatial index</i>	0.21	0.96	1.00	1.00	0.95	0.69	0.74	1.00	1.00	1.00
		<i>Working memory index</i>	0.33	0.96	1.00	1.00	0.99	0.66	0.74	1.00	1.00	1.00
	BRIEF-P	<i>Inhibitory control and impulsivity</i>	0.96	0.96	1.00	1.00	1.00	0.26	0.74	1.00	1.00	0.98
		<i>Shift</i>	0.38	0.96	1.00	1.00	1.00	0.03	0.39	0.33	0.39	0.33
		<i>Emotional control</i>	0.68	0.96	1.00	1.00	1.00	0.26	0.74	1.00	1.00	0.98
		<i>Working memory</i>	0.23	0.96	1.00	1.00	0.97	0.21	0.74	1.00	1.00	0.95
		<i>Planning/organisation</i>	0.38	0.96	1.00	1.00	1.00	0.19	0.74	1.00	1.00	0.94
	SRS	<i>Social Awareness</i>	0.59	0.96	1.00	1.00	1.00	0.06	0.72	0.83	0.72	0.55
		<i>Social Cognition</i>	0.58	0.96	1.00	1.00	1.00	0.10	0.74	1.00	1.00	0.75
		<i>Social Communication</i>	0.86	0.96	1.00	1.00	1.00	0.29	0.74	1.00	1.00	0.99
		<i>Social Motivation</i>	0.06	0.78	0.78	0.78	0.55	0.21	0.74	1.00	1.00	0.95
		<i>Repetitive Behaviour (RRB)</i>	0.80	0.96	1.00	1.00	1.00	0.74	0.74	1.00	1.00	1.00

*Adjusted For Confounding Variables. P₁ = Hochberg Sequential Procedure P₂ = Bonferroni Correction P₃ = Holm's Sequential Bonferroni Procedure P₄ = Dunn-Šidák Correction. CBCL = Child Behaviour Checklist; WPPSI = Wechsler Primary and Preschool Scales Of Intelligence; BRIEF-P = Behaviour Rating Inventory Of Executive Function, Preschool Version; SRS = Social Responsiveness Scale.

