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Master de Santé Publique

Paternal Psychopathology and Childhood Psychosocial Development in a French Cohort

The role of father involvement

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List of Acronyms

ALSPAC = Avon Longitudinal Study of Parents and Children

AUDIT-C = Alcohol Unit Disorders Identification Test C

CESD = Center for Epidemiologic Studies Depression Scale

EPDS = Edinburgh Post-natal Depression Scale

IFI = Inventory of Father Involvement

SDQ = Strengths and Difficulties Questionnaire

SES = Socioeconomic Status

Abstract

Context: Children of parents with psychopathology are at a higher risk of developing mental health problems in adulthood. The pathways of transmission from maternal mental health to childhood symptoms are well researched, but the effects of paternal psychopathology on children are less understood. This study examined the possible moderating role of the level of father involvement in the association between paternal depression and alcohol use and childhood emotional and behaviour problems.

Methods: Behaviour of 875 children from the French EDEN cohort was assessed when they were 8 years old using the Strengths and Difficulties Questionnaire (SDQ). Paternal depression was assessed using the CESD and alcohol use by self-reported weekly consumption. Factor analysis was conducted to develop factors to measure father involvement. Multiple linear regression was used, controlling for relevant confounders (including income, educational level, mothers depression at age 8, postnatal depression, and prematurity) with multiple imputations to account for missing data. Analysis were stratified by child sex to investigate potential sex differences.

Results: Father's depression was associated with children's total difficulties scores in both boys and girls, with a larger impact for boy's internalising behaviours. While girls internalising symptoms were related to paternal involvement, in particular accessibility, there was little evidence that involvement moderated the effects of paternal depression on child outcomes. No association of child outcomes with paternal alcohol use were found.

Conclusion: Father's depression should be included in research on children's difficulties in middle childhood. Future research into father's depression should consider, and systematically investigate, other possible moderators and routes of transmission of father's psychopathology to childhood emotional and behavioural problems.

Résumé

Contexte: Les enfants de parents psychopathe courent un plus grande risque de développer des problèmes de santé mentale à l'âge adulte. Les voies de transmission de la santé mentale maternelle aux symptômes de l'enfance sont bien étudiées, mais les effets de la psychopathologie paternelle sur les enfants sont moins bien compris. L'étude transversale actuelle a examiné le rôle modérateur possible de l'implication du père dans l'association entre la dépression paternelle et la consommation d'alcool et les problèmes émotionnels et comportementaux en enfance.

Méthodes: Le comportement de 875 enfants de la cohorte française EDEN a été évalué à 8 ans en utilisant le 'Strengths and Difficulties Questionnaire' (SDQ). La dépression paternelle a été évaluée à l'aide du CESD et la consommation d'alcool par consommation hebdomadaire auto-déclarée. Une analyse factorielle a été menée pour développer des facteurs permettant de mesurer l'implication du père. La régression linéaire multiple a été utilisée en tenant compte de variables de confusion, y compris la dépression maternelle, statut socio-économique, niveau d'éducation, dépression postnatale et naissance avant terme. Multiples imputations ont été utilisées pour tenir compte des données manquantes. Les résultats ont été stratifiés, selon le sexe de l'enfant pour étudier les différences sexuelles potentielles.

Résultats: La dépression du père était associée à des scores de difficultés totales chez les garçons et les filles et au comportement intériorisé des garçons. Les symptômes intériorisés des filles étaient liés à l'implication du père notamment l'accessibilité du père. Peu d'effets modérateurs de la participation paternelle ont été observés. Aucune association entre les résultats de l'enfant et la consommation d'alcool par le père n'a été trouvée.

Conclusion: Dans l'avenir la dépression du père devrait être incluse dans la recherche sur les difficultés des enfants à la phase intermédiaire de l'enfance. Les recherches sur la dépression paternelle devraient examiner et étudier systématiquement d'autres modérateurs et voies possibles de transmission de la psychopathologie paternelle aux problèmes émotionnels et comportementaux en enfance.

1. Introduction

Parental psychopathology influences the psychosocial development of children, with negative effects continuing into adulthood (Sweeney & McBeth, 2016). The children of parents with psychopathology have a higher risk than the children of parents without psychopathology of developing anxiety disorders, depression, and substance abuse problems (Connell & Goodman, 2002; Weissman et al., 2006). It is necessary to further understand the mechanisms involved in the contribution of parental mental health to children's social and emotional development. Such an understanding will improve prevention and treatment opportunities, especially as treatment at younger ages has the potential to reduce occurrence of problems later in life (Copeland et al., 2013).

It is becoming increasingly common to include the effects of paternal mental health in research on children's mental health (Goodman & Gotlib, 1999; Sweeney & McBeth, 2016). This may have become popular due to changing social norms and increasing levels of father involvement in childrearing (Fagan et al., 2014). Early research identified mothers as the "gatekeepers" of the relationship between fathers and their children (Kelly, 2000). However, family dynamics and the role of the father are changing in Europe. There is increasing diversity in family makeup, women are more involved in the workforce, and new policies have been introduced that promote men's contribution to caregiving (Oláh et al., 2017). As fathers become more directly involved in family life it is important to understand how paternal depression may influence children's psychosocial development, especially as around 7.1% of men aged 20 to 54 in France experienced a depressive episode in 2010 (Com-Ruelle et al., 2008). Additionally, one in two men aged 25 to 54 year old in France is an excessive drinker (Beck and Richard, 2014). The higher rates of alcohol use in men compared to women may be one of the reasons why paternal alcohol use is one of the most investigated aspects of paternal influences on children's mental health (Ramchandani & Psychogiou, 2009). Furthermore, higher levels of alcohol use increase the risk of depression while some people with depression report self-medicating with alcohol (Ramchandani & Psychogiou, 2009; Boden & Fergusson, 2011).

Paternal psychopathology, including depression and substance use, has frequently been shown to have negative effects on children, including internalising and externalising behaviours¹, conduct problems, ADHD, and substance use (Christensen & Bilenberg, 2000; Loukas et al., 2001; Brennan et al., 2002). The effects of paternal depression on childhood outcomes appear to be smaller than maternal effects (Malmberg & Flouri, 2011; Fitzsimons et

¹ Internalising and externalising behaviours are two factors commonly used to understand and predict child psychopathology with internalising behaviours featuring symptoms of distress and anxiety (directed at the self) and externalising behaviours featuring symptoms directed outwards such as hyperactivity and conduct problems (Doyle et al., 2016)

al., 2016). However, a meta-analysis showed that age of the children is correlated to the effect size found in studies into parental mental health on their offspring's internalising and externalising behaviours. Effect sizes of maternal depression tend to decrease as the child becomes older ($r = -0.15$ for internalising symptoms and $r = -0.19$ for externalising symptoms), while those for paternal depression increase with child age ($r = 0.34$ for internalising and $r = 0.23$ for externalising problems) (Connell & Goodman, 2002).

1.1 Potential Mechanisms of Transmission of Paternal Psychopathology

The proposed mechanisms of transmission of paternal psychopathology are difficult to establish for many reasons including the lack of research, the changing roles of fathers, and the bidirectional effects involved (Palkovitz, 2007). However, the model proposed by Ramchandani and Psychogiou (2009, figure 1) tried to capture these complex mechanisms through four causal pathways.

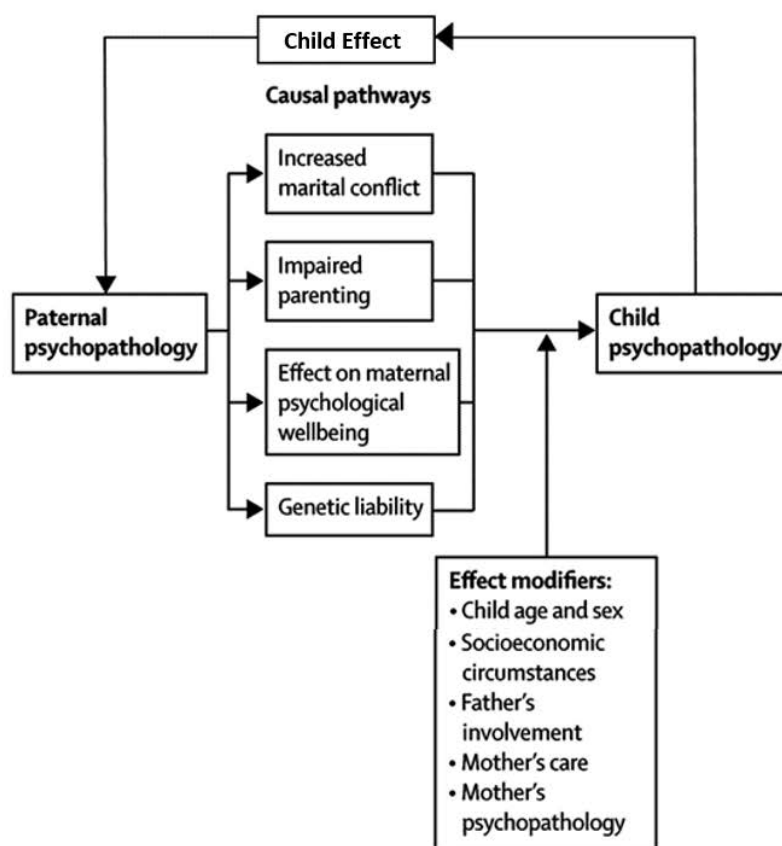


Figure 1: Model of mechanisms of intergenerational transmission of paternal psychopathology. Based on Ramchandani and Psychogiou (2009).

First, paternal psychopathology might impact child psychopathology through *genetic liability*. The genetic model emphasizes the role of shared genes between the father and the child

which contribute to the transmission of psychopathology (Sullivan et al., 2000; Flouri et al., 2016). Secondly, paternal psychopathology may also affect *maternal mental wellbeing* and therefore child psychopathology (Gabriel et al., 2016). Third, paternal psychopathology might lead to *impaired parenting*. A meta-analysis into parenting behaviour showed that depressed fathers may experience impaired parenting ability (Dietz et al., 2009; Wilson & Durbin, 2010), which is known to impact child development. Fourth, *marital conflict* and lower levels of marital satisfaction are frequently reported in couples in which one partner suffers from depression and are known to play a large and significant role in child psychopathology (Davies & Cummings, 1994; Hanington et al., 2011).

Complicating this model is the fact that bidirectional effects have also been reported. Flouri et al., (2016) have called this the *child effects* model. It has been found that child affect can influence paternal psychopathology, specifically girls internalizing symptoms can predict paternal depression (Andreas et al., 2018).

1.2 Effect modifiers

Several factors are mentioned in the literature that can alter the magnitude of the effect of paternal psychopathology on children's outcomes. These factors can be used to identify children who are most at risk. Each of the "effect modifier" factors shown in figure 1 is presumed to influence the transmission of paternal psychopathology, to their offspring. (Ramchandani & Psychogiou, 2009; Barker et al., 2017).

One of the most investigated factors is the *sex of the child*, as there may be sex differences in the type or severity of outcomes that children exhibit (Sarkadi et al., 2008). Sex differences become especially pronounced over time, with depression in parents generally accompanying internalizing symptoms in same sex children (Andreas et al., 2018). Alcoholism in parents has also been shown to increase depressive and internalizing symptoms in children when the child is the same sex as the affected parent (Christensen & Bilenberg, 2000). This suggests that the sex of both the parent and the child may be important to consider. One limitation of these studies is that they do not investigate gender roles played within the family.

Also, the younger *the age of the child* during the depressive episode the more it will affect their development (Goodman et al., 2011). Research on maternal mental health, particularly depression, has found that there may be critical periods for exposure, especially during pregnancy and the postnatal period. Connell and Goodman (2002) conducted a meta-analysis and showed that larger effect sizes are found between paternal psychological symptoms and child problem behaviours as the child's age increases. While for children under the age of 6,

mother's mental health was most important for the occurrence of child internalising problems, the impact of mothers and fathers was about equal during middle childhood. In children aged 13 and older, the impact of father's depression on child was larger than that of mother's depression (Connell & Goodman, 2002). Thus, the critical periods of exposure to paternal depression may be different than for mother's depression. According to the Gender Self-socialisation Model Theory, children begin to develop their gender stereotypes early, and attempt to emulate the same sex parent at around age 7 or 8 (Tobin et al., 2010). In line with this theory is the finding that paternal effects on children's development are larger later in childhood and in adolescence (Lewis et al., 2017; Andreas et al., 2018).

Socioeconomic circumstances can also have a large effect on childhood mental health. Fitzsimons et al. (2016) used a large longitudinal cohort in the UK and found that at ages 5 and 11 children's behavioural and emotional outcomes are consistently worse if they experienced poverty, especially if poverty was persistent, when controlling for parental depression. Parental educational level is often included as a measure of SES. Lower levels of both paternal and maternal education have been shown to be related to poorer outcomes on measures of child emotions and behaviour (Bøe et al., 2012; de Laat et al., 2016).

Maternal care and maternal psychopathology may also have an effect on the transmission of psychopathology from fathers to children. Research on paternal alcohol use found that a secure attachment style with the mother can reduce the effects of paternal alcoholism on externalising behaviours in children aged 3 years (Edwards et al., 2006). Additionally, Goodman and Gotlib (1999) proposed several specific pathways in which mothers can pass psychopathology to their children. The effects of maternal depression and paternal depression have been shown to accumulate, causing stronger externalizing problems in children when both parents are suffering from depression (Brennan et al., 2002).

1.3 “Father Involvement” as an effect modifier

Father involvement is often mentioned in the literature as a potential effect modifier, but there are many different ideas of what ‘Father Involvement’ is. The first widely accepted operationalization of “father involvement” was defined by Lamb et al. (1985). They stated that father involvement consists of three constructs: engagement, accessibility, and responsibility. *Engagement* is the time spent interacting with children, *accessibility* refers to if the father is present in the child's life, and therefore easy to engage with. Finally, *responsibility* is defined as the father's involvement in decision making pertaining to the child, and their role in the more serious aspects of caregiving, such as looking after children when they are sick (Lamb & Tamis-LeMonda, 2004).

In response to the more recent research findings on paternal involvement, Pleck (2010) amended the three primary aspects of paternal involvement: positive engagement activities, warmth and responsiveness, and control (monitoring children). Two secondary aspects were also included: indirect care (activities done for the child, not with the child), and process responsibility which is if the father monitors that all his child's needs are being met (Pleck, 2010). This shows that the idea of father involvement has changed over time from a focus on the quantity of the father's presence in family life to a concern about the quality of the father's involvement.

Recently, fathers parenting and attachment styles have also been included in work on father involvement. The reason for recent research into paternal parenting styles may be due to slow increases in paternal involvement in family life. Bianchi et al. (2007) looked at time use diaries to objectively measure how much time mothers and fathers spent with children in the United States and found that fathers spend more time with their children than they have in the past. Father's choice of parenting style can have different effects on children's behaviour and the father-child relationship may be a buffer for contextual risk factors such as socioeconomic disadvantage (Mezulis et al., 2004; Malmberg & Flouri, 2011). In a qualitative study into the understanding of being a 'good father' compared to being a 'good mother', mothers stated that being a good mother requires providing reliability and structure for the child, whereas fathers stated that being a good father entails participating in family life and spending time with their children (Pedersen, 2012). Pedersen stated that, "mothers ask *for* help whereas fathers ask *to* help" p242. This can explain why much of the research into paternal influences concerns how father presence or absence contributes to children's behaviours, whereas the research into maternal influences on children's behaviour stresses her parenting style.

1.4. Father Involvement and Child Socioemotional Development

Fathers are thought to provide a positive influence on their child the more contact they have with them (Sarkadi et al., 2008; Lamb, 2000). Sarkadi et al. (2008) conducted a meta-analysis and found that fathers who regularly engage with their children reduce behaviour problems, but found no significant effects for the accessibility aspect of father involvement which they measured by assessing cohabitation. Engaged fathers can even act as a buffer for the effects of mother's depression (Gere et al., 2013; Planalp & Braungart-Rieker, 2016). Engagement in this case was defined as direct contact with the child through caregiving and play.

There are many reasons why father involvement may change. Fathers become more involved in their children's lives as they grow, possibly due to changes in the child's needs and abilities (Planalp & Braungart-Rieker, 2016). However, the opposite has also been found (Yeung et al.,

2001). Contradictory findings may be due to the different types of activities and involvement that are measured, for example TV watching with children increases with age, whereas caring for children decreases (Yeung et al., 2001). Another interesting issue raised by Palkovitz (2007) is the concept that poor quality of the father-child relationship and the father's negative parenting behaviours could be a significant contributor to developmental difficulties in children. He states that the level of father involvement may be a surrogate for more complex aspects of parenting.

As suggested in figure 1, some research has been conducted into the possibility that father involvement can moderate the negative effects of paternal depressive symptoms on children's behaviours, but research testing this effect is often conducted in families where both parents are depressed with a particular focus on maternal depression. In families with both maternal and paternal depression, paternal depression intensified the effects of maternal depression on children's behaviour at age 5, but only if these fathers spent high amounts of time with their children. Additionally, father's parenting style and time spent with the child interacted to reduce the severity of internalizing behaviours in children with depressed mothers (Mezulis et al., 2004). This suggests that high levels of father involvement may not always lead to positive outcomes for children, and that the influence of paternal psychopathology on childhood outcomes may be moderated by the amount and type of paternal involvement. This could account for some differences between maternal and paternal effects on children's development as mothers spend significantly more time with their children.

Nerayanan and Naerde (2016) conducted research in Norway into the effects of a government policy designed to improve father-child relationships after childbirth. The policy stated that 14 weeks of the paid parental leave must be taken by fathers. Despite high uptake of paternal leave there was no change in the effects of paternal depression on child depressive symptoms at ages 6 months, or 1, 2, 3, or 4 years (Nerayanan & Naerde, 2016). One explanation the authors propose is that mothers may still take on the role of the primary caregiver, despite increased paternal involvement, or that the mechanisms of paternal and maternal involvement are different. Therefore, there is still a lack of clarity in understanding the role of father involvement in the transmission of psychopathology.

Complicating the issue are findings that fathers who are less depressed, more educated, and who have sufficient social support are more likely to be involved with their children (Roggman et al., 2002). Non-resident fathers were also more likely to suffer from substance dependency, anxiety, and had more criminal convictions than fathers who lived with their children all the time (Jaffee et al., 2001). Therefore, it is possible that these factors are confounding and reduce the positive effect of father involvement.

1.5. Rationale for the Current Study

It is not yet known how father involvement modifies the link between paternal psychopathology and childhood outcomes. Ramchandani and Psychogiou (2009) included father involvement as an effect modifier in their model, however the evidence base for the role of father involvement as a moderator in the transmission of psychopathology is small and mainly focused on fathers with antisocial behaviour (Ramchandani & Psychogiou, 2009; Jaffee et al., 2003). While many other associations in the model have a strong empirical backing, more research is needed to verify the claim that father involvement is also an effect modifier in the case of paternal depression and alcohol use. Furthermore, many previous studies into father involvement have been conducted using UK cohorts, such as the ALSPAC cohort. However, parents and children in this cohort were recruited in 1991-1992. Since the early nineties the role of the father's involvement has evolved, and fathers are now more invested in their children's upbringing. Finally, these questions have not yet been studied in the French context; outcomes based on a French cohort could contribute to the strength of the scientific inferences across different populations.

The aim of the current study is to determine the effects of paternal depression and paternal alcohol use on children's emotional and behavioural outcomes at 8 years and to identify if paternal involvement moderates the potentially negative effects of father's depression and alcohol abuse on children's behaviour.

This study will also investigate sex differences in the effects of paternal depression on children's emotional and behavioural outcomes at 8 years, as previous studies have shown differential effects according to child sex.

2. Methods

2.1. Data Collection

Data for this study come from the EDEN (Etude sur les déterminants pré et postnataux précoces du Développement et de la santé de l'ENfant) mother-child study, set up to assess the pre- and postnatal nutritional, social and environmental determinants of infant and child development, and health (Heude et al., 2016). Participants were recruited before 24 weeks of gestation from two university maternity clinics, one in Nancy and another in Poitiers, France. Recruitment took place between September 2003 and January 2006 by local clinical teams at the hospitals. All women who visited the two clinics during pregnancy were informed of the study. Only women who had singleton pregnancies, no gestational diabetes at inclusion, were able to speak and understand French and were not planning on moving to a different area for the next three years were included. Among eligible women, 55% (n=2002) agreed to participate (969 in Poitiers, 1033 in Nancy). Written consent was obtained for the mothers and fathers. After the delivery of the child, consent was obtained again by the parents on behalf of the child. The participants were able to withdraw at any time. Parents were informed of overall objectives of the study and frequently updated on the outcomes of completed research projects using the data from the cohort.

Of the 2002 women recruited during pregnancy, birth data were available for 1899 mother-infant pairs. During pregnancy and after birth, socio-demographic and biomedical data on the mother and child were gathered from medical records, face to face interviews, and mother's self-completed questionnaires. At multiple time points during the child's infancy and childhood (4, 8, 12, 24 months, 3, 4, and 5 years) mothers completed mailed questionnaires to collect data on child and maternal characteristics. Although not initially planned, the cohort continued beyond the 5 year data wave and included additional evaluations at 8 and 11 years. However, this also led to a high level of attrition. By the year 8 follow-up, data on child psychological exams or parent questionnaires were available for 877 participants (data for the 11 year wave are not yet available). Chi squared tests and T-tests were used to assess factors associated with attrition. Attrition rates from baseline were highest for families where the father was not French, had low income, were unmarried, or father did not live with the child at 24 months, parents had low education, mothers were younger, smoked in pregnancy, did not have any other children, experienced postpartum depression, or the mother had at least one childhood behaviour problem.

The study was approved by the Comité Consultatif de Protection des Personnes dans la Recherche Biomedicale (Ethics Committee, Kremlin Bicêtre Hospital), by the Commission

Nationale de l'Informatique et des Libertés (National Committee for Processed Data and Freedom (CNIL)), and by Sheffield University, UK (see Annex 1).

2.2. Measures

2.2.1. Child emotional and behavioural problems: Children's behaviour and emotions at age 8 were evaluated through the Strengths and Difficulties Questionnaire (SDQ) completed by the mother (Goodman, 1997). The SDQ includes 25 items scored on a three point likert scale: Not true (0); somewhat true (1); and certainly true (2). Five items are worded positively and reverse coded. The 25 SDQ items are divided into 5 subscales consisting of 5 questions, each with a possible range from 0 to 10. The subscales were emotional symptoms, conduct problems, peer problems, hyperactivity/inattention, and finally prosocial behaviour. Excluding prosocial behaviour, the remaining four subscales can be added together for a total SDQ score with a possible range of 0 to 40. Higher scores are indicative of more behavioural and emotional problems. The SDQ has good psychometric characteristics for screening child psychiatric disorders in community samples (Goodman et al., 2003). In our sample, Cronbach alpha for this scale is 0.79.

2.2.2. Paternal mental health: At the 8 year data wave the Center for Epidemiologic Studies Depression Scale (CESD) was used to assess paternal mental health (Radloff, 1977). 20 questions were asked including "I felt sad" and "I thought my life had been a failure". Answers were given using a four point likert scale ranging from "Rarely, or none of the time (less than one day)" to "Most or all of the time (5-7 days)". Scores can vary from 0 to 60, with a higher score indicating more depressive symptoms. Generally, a cut-pff score of ≥ 16 is used to indicate probable depression, but we considered the continuous score to capture the complete range of depressive symptomatology. In this study, the cronbachs alpha for this scale is 0.86.

2.2.3. Paternal alcohol use: A continuous measure of drinking was used at 8 years. Participants answered in the questionnaire how many standard units of different alcoholic beverages they consumed on average during week days and at the weekend. These answers were then summed to give an estimate of drinking throughout the week.

2.2.4. Paternal involvement: At the 8 year follow-up, 20 questions were asked to the fathers and mothers about father's involvement at home and school (see annex 2). Items used were not part of an existing measure. Example questions were: "How often do you play physical games outside with your child?", "Do you talk to your child about their friends from class?", and "How often do you supervise or help your child get to bed at bedtime?" Items were rated on three or five point Likert scales, with higher scores indicating more involvement. For example

a score of 1 corresponds to doing the activity 'Never or almost never' whereas a score of 5 corresponds to 'Everyday or almost everyday'.

Data Processing (factor analysis)

As the questions on father involvement were not grouped in specific way but were pulled from different questionnaires at the 8 year data wave, exploratory factor analysis was used to allow for the creation of variables that accurately measured father involvement with no expected outcomes (Williams et al., 2010). *A priori* tests were conducted on the variables to assess if factor analysis would be appropriate, as recommended by Williams et al. (2010). The Kaiser-Meyer-Olkin test (KMO test) for sampling adequacy tests for the proportion of variance explained by the variables. Results are between 0 and 1, with values over 0.5 and closer to 1 being ideal for factor analysis (Beavers et al., 2013). The KMO measure was 0.828 indicating that factor analysis can be useful on our dataset. Further, Bartlett's test for sphericity checks if variables are correlated and therefore can be reduced to less factors by comparing the correlation matrix of the variables to the identity matrix. The test was significant ($p=0.000$) which confirmed that using factor analysis would be appropriate.

With the 20 variables concerning father's involvement included in the analysis, the factor analysis initially led to the creation of 20 factors (see annex 3). To identify the number of factors to retain, several indicators were considered. First, it is recommended that only those factor solutions with an eigenvalue of higher than 1.00 be included. However, one factor had an eigenvalue of 0.95 which is close to 1 so in addition a scree plot was used to identify if this factor would also be useful to the analysis (Costello & Osborne, 2005; see annex 4). When analysing a scree plot, the point where the curve begins to level off shows the number of factors to be generated. Based on these indicators, three factors were included in the rotation. As the factors were assumed to be correlated, Oblique oblimin with a gamma value of zero was used for the rotation, as this method of rotation allows for correlations between the factors and resulted in a suitable factor structure (Costello & Osborne, 2005). A good rotation should have loadings either high or close to zero with very little in between (Abdi, 2003). Factor scores were then calculated using the regression method. This is a multivariate procedure which considers multiple correlations: between factors, between observed variables, between factors and observed variables, and between oblique factors and allows for maximum validity (DiStefano et al., 2009). Factor scores obtained with this method have a mean of roughly zero (DiStefano et al., 2009)

The exploratory factor analysis generated three main father involvement variables, which are similar to the measures of father involvement used in Bianchi et al. (2006). These three factors are: 1) playing inside/outside, 2) helping/teaching, and 3) talking/reading (see annex 5).

An additional binary indicator of father involvement will be used to identify if the father lived with the child or not at the age 8 wave. This will be useful to measure the 'accessibility' aspect of father involvement.

2.2.5. Confounding Factors: relevant confounding factors were identified from previous studies and controlled for in the multiple regression models if they were significantly associated ($p < .10$) with father's depression and children's overall SDQ score in bivariate analysis.

Child variables

Child's sex (male or female), premature birth (<37 or >37 weeks of gestation), and if the child is small for gestational age (no or yes, if weight is below the 10th percentile assessed during a clinical exam at birth) were taken into account.

Father variables

Father's previous drinking behaviour was measured during pregnancy and 2 years as a continuous measure of drinking during the week. Answers from these previous waves were summed to give an estimate of average drinking before the 8 year wave. Furthermore, father sociodemographic variables were taken into account: Age, nationality (French vs. other), employed at 8 year data wave (yes vs no), highest educational level (years of schooling) and finally if the father lived with the child at the 2 year data wave (yes vs no).

Mother variables

Maternal mental health during sensitive periods of child development was controlled for. This includes maternal depression during the first postpartum year (measured with the EPDS; Cox & Holden, 2003). The EPDS was administered at 4, 8 and 12 months postpartum. If mothers scored 12 or higher at any assessment moment they were said to have experienced postpartum depression. This cut off of 12 has been validated for use in French mothers (Adouard et al., 2005). Maternal mental health at age 8 was equally controlled for using total CESD score as was receiving any psychological help during pregnancy (yes or no), and maternal alcohol use and tobacco use during pregnancy (yes or no). Other mother variables were mothers' age at birth, and maternal highest educational level.

Family variables

Marital status was measured during pregnancy (married/ legal partnership, cohabiting with father, cohabiting with partner) and at age 8 (married, single, divorced, separated, civil partnership, other). Average monthly income across the different data waves was measured in the following categories (<€ 800, €801-1500, €1501-2300, €2301-3000, €3001-3800, €3801-4500, >€4500).

Marital conflict (yes or no) across all data waves was considered present if the mother reported on any of the following life events: partner separation, experience of physical abuse, harassment for sex from her partner. Equally, if she answered in an open ended question at the end of the life event inventory that she had experienced marital conflict, or partner conflict then the participant would be coded as having experienced marital conflict.

Items from subsets of the HOME questionnaire administered at 5 years old were controlled for in the analysis. The HOME questionnaire provides a measure of the amount of stimulation provided in the child's home (Totsika & Sylva, 2004). The subscales used were language stimulation, learning stimulation, and variety in experience and grouped into an overall HOME score. Number of siblings living at home when the child was 5 years old was also used as a possible confounder.

2.3. Data analysis

First missing data was analysed and multiple imputation was conducted to account for missingness. Missing data were imputed using fully conditional specification, also known as chained equations, which allows for data to be continuously imputed and can impute many different types of variables (White et al., 2010). Variables used were those associated with missingness and those known to be associated with the outcome variable. Following the recommendation by White et al. (2010) to impute slightly more data sets than the percentage of cases with missing data, 50 data sets were imputed. All analyses were conducted using the imputed datasets and coefficients and standard errors were adjusted for the variability between the imputations.

Univariate analyses were then conducted to describe associations between father, mother and family characteristics and SDQ total and subscale scores. The analysis of the association between paternal depression, paternal alcohol use and children's emotional and behavioral problems took place in several steps. The effects of paternal depression and paternal alcohol use were tested separately. First, we tested univariate associations between paternal psychopathology (depression and alcohol use) and children's behaviour scores using linear regression models. Second, associations between paternal psychopathology and children's behaviour were studied in multiple linear regression models controlling for the factor scores assessing paternal involvement, and paternal accessibility. Covariates significantly associated ($p < .10$) with children's overall behaviour score were also included in the adjusted model. In a third step, we tested father involvement as a potential effect moderator by including an interaction term for each involvement factor one by one. Interactions were tested one by one to maintain power.

Lastly, within the multivariate analyses we tested for sex differences by stratifying on child sex and completing the analysis. To check the validity of the linear models, we looked at variance inflation factors and tolerance values to identify if there was multicollinearity in the model. A post-test quantile-quantile plot, and a post-test residual plot was conducted using residuals from the complete case analysis of total SDQ scores without any interactions to check the assumption of homoscedasticity (see annex 6). For a sensitivity analysis, results were compared with the outcomes of a complete case analysis (see annex 7). As these outcomes were comparable to the imputed data, we present the imputed cases in the remainder of this report. Outcomes were considered significant at a conventional level of $\alpha=0.05$. Analyses were conducted with Stata version 15 and SPSS version 25

3. Results

3.1. Missing Data Analysis

As shown in figure 2, 46% of families included in the analysis had missing data for at least one variable. The variables with the most missing values were the three father involvement scores, which contributed to 12% of the cases with missing data. This high number is likely because cases with missing data on any of the 20 underlying variables were excluded from the factor analysis. 4% of cases missed data concerning the number of siblings, and another 4% had all of the variables for the father at the 8 year wave missing). All other missing variables contributed to less than 4% of the total missing data.

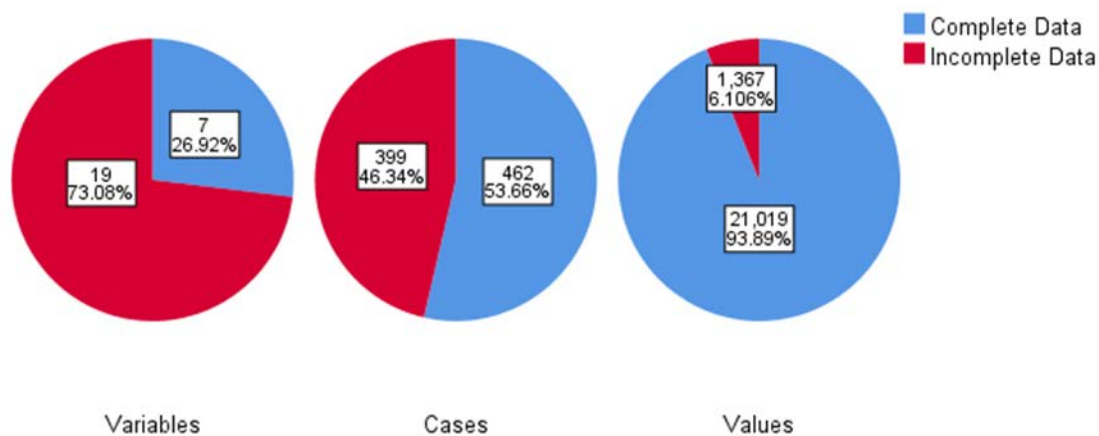


Figure 2: Pie charts showing the percentage of missing data for each variable, case (family) and value

3.2. Descriptive Results

The mean total SDQ score in the sample was 8.62 (sd=5.18), similar to scores which have been previously reported for French children of comparable age (Shojaei et al., 2009; see table 1). Slightly more of the children included were male (52%). At the eight year sweep fathers and mothers mean CESD scores were 8.04 (sd=7.51) and 9.32 (sd=8.41) respectively, with 12% of fathers and 18% of mothers scoring above the cut-off value of ≥ 16 indicating depression. Mean units per week consumed by the father was lower when the child was 8 years old (5.80 ± 8.07) compared to when the child was younger (10.76 ± 11.75) suggesting a general decline in alcohol use. Father's CESD score at age 8 was found to be only marginally correlated to their alcohol use $r(1) = 0.07$, $p = .06$ Most of the children (90%) had a father labelled as 'accessible' due to the father living with the child. As the other involvement factors are factor

scores their mean is approximately zero, meaning that scores less than zero indicate less involvement than average.

Average years of education for the mother and father are 14 and 13 respectively (corresponding to the French level of BAC+2 and BAC Professionnel; according to the International Standard Classification of Education the average mother has completed 'Short cycle tertiary education' whereas the average father has completed 'Post-secondary non-tertiary education'). During pregnancy only 2.42% of women were single, with all others either married, in a civil partnership, or cohabiting with the father of their child. By the 8 year sweep 7% were separated, 4 % were divorced, and 7% were single, but 68% were married. At the 8 year sweep most families (62%) were earning over 3001 euros per month, indicating that the sample included families with a high SES.

Table 1: Characteristics of EDEN cohort study participants (N= 875)

	Mean (sd) or Frequency (%)	N	% Missing
<i>Child Variables</i>			
SDQ Total score age 8	8.62 (5.18)	875	0
SDQ Relationship Problems score age 8	1.38 (1.56)	875	0
SDQ Hyperactivity score age 8	3.18 (2.50)	875	0
SDQ Emotional score age 8	2.39 (2.09)	875	0
SDQ Conduct Problems score age 8	1.67 (1.56)	875	0
SDQ Prosocial Behaviour score age 8	8.34 (1.72)	875	0
Recruitment Centre		875	0
Poitiers	413 (47.2)		
Nancy	462 (52.8)		
Sex of child		875	0
Boy	458 (52.34)		
Girl	417 (47.66)		
Premature (<37 weeks of gestation)		875	0
No	827 (94.51)		
Small for Gestational Age		875	0
No	792 (90.51)		
<i>Father Variables</i>			
Paternal depression age 8	8.04 (7.51)	791	9.60
Average units per week age 8	5.80 (8.07)	797	8.91
Scores for factor 1: Helping	~0 (0.92)	645	26.29
Scores for factor 2: Talking	~0 (0.92)	645	26.29
Scores for factor 3: Playing	~0 (0.84)	645	26.29
Father live with the child age 8: Accessibility		808	7.66
Yes	728 (90.10)		

Father's age at age 8 (years)	40.94 (5.47)	756	13.6
Years of education	13.41 (2.62)	875	0
Average units per week if child under 8	10.76 (11.75)	842	3.77
Fathers Nationality		864	1.26
French	840 (97.22)		
Father Employed at age 8		809	7.54
Yes	767 (94.81)		
Father live with child age 2		816	6.74
Yes	785 (96.20)		
<i>Mother Variables</i>			
Mother's age at birth (years)	30.23 (4.62)	875	0
Years of education	14.19 (2.56)	875	0
Maternal Depression at age 8	9.32 (8.41)	871	0.46
Post-Partum Depression		875	0
Yes	173 (20.87)		
Psychological Help in Pregnancy		875	0
Yes	73 (8.34)		
Smoking in Pregnancy		872	0.34
Yes	161 (18.46)		
Alcohol in Pregnancy		837	4.34
Yes	247 (29.51)		
Marital Status in Pregnancy		866	1.03
Married/legal partnership	501 (57.85)		
Cohabiting with father	344 (39.72)		
Single	21 (2.42)		
<i>Family</i>			
Number of siblings	1.32 (0.80)	808	7.66
Total HOME score (range 7-21)	17.23 (2.17)	867	0.91
Marital Problems		875	0
Yes	154 (17.60)		
Marital Status at age 8		874	0.11
Married	595 (68.08)		
Single	56 (6.41)		
Divorced	32 (3.66)		
Separated	29 (3.32)		
PACS	61 (6.98)		
Other	101 (11.56)		
Average monthly income		873	0.23
451-800 Euro	8 (0.92)		
801-1500 Euro	37 (4.24)		
1501-2300 Euro	171 (19.59)		
2301-3000 Euro	252 (28.87)		
3001-3800 Euro	227 (26.00)		
3801-4500 Euro	109 (12.49)		
4500+ Euro	69 (7.90)		

3.3. Unadjusted Model

In the unadjusted model (see table 2), paternal depression ($\beta=0.12$, $p=0.000$) was found to be related to the total SDQ scores as well as all of the five subscales: conduct problems ($\beta=0.02$, $p=0.015$), hyperactivity ($\beta=0.03$, $p=0.004$), emotional symptoms ($\beta=0.04$, $p=0.000$), and peer relationship issues ($\beta=0.03$, $p=0.000$) and prosocial behaviour ($\beta=-0.02$, $p=0.025$). Paternal alcohol use was not found to be related to the total SDQ score or any of the subscales. In a separate unadjusted model with sex and SDQ score, child sex was found to be related to total SDQ ($\beta=-1.20$, $p=0.001$) and all subscales except for peer relationship issues: conduct problems ($\beta=-0.51$, $p=0.000$); hyperactivity ($\beta=-0.88$, $p=0.000$); emotional symptoms ($\beta=0.36$, $p=0.011$); and prosocial behaviour ($\beta=0.60$, $p=0.000$).

3.4. Adjusted Model

After adjusting for possible confounders, the effects of paternal depression on total SDQ score was slightly attenuated, but still significant ($\beta=0.08$, $p=0.001$). Only internalizing subscales were related to paternal depression: emotional symptoms ($\beta=0.03$, $p=0.002$); and peer relationship issues ($\beta=0.03$, $p=0.000$). Prosocial behaviour was related to paternal depression although not at the 0.05 alpha level ($\beta=-0.02$, $p=0.054$). Concerning father involvement, we did not find an association for any of the three factor scores or father accessibility on overall SDQ scores. However, accessibility was related to peer relationship issues ($\beta=-0.69$, $p=0.008$), and helping was negatively related to prosocial behaviour ($\beta=-0.18$, $p=0.031$). Paternal alcohol use remained insignificant across all subscales (table 2).

3.5. Adjusted Model with Interactions

After including the interactions between paternal depression and the four paternal involvement measures in the regression models, none were significantly related to total SDQ score. Only the interaction between paternal depression and talking was associated with the emotional symptoms measure of the SDQ ($\beta=0.02$, $p=0.037$). None of the interactions between paternal alcohol use and the four paternal involvement measure were significantly related to SDQ scores.

Table 2: Linear regression models of paternal depression and children's behaviour at age 8 years in the EDEN cohort with imputations, N=874

	Total			Conduct Problems			Hyperactivity			Emotional Symptoms			Peer Relationship Issues			Prosocial Behaviour		
	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value
Unadjusted Model																		
Father Depression	0.12	(0.07 to 0.17)	0.000	0.02	(0.00 to 0.03)	0.015	0.03	(0.01 to 0.06)	0.004	0.04	(0.02 to 0.05)	0.000	0.03	(0.02 to 0.05)	0.000	-0.02	(-0.03 to -0.00)	0.025
Father Alcohol Use	0.02	(-0.03 to 0.07)	0.357	0.00	(-0.02 to 0.01)	0.873	0.02	(-0.00 to 0.04)	0.123	0.00	(-0.02 to 0.02)	0.825	0.01	(-0.01 to 0.02)	0.314	0.00	(-0.02 to 0.01)	0.894
Adjusted Model *																		
Father Depression	0.08	(0.03 to 0.12)	0.001	0.01	(-0.01 to 0.02)	0.289	0.01	(-0.01 to 0.04)	0.269	0.03	(0.01 to 0.05)	0.002	0.03	(0.01 to 0.04)	0.000	-0.02	(-0.03 to 0.00)	0.054
Father Alcohol Use	0.01	(-0.05 to 0.06)	0.820	-0.01	(-0.03 to 0.01)	0.203	0.00	(-0.03 to 0.03)	0.975	0.01	(-0.01 to 0.03)	0.424	0.01	(-0.01 to 0.02)	0.370	0.01	(-0.01 to 0.03)	0.241
Mother Depression	0.12	(0.08 to 0.16)	0.000	0.02	(0.01 to 0.03)	0.005	0.04	(0.02 to 0.06)	0.000	0.03	(0.01 to 0.05)	0.000	0.03	(0.02 to 0.04)	0.000	0.00	(-0.02 to 0.01)	0.677
Accessibility	-1.12	(-2.74 to 0.50)	0.175	-0.02	(-0.55 to 0.51)	0.948	-0.21	(-1.01 to 0.58)	0.595	-0.20	(-0.88 to 0.49)	0.576	-0.69	(-1.21 to -0.18)	0.008	-0.21	(-0.78 to 0.36)	0.474
Helping	0.21	(-0.24 to 0.66)	0.368	0.08	(-0.06 to 0.22)	0.272	0.14	(-0.09 to 0.36)	0.229	-0.05	(-0.24 to 0.14)	0.620	0.04	(-0.10 to 0.17)	0.574	-0.18	(-0.33 to -0.02)	0.031
Talking	-0.11	(-0.52 to 0.31)	0.604	-0.12	(-0.25 to 0.01)	0.081	-0.13	(-0.33 to 0.08)	0.237	0.09	(-0.08 to 0.26)	0.281	0.04	(-0.09 to 0.17)	0.563	0.12	(-0.03 to 0.27)	0.126
Playing	-0.27	(-0.79 to 0.26)	0.313	-0.05	(-0.21 to 0.11)	0.538	-0.09	(-0.34 to 0.16)	0.492	-0.13	(-0.34 to 0.09)	0.252	-0.01	(-0.16 to 0.15)	0.948	0.12	(-0.06 to 0.29)	0.193
Depression Interactions																		
Accessibility	0.04	(-0.09 to 0.16)	0.548	0.01	(-0.04 to 0.04)	0.964	0.02	(-0.04 to 0.08)	0.487	0.02	(-0.03 to 0.07)	0.355	-0.01	(-0.05 to 0.03)	0.731	-0.01	(-0.06 to 0.03)	0.531
Helping	0.04	(-0.01 to 0.10)	0.109	0.01	(-0.01 to 0.02)	0.292	0.01	(-0.02 to 0.04)	0.445	0.02	(-0.00 to 0.04)	0.094	0.01	(-0.01 to 0.02)	0.526	0.00	(-0.02 to 0.02)	0.850
Talking	0.03	(-0.02 to 0.08)	0.259	0.00	(-0.01 to 0.02)	0.848	-0.01	(-0.03 to 0.02)	0.552	0.02	(0.00 to 0.04)	0.037	0.01	(-0.00 to 0.03)	0.134	0.00	(-0.01 to 0.02)	0.827
Playing	0.00	(-0.06 to 0.06)	0.904	0.00	(-0.02 to 0.01)	0.698	0.00	(-0.03 to 0.03)	0.795	0.01	(-0.01 to 0.04)	0.307	-0.01	(-0.03 to 0.01)	0.309	0.01	(-0.01 to 0.03)	0.397
Alcohol Use Interactions																		
Accessibility	0.05	(-0.09 to 0.19)	0.503	0.00	(-0.04 to 0.05)	0.904	0.00	(-0.07 to 0.06)	0.907	0.03	(-0.03 to 0.08)	0.335	0.02	(-0.02 to 0.06)	0.335	-0.01	(-0.06 to 0.04)	0.654
Helping	-0.01	(-0.07 to 0.04)	0.675	0.00	(-0.02 to 0.01)	0.591	0.01	(-0.02 to 0.03)	0.561	0.00	(-0.02 to 0.02)	0.952	-0.01	(-0.03 to 0.00)	0.100	0.00	(-0.02 to 0.02)	0.939
Talking	0.01	(-0.01 to 0.03)	0.170	0.01	(-0.01 to 0.03)	0.170	0.01	(-0.02 to 0.03)	0.588	0.01	(-0.01 to 0.03)	0.385	0.00	(-0.01 to 0.02)	0.620	0.00	(-0.02 to 0.02)	0.737
Playing	-0.02	(-0.08 to 0.04)	0.572	-0.01	(-0.03 to 0.01)	0.298	0.00	(-0.03 to 0.03)	0.850	-0.01	(-0.04 to 0.01)	0.427	0.00	(-0.02 to 0.02)	0.996	-0.01	(-0.03 to 0.01)	0.545

* Adjusted for covariates: Age and nationality of father, mother's depression, marital status in pregnancy and at birth, smoking and alcohol use in pregnancy, postpartum depression, psychological help during pregnancy, father's drinking before 8 year data wave, average income, number of siblings, child sex, prematurity, small for gestational age, education of father, education of mother, marital conflict, father employment at 8 years, if father lived with child at 2 years, and HOME score.

3.6. Sex differences

Unadjusted analyses stratified by child sex (Tables 3 and 4) found that alcohol use remained insignificant in all analyses, but SDQ total scores were related to paternal depression in both boys (beta=0.13, p=0.000) and girls (beta=0.12, p=0.000). When looking at the different SDQ subscales, differences between boys and girls could be seen with paternal CESD scores being associated with more hyperactivity (beta=0.03, p=0.036), emotional symptoms (beta=0.04, p=0.001), and peer relationship issues (beta=0.04, p=0.001) in boys. In girls all subscales were related to paternal depression, although the emotional symptoms subscale was borderline significant at an alpha level of 0.05 (beta=0.03, p=0.056).

After controlling for confounders, paternal CESD scores remained positively correlated with total SDQ scores for girls (beta=0.08, p=0.013) and boys (beta=0.09, p=0.011) although this effect was slightly attenuated. In girls, paternal depression was positively associated to peer relationship issues (beta=0.03, p=0.008) and negatively related to prosocial behaviour (beta=-0.03, p=0.037). In boys paternal depression was positively associated to internalising symptoms only: emotional symptoms (beta=0.04, p=0.003); and peer relationship issues (beta=0.03, p=0.009).

Of the paternal involvement variables, in girls helping was negatively associated with prosocial behaviour (beta= -0.020, p=0.055) although not significantly. Accessibility was somewhat negatively correlated with internalising symptoms in girls: emotional symptoms (beta= -0.99, p=0.055) and peer relationship issues (beta= -0.73, p=0.042). None of the paternal involvement variables were correlated to boys SDQ outcomes. Father alcohol use was positively associated to girls prosocial behaviour (beta=0.03, p=0.046). However, associations with maternal depression were stronger for both girls (beta=0.11, p=0.000) and boys (beta=0.13, p=0.000).

In girls, the interaction between paternal depression and accessibility was significantly related to the peer relationships subscale of the SDQ (beta= -0.06, p=0.030) and there was an interaction between alcohol use and talking for the conduct problems subscale (beta=0.03, p=0.035). For boys there were no significant interactions for paternal depression or alcohol use and any of the father involvement factors.

Table 3: Linear regression models of paternal depression and children's behaviour for boys age 8 years in the EDEN cohort with imputations. N=455

	Total			Conduct Problems			Hyperactivity			Emotional Symptoms			Peer Relationship Issues			Prosocial Behaviour			
	β	(95% CI)	p value	β	(95% CI)	p value	β	(95% CI)	p value	β	(95% CI)	p value	β	(95% CI)	p value	β	(95% CI)	p value	
Unadjusted Model																			
	Father Depression	0.13	(0.06 to 0.19)	0.000	0.01	(-0.01 to 0.03)	0.241	0.03	(0.00 to 0.07)	0.036	0.04	(0.02 to 0.07)	0.001	0.04	(0.02 to 0.06)	0.001	-0.01	(-0.04 to 0.01)	0.234
	Father Alcohol Use	-0.01	(-0.08 to 0.06)	0.764	-0.01	(-0.03 to 0.01)	0.392	0.02	(-0.01 to 0.05)	0.265	-0.02	(-0.04 to 0.01)	0.149	0.00	(-0.02 to 0.02)	0.984	-0.01	(-0.03 to 0.01)	0.387
Adjusted Model *																			
	Father Depression	0.09	(0.02 to 0.16)	0.011	0.00	(-0.02 to 0.03)	0.718	0.02	(-0.02 to 0.05)	0.357	0.04	(0.01 to 0.07)	0.003	0.03	(0.01 to 0.05)	0.009	-0.01	(-0.03 to 0.02)	0.487
	Father Alcohol Use	-0.02	(-0.10 to 0.06)	0.633	-0.02	(-0.05 to 0.00)	0.103	0.01	(-0.03 to 0.04)	0.736	-0.01	(-0.04 to 0.02)	0.636	0.00	(-0.02 to 0.03)	0.850	0.00	(-0.03 to 0.03)	0.866
	Mother Depression	0.13	(0.06 to 0.19)	0.000	0.03	(0.01 to 0.05)	0.013	0.05	(-0.02 to 0.08)	0.002	0.02	(-0.00 to 0.05)	0.053	0.03	(0.01 to 0.05)	0.007	-0.01	(-0.03 to 0.01)	0.412
	Accessibility	-0.74	(-3.26 to 1.78)	0.563	-0.63	(-1.44 to 0.19)	0.132	-0.03	(-1.26 to 1.19)	0.960	0.53	(-0.44 to 1.50)	0.285	-0.61	(-1.41 to 0.19)	0.133	0.03	(-0.89 to 0.94)	0.954
	Helping	0.16	(-0.52 to 0.84)	0.648	0.10	(-0.12 to 0.32)	0.374	0.12	(-0.21 to 0.45)	0.481	-0.04	(-0.29 to 0.21)	0.766	-0.02	(-0.23 to 0.19)	0.833	-0.13	(-0.37 to 0.12)	0.312
	Talking	0.05	(-0.59 to 0.69)	0.882	-0.11	(-0.31 to 0.09)	0.269	-0.11	(-0.42 to 0.20)	0.474	0.20	(-0.03 to 0.43)	0.091	0.07	(-0.12 to 0.27)	0.466	0.13	(-0.09 to 0.35)	0.248
	Playing	-0.45	(-1.23 to 0.32)	0.246	-0.09	(-0.34 to 0.15)	0.463	-0.22	(-0.59 to 0.16)	0.252	-0.17	(-0.47 to 0.12)	0.241	0.03	(-0.20 to 0.26)	0.803	0.06	(-0.21 to 0.33)	0.644
Depression Interactions																			
	Accessibility	0.14	(-0.04 to 0.33)	0.136	0.01	(-0.05 to 0.07)	0.781	0.05	(-0.04 to 0.14)	0.262	0.04	(-0.03 to 0.11)	0.278	0.04	(-0.01 to 0.10)	0.142	-0.03	(-0.10 to 0.03)	0.286
	Helping	0.05	(-0.03 to 0.12)	0.206	0.01	(-0.02 to 0.03)	0.561	0.01	(-0.02 to 0.02)	0.400	0.01	(-0.02 to 0.04)	0.350	0.01	(-0.01 to 0.03)	0.296	0.01	(-0.01 to 0.04)	0.335
	Talking	0.03	(-0.03 to 0.10)	0.352	0.00	(-0.02 to 0.02)	0.989	0.00	(-0.03 to 0.03)	0.925	0.02	(-0.01 to 0.05)	0.123	0.01	(-0.01 to 0.03)	0.234	0.01	(-0.01 to 0.03)	0.420
	Playing	-0.01	(-0.10 to 0.08)	0.857	-0.01	(-0.04 to 0.02)	0.646	0.00	(-0.05 to 0.04)	0.961	0.01	(-0.03 to 0.04)	0.784	-0.01	(-0.03 to 0.02)	0.691	0.02	(-0.01 to 0.05)	0.152
Alcohol Use Interactions																			
	Accessibility	0.07	(-0.12 to 0.27)	0.462	0.02	(-0.03 to 0.08)	0.401	0.01	(-0.08 to 0.10)	0.762	0.01	(-0.06 to 0.09)	0.705	0.02	(-0.04 to 0.08)	0.503	-0.03	(-0.10 to 0.03)	0.319
	Helping	0.01	(-0.07 to 0.10)	0.749	0.00	(-0.03 to 0.03)	0.987	0.02	(-0.01 to 0.06)	0.211	0.01	(-0.02 to 0.04)	0.559	-0.02	(-0.05 to 0.00)	0.115	0.01	(-0.02 to 0.03)	0.615
	Talking	0.02	(-0.06 to 0.10)	0.623	0.00	(-0.02 to 0.03)	0.742	0.00	(-0.04 to 0.03)	0.860	0.01	(-0.02 to 0.04)	0.575	0.01	(-0.01 to 0.04)	0.404	0.00	(-0.03 to 0.02)	0.085
	Playing	0.00	(-0.08 to 0.08)	0.997	-0.01	(-0.03 to 0.02)	0.509	0.00	(-0.04 to 0.04)	0.953	0.01	(-0.02 to 0.04)	0.592	0.00	(-0.03 to 0.02)	0.912	0.00	(-0.02 to 0.03)	0.856

* Adjusted for covariates: Age and nationality of father, mother's depression, marital status in pregnancy and at birth, smoking and alcohol use in pregnancy, postpartum depression, psychological help during pregnancy, father's drinking before 8 year data wave, average income, number of siblings, child sex, prematurity, small for gestational age, education of father, education of mother, marital conflict, father employment at 8 years, if father lived with child at 2 years, and HOME score.

Table 4: Linear regression models of paternal depression and children's behaviour for girls age 8 years in the EDEN cohort with imputations. N=416

	Total			Conduct Problems			Hyperactivity			Emotional Symptoms			Peer Relationship Issues			Prosocial Behaviour			
	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	
Unadjusted Model																			
	Father Depression	0.12	(0.05 to 0.18)	0.000	0.03	(0.01 to 0.04)	0.007	0.03	(0.00 to 0.06)	0.034	0.03	(-0.00 to 0.05)	0.059	0.03	(0.01 to 0.05)	0.001	-0.02	(-0.05 to -0.00)	0.020
	Father Alcohol Use	0.06	(-0.01 to 0.13)	0.076	0.01	(-0.01 to 0.03)	0.381	0.02	(-0.02 to 0.05)	0.315	0.02	(-0.01 to 0.05)	0.196	0.02	(-0.00 to 0.04)	0.112	0.01	(-0.01 to 0.03)	0.327
Adjusted Model *																			
	Father Depression	0.08	(0.02 to 0.15)	0.013	0.01	(-0.01 to 0.03)	0.163	0.02	(-0.02 to 0.05)	0.312	0.03	(-0.00 to 0.05)	0.088	0.03	(0.01 to 0.05)	0.008	-0.03	(-0.05 to -0.00)	0.037
	Father Alcohol Use	0.03	(-0.05 to 0.11)	0.418	0.00	(-0.02 to 0.02)	0.997	-0.01	(-0.05 to 0.03)	0.627	0.03	(-0.01 to 0.06)	0.117	0.01	(-0.01 to 0.04)	0.251	0.03	(0.00 to 0.05)	0.046
	Mother Depression	0.11	(0.05 to 0.17)	0.000	0.01	(-0.01 to 0.03)	0.198	0.02	(-0.01 to 0.05)	0.114	0.04	(0.02 to 0.07)	0.002	0.03	(0.01 to 0.05)	0.001	0.00	(-0.02 to 0.02)	0.827
	Accessibility	-1.24	(-3.44 to 0.95)	0.265	0.61	(-0.01 to 0.03)	0.198	-0.14	(-1.22 to 0.99)	0.806	-0.99	(-1.99 to 0.02)	0.055	-0.73	(-1.44 to -0.03)	0.042	-0.49	(-1.27 to 0.30)	0.224
	Helping	0.31	(-0.31 to 0.94)	0.321	0.07	(-0.12 to 0.25)	0.473	0.21	(-0.10 to 0.51)	0.182	-0.07	(-0.35 to 0.22)	0.651	0.10	(-0.07 to 0.28)	0.247	-0.20	(-0.40 to 0.00)	0.055
	Talking	-0.30	(-0.88 to 0.28)	0.314	-0.10	(-0.19 to 0.21)	0.890	-0.16	(-0.45 to 0.13)	0.275	-0.04	(-0.30 to 0.28)	0.740	0.01	(-0.17 to 0.18)	0.935	0.09	(-0.11 to 0.29)	0.368
	Playing	0.00	(-0.75 to 0.75)	0.995	0.01	(-0.19 to 0.21)	0.890	0.05	(-0.29 to 0.40)	0.763	-0.05	(-0.37 to 0.28)	0.770	-0.02	(-0.23 to 0.19)	0.843	0.19	(-0.03 to 0.41)	0.095
Depression Interactions																			
	Accessibility	-0.07	(-0.25 to 0.10)	0.407	0.00	(-0.06 to 0.05)	0.962	-0.01	(-0.09 to 0.07)	0.799	0.00	(-0.07 to 0.08)	0.970	-0.06	(-0.12 to -0.01)	0.030	0.00	(-0.05 to 0.06)	0.916
	Helping	0.03	(-0.05 to 0.11)	0.516	0.02	(-0.01 to 0.04)	0.153	0.01	(-0.04 to 0.05)	0.782	0.02	(-0.02 to 0.06)	0.246	-0.02	(-0.05 to 0.01)	0.143	-0.01	(-0.04 to 0.02)	0.373
	Talking	0.01	(-0.08 to 0.10)	0.865	0.01	(-0.02 to 0.03)	0.675	-0.01	(-0.06 to 0.04)	0.673	0.02	(-0.03 to 0.06)	0.476	0.00	(-0.03 to 0.02)	0.809	-0.01	(-0.04 to 0.02)	0.609
	Playing	-0.01	(-0.09 to 0.08)	0.898	0.01	(-0.01 to 0.04)	0.303	0.00	(-0.05 to 0.04)	0.883	0.01	(-0.03 to 0.05)	0.694	-0.02	(-0.05 to 0.00)	0.094	-0.01	(-0.05 to 0.02)	0.377
Alcohol Use Interactions																			
	Accessibility	-0.06	(-0.30 to 0.18)	0.633	-0.05	(-0.12 to 0.02)	0.181	-0.06	(-0.17 to 0.05)	0.296	0.04	(-0.06 to 0.14)	0.455	0.01	(-0.06 to 0.09)	0.707	0.01	(-0.07 to 0.10)	0.737
	Helping	-0.03	(-0.11 to 0.05)	0.399	-0.01	(-0.03 to 0.02)	0.622	-0.01	(-0.05 to 0.03)	0.558	-0.01	(-0.05 to 0.03)	0.501	0.00	(-0.03 to 0.02)	0.794	0.00	(-0.03 to 0.03)	0.995
	Talking	0.05	(-0.03 to 0.04)	0.232	0.03	(-0.00 to 0.05)	0.035	0.02	(-0.02 to 0.07)	0.275	0.01	(-0.03 to 0.05)	0.771	0.00	(-0.03 to 0.02)	0.744	-0.01	(-0.04 to 0.02)	0.497
	Playing	-0.02	(-0.13 to 0.08)	0.633	0.01	(-0.02 to 0.03)	0.716	0.01	(-0.04 to 0.06)	0.642	-0.04	(-0.09 to 0.01)	0.080	0.00	(-0.03 to 0.03)	0.942	-0.02	(-0.06 to 0.02)	0.290

* Adjusted for covariates: Age and nationality of father, mother's depression, marital status in pregnancy and at birth, smoking and alcohol use in pregnancy, postpartum depression, psychological help during pregnancy, father's drinking before 8 year data wave, average income, number of siblings, child sex, prematurity, small for gestational age, education of father, education of mother, marital conflict, father employment at 8 years, if father lived with child at 2 years, and HOME score.

4. Discussion

To our knowledge, this is one of the few studies exploring the association between paternal depression and alcohol use and child emotional and behavioural problems in middle childhood, and the possible moderating role of father involvement. Overall, we found paternal depressive symptoms to be significantly related to child emotional and behavioural problems at age 8, albeit to a lesser extent than that of maternal depression. Our study showed that children's internalising behaviours were particularly affected. Conversely, paternal alcohol use was not associated with children's scores. We only found limited evidence that father involvement functions as a potential moderator in these associations, with the exception of children showing slightly higher levels of emotional symptoms when their depressed father talked more to them.

4.1. Paternal depression and child outcomes

Paternal depression is significantly related to child SDQ scores at age 8, even when controlling for confounding variables. This is in line with previous literature which has shown that father depression plays a role in children's emotional and behavioural outcomes, especially in middle childhood (Connell & Goodman, 2002; Ramchandani & Psychogiou's, 2009; Sweeney & MacBeth, 2016). Previous work suggests that paternal depression may affect children mostly through effects on the family environment, which can be considered as a mediating factor (Gutierrez-Galve et al., 2015). The specific family environment factors that have previously been investigated were marital conflict, maternal depression, and paternal non-involvement at 18 months. Gutierrez-Galve et al., (2015) found that marital conflict and maternal depression had the largest mediating effects on children's behaviour at age 3.5 and 7 years. In the current study, concurrent maternal depression at age 8 was also related to childhood outcomes. Maternal depression was related to childhood outcomes slightly more than paternal depression, but not by a significant amount. Other factors that were identified as having a significant effect on childhood outcomes included sex of the child, maternal post-partum depression, prematurity, being small for gestational age and cohabiting with the father during pregnancy. Marital conflict was not found to be related to total SDQ scores. However, we were not able to test the potential mediating character of these variables in the association between father's depression and child outcomes, because we had no earlier indicators of father's mental wellbeing to our disposal.

4.2. Paternal alcohol use and child outcomes

We did not find an association between father's alcohol use and child emotional and behavioural problems. This outcome is at odds with those from previous studies, which found that paternal alcohol use can lead to externalising behaviours, especially in boys (Christensen & Bilenberg, 2000; Loukas et al., 2001). The results for alcohol use may have been insignificant in this sample as there was not enough variation in the data. The average units per week consumed at the 8 year data wave was low at 5.80 units, which is well within the public health recommendations for responsible alcohol consumption (Roger, 2017). This suggests that fathers who drink in the sample are not problem drinkers. It is also possible that father's alcohol use does not affect children's SDQ scores. Godleski et al., (2018) found that alcohol use leads to externalising behaviours in children only if both parents are heavy drinkers, and not if only one parent is a heavy drinker.

4.3. The role of father involvement

The fact that some aspects of father involvement exhibited a direct effect on children's psychosocial outcomes suggests that there are some benefits to having an involved father. However, the effects of father accessibility (if the father lives with the child or not) as well as time the father spends helping out, talking, and playing with his child were all smaller than expected after the literature review, and they did not influence total outcome scores. However, caution should be taken when interpreting these outcomes, as due to the high number of different tests that were conducted it is possible that these findings are not robust.

Father accessibility was not associated total SDQ scores suggesting that living with the father is much less important than past literature has found, possibly due to the recent increase in co-parenting. Sarkadi et al. (2008) found that engagement had a stronger effect than accessibility (cohabitation). However, accessibility was significant for the peer relationships subscale showing that, if the father lived with the child, the child would have less peer relationship issues. This may be because children in middle childhood have better relationships with their peers when they are close to their fathers (Cabrera et al., 2012). Living with their biological father creates opportunities to have a good relationship between the father and the child, however the father's shared residence is not necessary for a good father child relationship (Cabrera et al., 2012).

Another finding was that if the father was more helpful with tasks relating to the child, the child would demonstrate less prosocial behaviour. This seems counterintuitive. It is hypothesised that children will copy their parent's behaviours, however maternal behaviour

has been found to be more related to prosocial behaviour in early childhood than paternal behaviours (Newton et al., 2014). One explanation for our finding may be that fathers help out more if the mother is unable to, due to factors such as long term health problems, or if the mother has a very high stress job. It could also be that in case of emotional and behavioural problems, fathers step in more in child related tasks, which has previously been demonstrated for hyperactivity or conduct problems (Flouri et al., 2016). However there is no evidence for this concerning reduced prosocial behaviour. Finally, we found some indications that the more the father talked with the child, the less conduct problems he displayed. This may be related to the findings by Flouri et al. (2016), as fathers may be effectual in their attempts to reduce conduct problems.

The current study suggests that paternal involvement may have a small moderating effect in the association between paternal depression and child emotional and behavioural problems. The more depressed fathers talk to their children (in particular boys) the higher their emotional symptoms may be, compared to non-depressed fathers who talk to their children the same amount. The reason for this may be that depressed fathers exhibit higher levels of expressed emotion (criticism, hostility, emotional over-involvement) when interacting with their children. Indeed, Brennen et al. (2002) found that expressed emotion may be a mediator between father's psychopathology and depression in adolescence.

Contrary to our study, in which paternal involvement was considered a moderator, Gutierrez-Galve et al.'s (2015) study identifies the concept of paternal involvement as a mediator. They found that paternal involvement only explained 5% of the relationship between paternal depression and childhood outcomes when taking maternal depression and couple conflict into account as well. While Ramchandani & Psychogiou's (2009) model in figure 1 explicitly states that paternal involvement is a modifier, it is possible that the mediating pathway 'impaired parenting' could also be considered as a form of paternal involvement. If that is the case, paternal parenting behaviour may have a larger effect on paternal transmission of depression. Parenting styles could also be an alternative reason why there are differences in developmental outcomes according to paternal depression, supported by findings that fathers use harsher discipline than mothers, and this type of discipline is related to an increase in behaviour problems (McKee et al., 2007). However, the effects of paternal involvement measured by father's childcare activities (as in the current study and Gutierrez-Galve et al., 2015) only reflect a small element of parenting and thus may have a much smaller effects than previously thought.

4.4. Differential impact of paternal depression according to child sex

When stratifying the analyses by child sex, we saw significant differences on all subscales of the SDQ, except peer relationship issues. This has also been previously found in French children aged 6 to 11, with boys experiencing more externalizing symptoms and a higher total score, whereas girls have higher prosocial scores (Shojaei et al., 2009). The adjusted model shows that both paternal and maternal depression are related to children's psychosocial development. However, paternal depression is more related to internalising behaviours, especially in boys, and maternal depression is more related to girls' internalising behaviours, similar to previous studies, and in support of the Gender Self-Socialisation Model which suggests that children begin to imitate their same sex parent at around age 7 or 8 (Tobin et al., 2010; Andreas et al., 2018).

In girls, father accessibility (father not living with the child) was related them experiencing more internalising symptoms. This is concurrent with some literature stating that girls experience more challenges when their father is not present (Ellis et al., 2003; Chandra et al., 2010). Furthermore, for girls, when their depressed fathers are present there is a decrease in peer relationship problems compared to when their depressed fathers are absent. This association was not found for boys. Father accessibility may have different effects on girls and boys, possibly because accessible fathers may parent differently according to the child's gender, utilising harsher discipline with boys than with girls (McKee et al., 2007).

Slightly stronger relationships were found between both paternal and maternal depression and boys total SDQ scores compared to girls. In boys paternal depression was also positively associated with internalising symptoms (emotional symptoms and peer relationship issues). However, father helping, playing, talking, and accessibility did not seem to play a role in boy's outcomes at age 8. Maternal depressive symptoms seemed to be correlated to all subscales of the SDQ except prosocial behaviour in boys.

4.5. Differential impact of paternal alcohol use according to child sex

Paternal alcohol use was found to be statistically non-significant in almost all analyses, except for girl's prosocial behaviour, in which higher alcohol use led to higher scores on the prosocial behaviour scale. This is opposite to findings that paternal alcohol use leads to less social competence, which includes prosocial behaviour (Eiden et al., 2009). This may be due to the low consumption of alcohol in the current sample. Some research has shown that moderate drinkers may score lower on extraversion and sociability than non-consumers

(Cook et al., 1998; Walton & Roberts, 2004). There were 235 reported non-consumers in the current sample so personality differences of non-consumers could explain why some positive effects of drinking were found, however this research was not conducted using a comparable sample to the current study so this finding should be interpreted with caution.

4.6. Strengths and limitations

An advantage of the current study is the use of a birth cohort which allows to control for past experiences that have previously been found to influence child emotional and behavioural development, such as income and adverse exposures during gestation, thus minimising the possibility of bias. Additionally, many standardized questionnaires were used, including the SDQ and CESD scores.

However, some limitations need to be acknowledged as well, the most important being that as fathers' depression scores were only available at the 8 year data wave, not making it possible to test the complete model in figure 1. With the resulting cross-sectional study design, causality cannot be inferred, and any effects found may be due to reverse causation (i.e. fathers become more depressed because of their children's emotional and behavioural problems). In addition, significant attrition was present from the cohort at the eight year data wave. Analysis showed that this attrition was selective (for example there was more attrition in families where the father was not French, had low income, or the mothers were younger), which may limit our ability to observe statistically significant associations between paternal depression and children's behaviour problems. We did use multiple imputation to account for the lack of missing items across the different waves. Sensitivity analyses with complete cases give largely similar results, although the playing involvement factor was found to be more related to children's outcomes and interacted with depression.

Furthermore, using a factor analysis to generate measures of father involvement from ordinal response scales led to factor scores that are not standardized and therefore do not have external validity. The use of factor scores can provide a useful measure of father involvement from the provided information, however factor scores are dependent on the questions asked, and different scores may have been created if different questions were posed to the fathers. The questions in the current study focused on activities the father did with or for the child, however there are many other aspects of fatherhood, including the father's parenting style and expressed emotion. However, using a factor analysis to generate measures of father involvement from ordinal response scales has previously been used in similar research (Opondo et al., 2017). The current study included questions similar to those used to measure paternal non-involvement in Gutierrez-Galve et al. (2015) study. Research in father involvement

has not advanced to a stage where there are widely used standardised measures of involvement, except for the Inventory of Father Involvement (IFI; Hawkins, 2002). To our knowledge, a French version of the IFI has not been validated and it is commonplace for studies using the IFI to create a new measure from the questions, rather than using the entire questionnaire (Trahan & Cheung, 2016; Potter, 2017). Questions regarding four of the nine IFI subscales were included in our factor analysis (school encouragement, talking together, homework support, and future concerns). Questions on attentiveness, support of the child's mother, praise and affection, teaching responsibility, and providing were not included. Other measures exist for slightly different aspects of fatherhood, for example the Parental Support for Father Involvement Scale, and self-efficacy in the parenting role measured by the Parenting Sense of Competence Scale (Trahan & Cheung, 2016). The latter has been shown to be related to children's SDQ scores. However, self-reported self-efficacy may not be valid in those who are suffering from depression (Milanovic et al., 2018).

Thirdly, child emotional and behavioural outcomes age 8 were reported by the mother and are not a diagnosis of developmental difficulties as they only assess symptoms. Teacher evaluations could have been used besides maternal evaluations to confirm the reports of children's SDQ scores, especially as depressed mothers may exhibit errors in reporting (Fergusson et al., 1993). Children's SDQ scores in the current sample were similar to those previously found in a French sample, however as both samples had a larger proportion of high SES families findings cannot be generalised to all French children (Shojaei et al., 2009).

Equally, the level of depressive symptoms in fathers and mothers are based on self-reports rather than clinical diagnoses. While we could not examine the most severe forms of psychopathology, this enabled us to study the entire spectrum of paternal depression scores, which is a closer estimate of variations in symptomatology at the population level (Morin et al., 2011). Associations between paternal clinical depression and children's outcomes are probably stronger than we report.

Fourth, for brevity only 4 questions concerning alcohol use were asked at the 8 year data wave. Thus, we were only able to create a general score of number of alcoholic beverages consumed in a typical week, which may not be reflective of alcohol abuse which also includes binge drinking. This could be another reason why findings regarding alcohol use were insignificant. A standardised measure of alcohol use, such as the Alcohol Unit Disorders Identification Test C (AUDIT-C) would have likely been more accurate, reliable, and uses only requires 3 questions (Bush et al. 1998). Unfortunately the AUDIT-C was not administered to this cohort. Finally, marital conflict is known to play a large role in children's psychosocial development as well as a determinant of depression in adults but this study

was unable to include a standardized measure of marital conflict (Davies & Cummings, 1994; Choi & Marks, 2008; Hanington et al., 2011). A binary measure of extreme marital conflict was used instead and although this enabled us to account for the most serious cases of marital conflict, cases characterised by frequent verbal arguments may have been missed.

4.7. Recommendations for research and practice

Although most of the studied interactions were insignificant, there is reason to believe that some aspects of father involvement may play a role in children's development, particularly in the case of paternal depression. The findings support the model of father transmission of psychopathology but suggest that paternal parenting behaviour, rather than the amount of involvement, should be the focus of future research. Research into paternal parenting behaviours of fathers with psychopathology may be particularly relevant as conceptualisations of father involvement are changing to include aspects such as parenting behaviours and the father-child relationship. In addition Wilson and Durbin, (2010) found that father's parenting behaviour is influenced by depression to a similar degree that maternal depression affects maternal parenting style.

In this context it is also important to test the role of father involvement as a potential mediator in the association between father psychopathology and childhood outcomes. This was not possible in the current study due to its cross-sectional design. In general, more research is needed to investigate the different pathways of transmission of paternal psychopathology to children's outcomes in order to improve on the model of paternal transmission and strengthen its empirical support.

As we saw that paternal depression can have an impact on children's outcomes at 8 years of age, it is advised that fathers are not left out of family therapy sessions. Clinicians may be more understanding when fathers do not become involved in family counselling, often assuming they must work and not encouraging them to join (Walters et al., 2001). Fathers themselves are commonly less willing to attend appointments, but it has been found that this is related to their own experiences of parenting rather than their actual inability to attend (Walters et al., 2001). Therefore, it is important that those involved in the child's treatment stress the importance of the father's role. This is true even for the fathers who are not as involved with their children, such as those who may not live with their children, as the current study shows that these fathers are just as important to their child's development. Fathers should likewise be included in interventions aimed at improving developmental outcomes for children.

Furthermore, barriers to men seeking help for depression, such as embarrassment and poor communication with doctors, should be investigated (Yousaf et al., 2015). Trials have been conducted on screening of maternal depression by paediatricians, using the Patient Health Questionnaire, which consists of only 2 items (Olsen et al., 2006). It is possible that this could also be used for fathers of older children also, as this measure is not gender specific, and unlike the EPDS for fathers it can be administered when the child is any age (Kumar et al., 2017).

Finally, when investigating parental psychopathology and behavioural outcomes in middle childhood it is important to take into account sex differences of the children, as sex may interact with parental depression. This is in line with previous research that gender differences in response to parental psychopathology become more pronounced over time (Andreas et al., 2018).

5. Conclusions

Child behaviours at ages seven to nine are predictive of behaviours in early adulthood such as crime and mental health issues (Fergusson et al., 2005). This suggests that outcomes at this age are especially important when looking at development over the life course. Our findings suggest that, in middle childhood, in a French cohort, paternal depression may be related to children's emotional and behavioural problems, to a similar extent as maternal depression. Paternal depression was particularly related to boys internalising symptoms, whereas maternal depression was particularly related to girls internalising symptoms. While we could not confirm that father involvement moderates this association, there are indications that paternal accessibility is related to girls internalising behaviours. Given the increasingly important roles modern fathers play in their children's lives, future research should continue to investigate the impact of their day to day involvement. In particular research should be focused on father's parenting behaviours in order to provide guidance and support to fathers as their roles and responsibilities in the family continue to change.

6. References

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Annex 1: Ethical Approval from Sheffield University, UK



Downloaded: 16/02/2018
Approved: 15/02/2018

Katharine Palmer
Registration number: 160217687
School of Health and Related Research
Programme: HAR6024

Dear Katharine

PROJECT TITLE: Paternal Mental Health and Children's Development
APPLICATION: Reference Number 017747

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 15/02/2018 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- ◆ University research ethics application form 017747 (dated 15/02/2018).

If during the course of the project you need to [deviate significantly from the above-approved documentation](#) please inform me since written approval will be required.

Yours sincerely

Charlotte Claxton
Ethics Administrator
School of Health and Related Research

Annex 2: Questions on paternal involvement from the EDEN 8 year questionnaire included in
 Factor Analysis

	Original in French	English Translation
1	Qui aide votre enfant dans son travail scolaire à la maison, et à quelle fréquence? Son père	Who helps your child with their school work at home, and how often? Father
2	Les personnes suivantes sont-elles présentes à la maison quand votre enfant rentre de l'école, du centre de loisir, de l'étude? Son père	Are the following people present at home when your child returns from school, recreation center, or study? Father
3	Jouer à des jeux à la maison (jeux de société, de cartes)	Play games at home (board games, cards)
4	Jouer à des jeux physiques à l'extérieur (ballon, raquettes, piscine)	Play physical games outdoors (ball, rackets, pool)
5	Faire des ballades (à pied, en vélo, à roller)	Go for walks (on foot, by bike, on rollerblades)
6	Faire des sorties culturelles (cinéma, spectacles, musée, zoo)	Cultural outings (cinema, shows, museum, zoo)
7	Regarder la télévision, jouer à des jeux vidéo	Watch TV, play video games
8	Partager les repas	Share a meal together
9	Superviser ou l'accompagner au moment du coucher	Supervise or accompany him at bedtime
10	L'accompagner ou le chercher à l'école, ou à une activité de loisir	Accompany him or pick him up at school, or a leisure activity
11	Superviser les devoirs, faire réciter les leçons	Supervise homework, recite lessons
12	Discuter de ce qu'il a fait ou va faire	Discuss what he did or will do
13	Faire des courses	Go shopping
14	L'année dernière (hors vacances scolaires), combien de temps au total estimez-vous avoir passé à aider votre enfant EDEN dans ses devoirs?	Last year (excluding school holidays), how much time do you think you spent helping your EDEN child with his or her homework?
15	Parlez-vous avec votre enfant de ce qu'il apprend à l'école?	Do you talk to your child about what he is learning at school?
16	Parlez-vous avec votre enfant de ses camarades de classe?	Do you talk with your child about his classmates?
17	Parlez-vous avec votre enfant de la vie en classe?	Do you talk with your child about life in the classroom?
18	Parlez-vous avec votre enfant de son maitre or sa maitresse?	Do you speak with your child about his teacher?
19	Parlez-vous avec votre enfant de son avenir scolaire?	Do you talk to your child about his or her future?
20	Parlez-vous avec votre enfant de son avenir professionnel?	Do you speak with your child about his or her professional future?

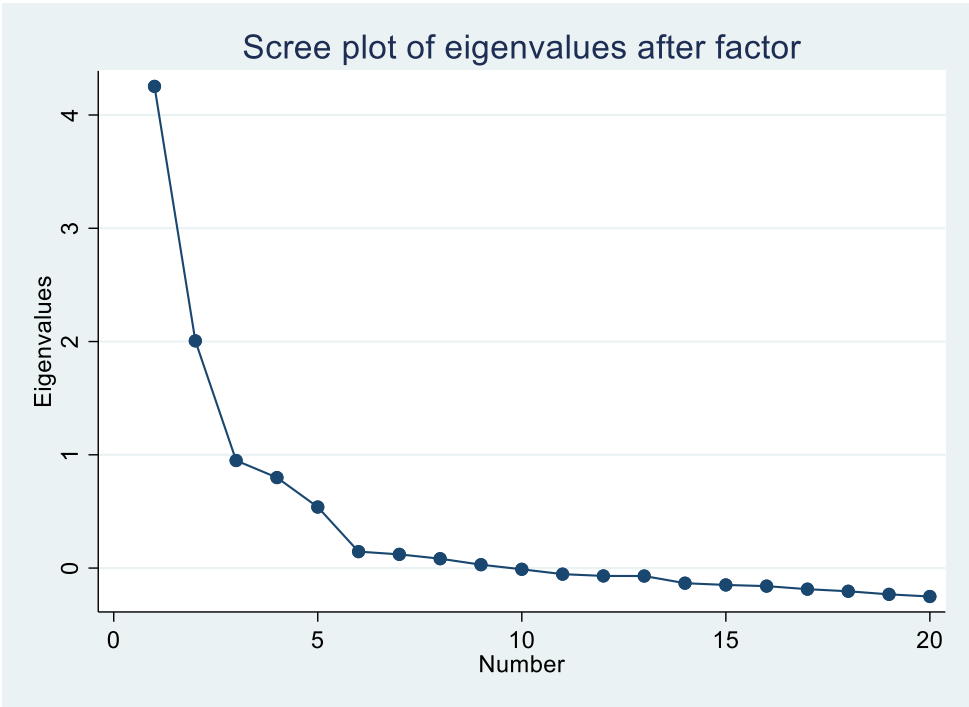
Annex 3: Information on factor analysis

Unrotated Factor and Eigenvalues

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.25283	2.24659	0.5740	0.5740
Factor2	2.00624	1.05644	0.2708	0.8448
Factor3	0.94980	0.15063	0.1282	0.9730
Factor4	0.79917	0.26001	0.1079	1.0809
Factor5	0.53917	0.39369	0.0728	1.1537
Factor6	0.14548	0.02427	0.0196	1.1733
Factor7	0.12121	0.03825	0.0164	1.1896
Factor8	0.08296	0.05283	0.0112	1.2008
Factor9	0.03014	0.04092	0.0041	1.2049
Factor10	-0.01078	0.04262	-0.0015	1.2035
Factor11	-0.05341	0.01582	-0.0072	1.1962
Factor12	-0.06923	0.00077	-0.0093	1.1869
Factor13	-0.07000	0.06320	-0.0094	1.1775
Factor14	-0.13320	0.01560	-0.0180	1.1595
Factor15	-0.14880	0.01048	-0.0201	1.1394
Factor16	-0.15928	0.02703	-0.0215	1.1179
Factor17	-0.18630	0.01828	-0.0251	1.0928
Factor18	-0.20458	0.02730	-0.0276	1.0651
Factor19	-0.23188	0.01883	-0.0313	1.0338
Factor20	-0.25071	.	-0.0338	1.0000

Eigenvalues of roughly 1 or more should be retained (Costello and Osborne, 2005)

Annex 4: Scree Plot of eigenvalues after factor analysis.

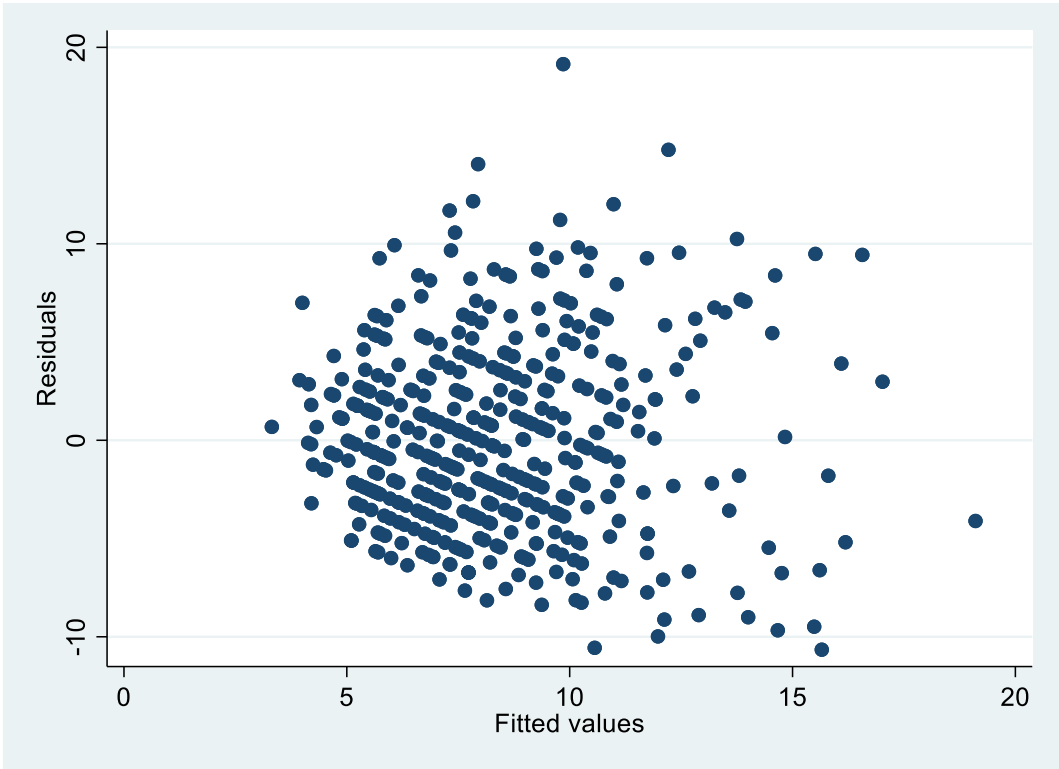


Annex 5: Rotated Factor Loadings

Rotated factor loadings and unique variances

Variable	Factor1 Helping/Teaching	Factor2 Talking/Reading	Factor3 Indoor/Outdoor Playing	Uniqueness
How often do you help with school work	0.5383	-0.0610	0.0527	0.7009
Are present at home when child returns	0.6302	-0.0267	0.0003	0.6097
Play games at home	0.1343	0.0289	0.5259	0.6459
Play physical games outside	0.0650	0.0195	0.6410	0.5485
Go for walks	0.0554	0.0014	0.5723	0.6471
Go on cultural outings	0.0448	-0.0334	0.4460	0.7929
Watch TV, play video games	0.1312	0.0238	0.1942	0.9231
Eat a meal together	0.4511	-0.0431	0.0356	0.7920
Supervise child at bedtime	0.4360	0.0523	0.1141	0.7462
Take child to school or activities	0.6124	-0.0036	-0.0068	0.6288
Supervise homework	0.7771	-0.0079	0.0722	0.3553
Talk about what they did	0.5289	0.3030	-0.0326	0.5714
Go shopping	0.1688	0.0215	0.2084	0.8993
Help with homework	0.4838	0.0154	0.1753	0.6717
Talk about what they learnt	0.2212	0.5484	-0.0971	0.6289
Talk about their friends	0.0941	0.6608	-0.0472	0.5436
Talk about their school day	0.0399	0.7508	-0.0719	0.4468
Talk about their teacher	0.0221	0.7250	0.0213	0.4576
Talk about their future studies	-0.1734	0.6169	0.1891	0.5625
Talk about their future jobs	-0.1872	0.5756	0.1780	0.6191

Annex 6: Residual plots for complete case analysis of total SDQ scores.



Annex 7: Complete Case Results for a Sensitivity Analysis

Linear regression models of paternal depression and children's behaviour age 8 years in the EDEN cohort without imputations. N=875

	Total			Conduct Problems			Hyperactivity			Emotional Symptoms			Peer Relationship Issues			Prosocial Behaviour			
	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	β	(95% CI)	<i>p</i> value	
Unadjusted Model																			
	Father Depression	0.14	(-0.09 to 0.18)	0.000	0.02	(0.01 to 0.03)	0.008	0.04	(0.02 to 0.06)	0.001	0.04	(0.02 to 0.06)	0.000	0.04	(-0.02 to 0.05)	0.000	-0.02	(-0.04 to 0.01)	0.004
	Father Alcohol Use	0.02	(-0.03 to 0.07)	0.414	0.00	(-0.02 to 0.02)	0.769	0.02	(-0.01 to 0.04)	0.174	0.00	(-0.02 to 0.02)	0.807	0.01	(-0.01 to 0.02)	0.244	0.00	(-0.02 to 0.01)	0.872
Adjusted Model *																			
	Father Depression	0.13	(0.06 to 0.19)	0.000	0.01	(-0.01 to 0.03)	0.216	0.04	(0.01 to 0.07)	0.009	0.04	(0.01 to 0.07)	0.007	0.03	(0.01 to 0.05)	0.002	-0.03	(-0.05 to -0.00)	0.017
	Father Alcohol Use	0.01	(-0.07 to 0.09)	0.794	0.00	(-0.03 to 0.02)	0.711	0.00	(-0.03 to 0.04)	0.815	0.00	(-0.04 to 0.03)	0.796	0.01	(-0.01 to 0.04)	0.218	0.00	(-0.02 to 0.03)	0.756
	Mother Depression	0.14	(0.08 to 0.21)	0.000	0.01	(-0.01 to 0.03)	0.192	0.05	(0.02 to 0.07)	0.003	0.04	(0.01 to 0.07)	0.003	0.04	(0.02 to 0.06)	0.000	0.00	(-0.02 to 0.02)	0.907
	Accessibility	-2.95	(-5.73 to -0.18)	0.037	0.16	(-0.68 to 1.00)	0.712	-0.47	(-1.77 to 0.83)	0.477	-1.35	(-2.53 to -0.16)	0.026	-1.29	(-2.14 to -0.45)	0.003	-0.19	(-1.11 to 0.73)	0.684
	Helping	0.03	(-0.56 to 0.62)	0.916	0.04	(-0.14 to 0.22)	0.670	0.03	(-0.24 to 0.31)	0.813	-0.04	(-0.30 to 0.21)	0.731	0.00	(-0.18 to 0.18)	0.967	-0.12	(-0.31 to 0.08)	0.235
	Talking	0.07	(-0.48 to 0.61)	0.807	-0.12	(0.28 to 0.05)	0.162	-0.12	(-0.38 to 0.13)	0.342	0.21	(-0.03 to 0.44)	0.081	0.10	(-0.06 to 0.27)	0.229	0.11	(-0.07 to 0.29)	0.213
	Playing	-0.63	(-1.28 to 0.01)	0.055	-0.10	(-0.30 to 0.09)	0.295	-0.21	(-0.51 to 0.09)	0.175	-0.20	(-0.48 to 0.08)	0.157	-0.12	(-0.32 to 0.08)	0.235	0.24	(0.02 to 0.45)	0.030
Depression Interactions																			
	Accessibility	0.05	(-0.18 to 0.28)	0.667	0.01	(-0.06 to 0.07)	0.880	-0.01	(-0.11 to 0.10)	0.909	0.07	(-0.03 to 0.16)	0.187	-0.01	(-0.08 to 0.05)	0.679	0.03	(-0.04 to 0.11)	0.411
	Helping	0.00	(-0.06 to 0.07)	0.893	0.01	(-0.02 to 0.03)	0.607	-0.02	(-0.05 to 0.02)	0.333	0.02	(-0.01 to 0.05)	0.215	0.00	(-0.03 to 0.02)	0.742	0.00	(-0.02 to 0.03)	0.800
	Talking	0.04	(-0.01 to 0.10)	0.141	0.01	(-0.01 to 0.02)	0.544	-0.01	(-0.04 to 0.02)	0.476	0.03	(-0.01 to 0.05)	0.018	0.02	(-0.00 to 0.04)	0.044	0.00	(-0.02 to 0.02)	0.908
	Playing	-0.05	(-0.13 to 0.03)	0.206	-0.01	(-0.03 to 0.02)	0.603	-0.03	(-0.07 to 0.01)	0.109	0.01	(-0.03 to 0.04)	0.675	-0.02	(-0.05 to 0.00)	0.077	0.01	(-0.01 to 0.04)	0.312
Alcohol Use Interactions																			
	Accessibility	0.01	(-0.31 to 0.34)	0.942	-0.07	(-0.17 to 0.03)	0.147	-0.03	(-0.18 to 0.12)	0.675	0.07	(-0.07 to 0.21)	0.334	0.05	(-0.05 to 0.15)	0.332	-0.07	(-0.18 to 0.03)	0.183
	Helping	-0.03	(-0.10 to 0.04)	0.413	-0.01	(-0.03 to 0.01)	0.461	0.00	(-0.03 to 0.04)	0.807	-0.01	(-0.04 to 0.02)	0.690	-0.02	(-0.04 to 0.00)	0.076	0.00	(-0.02 to 0.02)	0.954
	Talking	0.04	(-0.04 to 0.11)	0.350	0.02	(-0.00 to 0.04)	0.115	0.00	(-0.03 to 0.04)	0.863	0.01	(-0.02 to 0.04)	0.671	0.01	(-0.02 to 0.03)	0.525	0.00	(-0.02 to 0.03)	0.748
	Playing	-0.06	(-0.15 to 0.04)	0.237	-0.01	(-0.04 to 0.02)	0.424	-0.01	(-0.05 to 0.04)	0.804	-0.04	(-0.08 to -0.00)	0.030	0.00	(-0.02 to 0.03)	0.733	-0.14	(-0.04 to 0.02)	0.377

* Adjusted for covariates: Age and nationality of father, mother's depression, marital status in pregnancy and at birth, smoking and alcohol use in pregnancy, postpartum depression, psychological help during pregnancy, father's drinking before 8 year data wave, average income, number of siblings, child sex, prematurity, small for gestational age, education of father, education of mother, marital conflict, father employment at 8 years, if father lived with child at 2 years, and HOME score.