1   *Title:* Does father-child conflict mediate the association between fathers' postnatal depressive symptoms and

2   children's adjustment problems at 7 years old?

3   Selina Nath[1,4], Ginny Russell[2], Willem Kuyken[3], Lamprini Psychogiou[1], Tamsin Ford[2]

4   [1] Mood Disorders Centre University of Exeter, Exeter, UK

5   [2] Institute of Health Research, University of Exeter Medical School, Exeter, UK

6   [3] University Department of Psychiatry, University of Oxford, Warneford Hospital, Oxford, UK

7   [4] Institute of Psychiatry, Psychology & Neuroscience, King's College London, De Crespigny Park, London, UK

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10 **Correspondence:** Selina Nath, Institute of Psychiatry, Psychology & Neuroscience (IOPPN), King's College

11 London, De Crespigny Park, London, UK*;* Email: selina.nath@kcl.ac.uk ; Telephone Number: 020 7848 0739

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Background: Paternal depressive symptoms are associated with children's emotional and behavioural problems, which may be mediated by negative parenting. But there is no research on the influence of paternal depressive symptoms on children's emotion regulation and limited literature investigating fathers' parenting as a mediator in the pathway between paternal depressive symptoms and children's externalising and internalising problems. We aimed to investigate the mediating role of father-child conflict (at 3 years) in the association between postnatal paternal depressive symptoms (at 9-months) and children's emotional and behavioural (at 7 years) (aim 1). We also examined whether mediation pathways were more pronounced for boys or for girls (aim 2).

Methods: Secondary data analysis was conducted on the Millennium Cohort Study, when children were 9-months, 3-years and 7-years-old (n=3,520). Main study variables were measured by self-report questionnaires. Fathers completed the Rutter Scale (depressive symptoms) and the parent-child relationship questionnaire (father-child conflict), while mothers completed the Strengths and Difficulties questionnaire and the Social behaviour questionnaire (child emotional and behavioural problems, emotion regulation). We used structural equation modelling to estimate direct, indirect and total effects of paternal depressive symptoms on child outcomes, mediated by father-child conflict whilst adjusting for relevant covariates (maternal depressive symptoms, child temperament, marital conflict, and socio-economic factors such as poverty indicator and fathers' education level). Multi-group and interaction analysis was then conducted to determine the differential effect by gender of the association between paternal depressive symptoms on child outcomes via father-child conflict.

Results: Father-child conflict mediated the association between paternal depressive symptoms and emotion regulation problems (SIE – CI: -0.03 - -0.01, p<0.001; STE–CI: -0.03 - -0.01, p<0.05) (aim 1). Father-child conflict mediated a larger proportion of the effect in boys (SIE CI: -0.03- -0.01, p<0.001, STE–CI: -0.05- -0.00, p=0.063) than it did in girls (SIE–CI: -0.02- -0.01, p<0.001, STE–CI: -0.04 - 0.01, p=0.216) (aim 2).

Conclusions: Father-child conflict may mediate the association between postnatal paternal depressive symptoms and children's emotion regulation problems. Paternal depressive symptoms and father-child conflict resolution may be potential targets in preventative interventions.

Key words: Paternal depressive symptoms, parenting, father-child conflict, behavioural problems, emotion regulation.

Introduction

Postnatal depressive symptoms in fathers are associated with behavioural and emotional problems in children (Davé *et al.*, 2008, Fletcher *et al.*, 2011, Ramchandani *et al.*, 2005, Ramchandani *et al.*, 2008b), but there is limited understanding about the underlying mechanisms that explain these associations. Childhood behavioural and emotional problems are associated with poor outcomes during adulthood, including academic underachievement, psychiatric problems, relationship difficulties, substance abuse and dependency on services (Caspi *et al.*, 1996, Fergusson *et al.*, 2005). This causes considerable burden on public services and has huge costs on society (Scott *et al.*, 2001, Snell *et al.*, 2013). Improved understanding of how paternal depressive symptoms influence children's behavioural and emotional outcomes during childhood may improve theoretical understanding about the transmission of risk from parents to children and might provide targets for interventions involving fathers (Garfield, 2015, Ramchandani and Murphy, 2013).

Using longitudinal data form the Millennium Cohort Study (MCS), Malmberg and Flouri (2011) found that paternal depressive symptoms at 9 months old predicted behavioural problems in children when they were 3 years old via lower overall quality (lower warmth and higher conflict) in father-child relationship. Using another large cohort study (Longitudinal Study of Australian Children: LSAC study), Giallo *et al.* (2014b) reported that paternal depressive symptoms during infancy were associated with children's emotional and behavioural problems at 4-5 years old, and the association was mediated via increased hostile parenting. Child gender did not appear to moderate this association. In both studies, fathers' parenting and children's outcomes were measured at the same time-point, therefore causality cannot be assumed. Finally, a study of fathers with children aged 5-9 years old found inconsistent discipline practices mediated the association between paternal depressive symptoms and their sons' hyperactivity, but not their daughters' (Dette-Hagenmeyer and Reichle, 2014). Although there was a longitudinal element to this study, paternal depressive symptoms and parenting were measured simultaneously and the measure of child outcomes was collected 6-months later, making the analysis almost cross-sectional.

Evidence suggests that poor emotion regulation in children may be associated with increased externalising and internalising behavioural problems (Eisenberg *et al.*, 2010). Difficulty with regulating anger and impulsivity (under-regulation) has been linked with externalising problems, whereas inability to control cognition and attention (over-regulation involved in rumination and negative bias) have been associated with internalising

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89   problems (Gross, 1998). Studies have also focused on the effects of maternal depression on children's emotion

90   regulation, and have reported that children of depressed mothers have poorer emotion regulation compared to

91   children of non-depressed mothers (Silk *et al.*, 2006). This may be due to the environmental influence of

92   depressed mothers' inability to parent sensitively or children modelling mothers' maladaptive emotion

93   regulation strategies (Eisenberg *et al.*, 2001, Hoffman *et al.*, 2006). Although there have been studies on the

94   importance of fathers to the development of emotion regulation among children (Cabrera *et al.*, 2007, Kiel and

95   Kalomiris, 2015, Wilson *et al.*, 2014), to our knowledge there are no studies that examine the association

96   between paternal depressive symptoms and children's emotion regulation.

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98   There are some studies that provide evidence for the potential mechanisms by which paternal depressive

99   symptoms may influence children's emotional and behavioural problems. One hypothesis proposes that paternal

100   depressive symptoms may influence children's development via fathers' impaired parenting (Ramchandani and

101   Psychogiou, 2009). Depression in parents has been associated with negative parent-child interactions

102   (Psychogiou and Parry, 2014, Sethna *et al.*, 2015) and a meta-analysis of 28 studies reported paternal depressive

103   symptoms to be associated with increased negative (intrusive, hostile, harsh, controlling, and critical) and

104   decreased positive parenting behaviours (sensitive responding, accepting, warm, affectionate, and supporting)

105   towards children (Wilson and Durbin, 2010). One study found that fathers' disengaged parenting when their

106   infants were 3-months old predicted externalising problems at 1 year in their sons, but not daughters

107   (Ramchandani *et al.*, 2013). Another meta-analysis consisting of 6 studies reported that father-child conflict

108   mediated the association between paternal depressive symptoms and children's emotional problems (Kane and

109   Garber, 2004). However, the studies in this meta-analysis included children with a wide age range (from 3 to 14

110   years) and most studies were cross-sectional. To infer mediation, it is necessary to study the exposure of

111   paternal depressive symptoms, fathers' parenting and children's outcomes longitudinally (Selig and Preacher,

112   2009). Thus, the variables need to be measured at different time-points. Additionally, given that there were only

113   6 studies on father-child conflict, mediation requires further investigation.

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115   Although studies have found a link between paternal depressive symptoms and children's behavioural and

116   emotional problems (Davé *et al.*, 2008, Ramchandani *et al.*, 2005, Ramchandani *et al.*, 2008b), there are mixed

117   findings about the influence of paternal depressive symptoms regarding child gender-specific pathways of risk

118   transmission. Postnatal depressive symptoms in fathers 8 weeks after child birth were associated with children's

119 psychopathology at 3 and 7 years old in the UK Avon Longitudinal Study of Parents and Children (ALSPAC)

120 (Ramchandani *et al.*, 2005, Ramchandani *et al.*, 2008b); sons of fathers with high depressive symptoms were

121 reported to display more conduct problems compared to daughters. In contrast, findings from the LSAC

122 suggested that the daughters of fathers with high depressive symptoms in the first post-natal year were more

123 likely to have emotional and conduct problems when they were 4-5 years old, whereas sons were more likely to

124 exhibit hyperactivity problems and lower levels of prosocial behaviour (Fletcher *et al.*, 2011). Exploring gender-

125 specific pathways may help explain the possible father to child transmission of risk which may subsequently

126 enable us to identify whether girls and/or boys are more vulnerable to their fathers' depressive symptoms. This

127 could influence the content and direction of interventions with depressed fathers.

128

129   [Insert Figure 1 here]

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132 This study aims to address these gaps in the current literature using a large representative sample of fathers from

133 the MCS in the UK. The primary objective is to test the proposed model (Figure 1) and investigate whether

134 father-child conflict mediates the association between paternal depressive symptoms and children's emotional

135 and behavioural outcomes. The exposure of paternal depressive symptoms during infancy has been identified as

136 a potential sensitive period where paternal depressive symptoms may influence children's later outcomes

137 (Ramchandani *et al.*, 2008a). The mediator variable father-child conflict was measured at 3 years old during the

138 preschool year when fathers' become more involved in parenting their children (Bruce and Fox, 1999,

139 Grossmann *et al.*, 2002, MacDonald and Parke, 1986). Previous literature has associated father-child conflict

140 with paternal depression and negative outcomes in children (Kane and Garber, 2004, 2009) . Additionally, using

141 the MCS dataset, a recent study found an association between paternal depressive symptoms and father-child

142 conflict, but not father-child warmth or fathers' involvement in parenting activities, suggesting that father-child

143 conflict may be an important construct that is influenced by paternal depressive symptoms (Nath *et al.*, 2015).

144 Children's outcomes were measured at 7 years old. This is a developmentally challenging period as children

145 learn new behaviour and emotion management skills and problems with adjustment at this age predict poor

146 outcomes in adulthood (Fergusson *et al.*, 2005, Pianta *et al.*, 1995). Given that maternal depression, marital

147 conflict, child temperament, child gender, and family socio-economic status may be associated with fathers'

148 depressive symptoms, parenting and children's emotional and behavioural outcomes (Flouri *et al.*, 2014,

149 Goodman, 2004, Gutierrez-Galve *et al.*, 2015, Hanington *et al.*, 2012, Hanington *et al.*, 2010, Kiernan and

150 Huerta, 2008, Malmberg and Flouri, 2011), we controlled for these factors in our models. Our secondary

151 objective was to test the moderating influence of child gender on any potential associations. We predicted that

152 higher father-child conflict at 3 years old would mediate the association between higher paternal depressive

153 symptoms at 9-months old and children's increased behavioural-emotional outcomes at 7 years. We expected

154 that child gender would moderate this mediation, but did not expect a specific direction given the mixed

155 literature.

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157

158 **Methods**

159

160 *Participants*

161 This secondary data analysis was conducted using the first (S1), second (S2) and forth (S4) sweeps of the

162 Millennium Cohort Study (MCS), when children were 9 months, 3 years and 7 years old. The MCS is a large-

163 scale survey of infants (n=19,519) born in four constituent countries of the United Kingdom (Dex and Joshi,

164 2005). The sample design allowed for over-representation of families living in areas with high rates of child

165 poverty or high proportions of ethnic minorities in England and the three smaller countries in the UK (Northern

166 Ireland, Wales, and Scotland). Full details of the survey, objectives, content of survey and sampling strategy can

167 be found in the documentation attached to the data deposited with the UK Data Archive and elsewhere (Hansen,

168 2014, Plewis and Ketende, 2006). MCS had informed consent from participants and ethical approval (Hansen,

169 2012). Our work was a secondary analysis of anonymised data that is publically available on the website

170 (http://discover.ukdataservice.ac.uk/series/) requiring no direct contact with the individual participants, so

171 further ethical approval was not required.

172

173 The first wave (S1) of data was collected from 2001-2002 on 18,533 families, with a total of 18,819 infants aged

174 between 9-11 months. The same sample were then invited to follow-up with 15,590 families in the second wave

175 (S2) when the children were approximately 3 years old and 13,857 in the fourth wave (S4) when children were

176 approximately 7 years old.

177

178   The MCS collected data from main respondents (usually mothers) and partner respondents (fathers, step fathers,

179   same sex partners). For the current study, the sample was limited to biological fathers (partner respondents) and

180   mothers (main respondents). Fathers who were main respondents were excluded to simplify analysis as main

181   and partner questions were not identical. Part-time resident and step-fathers were also excluded due to

182   insufficient numbers. A small sample of twins and triplets were excluded to avoid the need to include an extra

183   level of analysis that would have accounted for intra-family variability. Thus, only one child per family (the first

184   cohort member) was studied. See Figure 2 for details of eligibility, sample size at each stage and final sample

185   used for main analysis.

186

187   [Insert Figure 2 here]

188

189   *Measures*

190   Paternal depressive symptoms

191   Rutter's 9-item Malaise Inventory (S1 – 9 months old) was used as an indicator for depressive symptoms in S1

192   completed by fathers (Dex and Joshi, 2004, Rutter *et al.*, 1970). This is the shortened version of the Rutter's 24-

193   item Malaise Inventory self-completion questionnaire measuring psychological distress (Bartley *et al.*, 2004,

194   Johnson, 2012, Rutter *et al.*, 1970). The 9-item short form included items "feel tired most of the time", "feel

195   miserable or depressed", "worried about things", "often get into a violent rang", "suddenly become scared for no

196   good reason", "easily upset or irritated", "constantly keyed up and jittery", "every little thing gets on nerves and

197   wears you out", and "heart race like mad". Scores from these were summed to create a continuous scale. This

198   scale has been used in previous studies as an indicator of depressive symptoms (Kiernan and Huerta, 2008,

199   Malmberg and Flouri, 2011). Using Cronbach's alpha (α) coefficient the internal consistency of the scale was

200   0.75 for mothers and 0.71 for fathers which is similar to previous validation studies on the scale (Rodgers *et al.*,

201   1999). The original scale has also shown acceptable validity (Area Under the Curve (AUC) = 0.74 with mental

202   health problems , AUC = 0.77 with psychiatric diagnosis, AUC = 0.87 with depression) (Rodgers *et al.*, 1999).

203

204   Fathers' parenting: Father-child conflict

205   Fathers' parenting was measured using The Child-Parent Relationship Scale reported by fathers (CPRS; Short

206   form, (Johnson, 2012, Pianta and Steinberg, 1992). In this study, father-child conflict refers to the

207   communication and relationship between the parent and the child which is measured by 8 self-report items on a

208 5-point Likert scale (ranging from 1=definitely does not apply to 5= definitely applies). All items were summed

209 to create a continuous scale. Items include "child and I always seem to be struggling with each other", "child

210 uncomfortable with physical affection or touch by me", "child easily becomes angry with me", "child remains

211 angry/resistant after discipline", "dealing with my child drains my energy", "when child wakes up in bad mood,

212 I know we're in for a long and difficult day", "child's feelings towards me can be unpredictable or change

213 suddenly" and "child is sneaky or manipulative with me". This scale has been used by other studies as an

214 indicator of parenting (Kiernan and Huerta, 2008, Mensah and Kiernan, 2011, Nath *et al.*, 2015) and the items

215 originate from attachment theory, Attachment Q-set and literature on parent-child relationships to form a

216 subscale looking at negative approach towards father-child relationship (conflict). Higher scores on the scale

217 indicated higher conflict in relationship. Fathers' reports are comparable to mothers' reports and have been

218 validated against observational data on parent-child interactions which has shown conflict ratings on the CPRS

219 to correlate with observational coding of hostility (Driscoll and Pianta, 2011). The scale had adequate internal

220 consistency (α=0.73).

221

222 Child behavioural and emotional problem

223 The Strengths and Difficulties Questionnaire (SDQ; (Goodman, 2001)) completed by mothers was used to

224 assess child emotional and behavioural problems (S4, 7 years old). The SDQ is validated for children aged 3-16

225 years old and was developed as a clinical tool to identify psychopathology. There are 25 items in total consisting

226 of five continuous subscales: emotional symptoms, conduct problems, hyperactivity, peer problems and

227 prosocial behaviour. The scores for each subscale range between 0-10. All sub-scales were used in the analysis.

228 Higher scores indicate greater problems on the emotional, conduct, hyperactivity, and peer problems, whereas

229 higher scores on the prosocial scale indicated more prosocial behaviour. The internal consistencies from the

230 MCS were: conduct problems α= 0.55, emotional problems α=0.68, hyperactivity α= 0.78, peer problems

231 α=0.59 and prosocial α=0.71. These are similar to internal consistencies reported in other studies using non-

232 clinical samples of children (Muris *et al.*, 2003, Niclasen *et al.*, 2012). The scale has also been reported to have

233 sufficient validity against diagnostics of DSM-IV disorders (specificity=96%, sensitivity=49%) (Goodman,

234 2001) and Child Behaviour Chick List (CBCL; r=0.76) (Stone *et al.*, 2010).

235

236 Child emotion regulation

237   The MCS team selected items from the Child Social Behaviour Questionnaire (CSBQ) (Hogan *et al.*, 1992,

238   Johnson, 2012) that were completed by mothers and used to generate three continuous sub-scales; 1) self-

239   regulation defined as children's ability to adapt to situations independently, 2) emotion dysregulation defined as

240   children's inability to deal with difficult/frustrating situations, and 3) cooperation defined as children's ability to

241   cooperate with others. The self-regulation and the reverse of emotion dysregulation scales were significantly

242   correlated (r=0.32, p<0.001) and were summed to create an emotion regulation scale for the analysis. The

243   cooperation subscale was not used because it does not belong to the emotion regulation construct. Higher scores

244   on the emotion regulation scale indicated more adaptive emotion regulation. The internal consistency of the

245   scale was α= 0.72. This scale devised by the MCS team has been used in other studies to measure emotion

246   regulation (Flouri *et al.*, 2014).

247

248   Family context covariates

249   Maternal depressive symptoms (S1- 9 month) were measured using the Rutter Malaise Inventory as above (Dex

250   and Joshi, 2004, Johnson, 2012, Rutter *et al.*, 1970). Children's temperament (S1- 9 months) was measured with

251   mothers' reports on the Carey Infant Temperament Scale (Carey and McDevitt, 1978). Fourteen items from the

252   original scale were selected by the MCS team to measure regularity (4 items), approach withdrawal (3 items),

253   adaptability (2 items) and mood (5 items), and has also been used in other studies as an indicator of child

254   temperament (Flouri and Malmberg, 2012, Kiernan and Huerta, 2008). Items were on a 5-point scale (almost

255   never, rarely, usually does not, often, almost always). All scores were on a continuous scale ranging from (14 –

256   70) consisting of the total score of all items. Higher scores indicated easier infant temperament and lower scores

257   indicated more difficult temperament. The internal consistency of the scale was α=0.66. Marital conflict (S1- 9

258   months) was measured using the modified version of the Golombok Rust Inventory of Relationship State (Rust

259   *et al.*, 1990). The original 28-item questionnaire had high content validity and reliability of Cronbach's alpha =

260   0.91 (men) and 0.87 (women). The MCS selected seven items at S1 and S2, and three items at S4 (Johnson,

261   2012). These were summed to create continuous scales where higher scores indicate higher levels of relationship

262   conflict.

263

264   Socioeconomic Status (SES)

265   Households were classed as living in poverty if their income was equal to or less than 60% of the median

266   household income for the UK (dichotomous scale), the definition of poverty set by the UK government

267 (Ketende and Joshi, 2008). Paternal education was reported by fathers and was categorised into two groups: no

268 qualification or school level, degree and higher degree (NVQ level or equivalent, undergraduate and post-

269 graduate degree).

270

271 *Statistical analysis*

272 Structural Equation Modelling (SEM) using Stata for Windows version 13 was used to test the mediation model

273 illustrated in Figure 1, i.e., whether 'father-child conflict' (3 years) mediated the association between 'paternal

274 depressive symptoms' (9 months) and 'child outcomes' at 7 years old (conduct problems, emotional problems,

275 hyperactivity, peer problems, prosocial and emotion regulation). The model estimated standardised direct,

276 indirect and total effects, as well as adjusting for a number of relevant covariates (maternal depressive

277 symptoms, marital conflict, child temperament, child gender and SES) (model 1). Outcomes that were

278 significantly associated with paternal depressive symptoms in model 1 were taken forward into a multi-group

279 SEM analysis. This investigated whether child gender moderated the associations between 'paternal depressive

280 symptoms' and 'child outcomes' mediated by 'father-child conflict' while controlling for maternal depressive,

281 symptoms, marital conflict, child temperament and SES (model 2). The SEM mediation model was run again

282 using interaction terms to further investigate whether gender interacted with the exposure or mediator to

283 influence the outcome child variables while controlling for maternal depressive symptoms, marital conflict,

284 child temperament and SES (model 3). Finally, we further controlled for marital conflict in subsequent sweeps

285 to increase the validity of any associations found in model 3 (model 4).

286

287 As the sample was stratified, sampling weights were used in all analyses to adjust for the disproportionate

288 number of participants from ethnic minority and low socio-economic status backgrounds initially recruited into

289 the sample at S1. Weights aimed to return the sample to the structure of the UK population and also to account

290 for the effect of attrition and multi-stage cluster sampling strategy used by the MCS. The use of the weights is

291 recommended by the MCS team and available with the dataset. Missing data were not analysed. Only data with

292 complete cases on variables of interest across time-points were included in the analysis. In order to check that

293 the results in the 'complete cases' model were robust to the effects of attrition, missing data were imputed from

294 all variables included in the analysis. A sensitively analysis was conducted to check that results were broadly

295 replicated when missing data were imputed.

296

297   **Results**

298   *Descriptive statistics*

299   Table 1 shows descriptive statistics for the study main measures (exposure, mediator and outcomes). Logistic

300   regression analyses were used to test for gender differences. Compared to boys, girls had lower odds of conflict

301   with their fathers (OR: 0.99, 95% CI: 0.98-0.98, p=0.011), conduct problems (OR: 0.84, 95% CI: 0.80-0.87,

302   p=<0.001), hyperactivity (OR: 0.85, 95% CI: 0.83-0.88, p=<0.001), and peer problems (OR: 0.92, 95% CI:

303   0.89-0.96, p=<0.001), but higher odds of prosocial problems (OR: 1.25, 95% CI: 1.21-1.30, p=<0.001) and

304   adaptive emotion regulation (OR: 1.54, 95% CI: 1.41-1.68, p=<0.001). There was no significant associations

305   between child gender and fathers depressive symptoms (OR: 0.98, 95% CI: 0.95-1.01, p=1.135) or child

306   emotional problems (OR: 1.03, 95% CI: 0.99-1.07, p=0.100).

307

308   The predictor (paternal depressive symptoms), mediator (father-child conflict) and outcomes (child emotional

309   and behavioural problems) were significantly correlated, a necessary requirement for mediation to occur (Table

310   2).

311

312   [Insert Table 1 here]

313

314   [Insert Table 2 here]

315

316   *Attrition and missingness*

317   Attrition (i.e. fathers who did not take part in Sweeps 2 (3 years) and 4 (7 years)), and missingness (i.e fathers

318   who did not provide complete answers to survey questions) were associated with low socio-demographic factors

319   (Table 3). Fathers had a higher odds of dropping out by both follow-up sweeps if they were below the 60%

320   median of the poverty indicator (S2 –OR: 3.14, 95% CI: 2.63-3.74, p=<0.001; S4 - OR: 2.31, 95% CI:1.96-2.72,

321   p=<0.001) and had lower odds if they were educated (S2 –OR: 0.45 , 95% CI: 0.35–0.50, p=<0.001; S4 - OR:

322   0.63, 95% CI:0.53-0.75, p=<0.001). Fathers with higher depressive symptoms also had higher odds of dropping

323   out (S2 –OR: 1.08, 95% CI: 1.06-1.11, p=<0.001; S4 - OR: 1.07, 95% CI: 1.04-1.10, p=<0.001).

324

325   [Insert Table 3 here]

326

11

327 *Covariates*

328 All family and socio-economic covariates that were associated with higher paternal depressive symptoms,

329 father-child conflict and child outcome, and therefore were controlled for in the analysis models (See online

330 supplementary tables 1 and 2).

331

332 *Mediation model*

333 Table 4 (Model 1) shows that after adjusting for relevant covariates (maternal depressive symptoms, child

334 temperament, marital conflict, child gender and family SES), higher father-child conflict mediated the

335 association between high paternal depressive symptoms at 9-months and children's increased conduct problems,

336 and emotion dysregulation at age 7 years old. The estimated total effects of paternal depressive symptoms on

337 children's emotional, hyperactivity, prosocial behaviour and peer problems were not significant and therefore

338 were not taken forward into model 2. Table 4 shows the coefficients for each outcome (Model 1).

339

340

341 [Insert Table 4 here]

342

343 *Moderation by gender*

344 Model 2 tested for child gender moderator effects (Table 4). This model included significant outcomes from

345 model 1 (conduct problems and emotion regulation) and also adjusted for maternal depressive symptoms,

346 marital conflict, child temperament and SES. Higher father-child conflict mediated the association between

347 higher paternal depressive symptoms and boys increased conduct problems (Table 4, Model 2). This association

348 was also marginally significant for emotion regulation. No significant effects were found for girls, which

349 suggest that paternal depressive symptoms may have an effect via conflict on conduct and emotion regulation

350 problems in their sons but not in their daughters.

351

352 After testing for interaction effects (Model 3), high father-child conflict still significantly mediated the

353 association between higher post-natal paternal depressive symptoms and boys' conduct problems and emotion

354 regulation. Table 4 (Model 3) shows the standardised coefficients for each outcome according to gender

355 interaction with the exposure paternal depressive symptoms and mediator father-child conflict. For conduct

356 problems, child gender interacted with both paternal depressive symptoms and father-child conflict while for

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357 emotion regulation, child gender interacted significantly with father-child conflict. After further adjusting the

358 model for marital conflict at all time-points (table 5, model 4), higher father-child conflict still significantly

359 mediated the association between high post-natal paternal depressive symptoms and emotion regulation, but the

360 association between paternal depressive symptoms and child conduct problems became non-significant. In this

361 model, child gender interacted significantly with father-child conflict, but not paternal depressive symptoms in

362 the association between paternal depressive symptoms and child emotion regulation. The model fit statistics

363 show that model 4 is the best fit. The final overall model (model 4) explained 59% of the variance ($R^2 = 0.59$).

364

365 *Sensitivity analysis*

366 The sensitivity analysis using imputed data replicated the findings in the main analysis in that all effects

367 remained significant. In fact, significant findings increased in the main analysis model 1 (see online

368 supplementary table 3). Therefore, this suggests that we have underestimated the effects of paternal depressive

369 symptoms on children's emotional and behavioural problems via father-child conflict; therefore further analysis

370 was not undertaken using the imputed datasets on models 2, 3 and 4.

371

372

373 **Discussion**

374 As hypothesised, higher paternal depressive symptoms at 9 months were significantly associated with children's

375 emotion regulation at 7 years old, via higher father-child conflict when children were 3 years old. Thus,

376 depressive symptoms in fathers may influence their mood. Therefore these fathers may struggle with conflict

377 resolution with their toddlers and this negative interaction may later impact on their children's emotional

378 development during early school years. These findings extend previous studies investigating the association

379 between paternal depressive symptoms, fathers' parenting and children's emotional and behavioural problems

380 (Dette-Hagenmeyer and Reichle, 2014, Giallo *et al.*, 2014b, Kane and Garber, 2009, Malmberg and Flouri,

381 2011, Ramchandani *et al.*, 2005, Ramchandani *et al.*, 2008b) and add to literature by using longitudinal data

382 from key time points. This study is also the first to our knowledge that has investigated the association between

383 paternal depressive symptoms and children's emotion regulation. Our findings also extend the literature by

384 adding that father-child conflict may mediate this association path. Furthermore, we found that gender had an

385 interaction effect with father-child conflict and not fathers' depressive symptoms. These findings suggest that

386 father-child conflict may be an important factor that could be targeted to reduce emotional and behavioural

387   problems in sons of fathers suffering from depression. Our findings that boys with poorer emotion regulation

388   abilities had higher externalising problems is also in line with previous research (Eisenberg *et al.*, 2010).

389

390   Parental socialisation provides an environmental explanation for our findings (Eisenberg *et al.*, 2001). Previous

391   studies have shown that maternal depression negatively impacts on their daughters' emotion regulation abilities

392   but not sons' (Silk *et al.*, 2006). As emotion regulation abilities are learnt from socialisation with parents during

393   early development, these results may indicate that same-gendered parents have a greater influence on their

394   children in this process (Eisenberg *et al.*, 2001). Compared to mothers, fathers have been reported to respond

395   more harshly and provide less support towards their son's emotional expressions, which according to role model

396   theory may subsequently be imitated by boys (Brody and Hall, 2008, Brown *et al.*, 2015, Chaplin *et al.*, 2005,

397   Fischer, 2000, Sanders *et al.*, 2015). This may cause conflict interactions between fathers and their sons, which

398   may lead to emotional and behavioural problems (Kane and Garber, 2004, 2009). An alternative explanation is

399   that our findings could be due to genetic heritability or an interplay between gene-environment (Natsuaki *et al.*,

400   2014, Ramchandani and Psychogiou, 2009). Sons of depressed fathers could be genetically predisposed to

401   developing depressive symptoms and also exposed to the family environmental factors associated with paternal

402   depressive symptoms (Gutierrez-Galve *et al.*, 2015, Rutter, 2009, Rutter *et al.*, 1997), which may increase

403   father-child conflict and child emotional problems. However, more research is needed to support both of these

404   explanations. As the current study could not control for genetic influences, this is something that could be

405   addressed by future research.

406

407   We also found that higher paternal depressive symptoms at 9 months were significantly associated with

408   children's conduct problems at 7 years old, via higher father-child conflict when children were 3 years old after

409   controlling for maternal depressive symptoms, child temperament, and family SES which was in line with

410   previous literature (Ramchandani *et al.*, 2005, Ramchandani *et al.*, 2013, Ramchandani *et al.*, 2008b). However,

411   after further controlling for marital conflict at all time-points, the overall associations between paternal

412   depressive symptoms and child conduct problems became non-significant. One explanation for this could be that

413   marital conflict may have a stronger influence on children's behavioural problems (Braithwaite *et al.*, 2015,

414   Hanington *et al.*, 2012) compared to paternal depressive symptoms (predictor variable). Additionally, marital

415   conflict and father-child conflict (mediator variable) are closely related variables that may jointly be influencing

416   the association between paternal depressive symptoms and child outcomes within the model (Cummings and

417   Miller-Graff, 2015, Margolin *et al.*, 2001). Therefore, future studies should aim to differentiate and disentangle

418   the effects of different conflictual relationships within the family in relation to child adjustment, perhaps with

419   observational rather than self-report measures.

420

421   The current study has a number of strengths. First, the MCS is a unique dataset with a large representative

422   sample of UK fathers (Hansen, 2014, Plewis and Ketende, 2006). Second, the MCS collected a large number of

423   measures on mothers, fathers and children, most of which were well validated and reliable and we tested

424   children's outcomes longitudinally (Johnson, 2012). Third, our findings are further strengthened by child

425   outcomes being reported from mothers, decreasing any variances produced by same informant reporter bias of

426   predictors and outcomes. Finally, the MCS (like other cohort datasets) is subjected to attrition and missing data.

427   However, research indicates that even when dropouts are taken into account, regression models with large

428   cohort studies are still robust (Wolke *et al.*, 2009). In addition, our analysis accounted for attrition/missing data

429   by utilising sampling weights recommended by the MCS team (Ketende and Jones, 2011). This increased the

430   representativeness and accounted for missing data/attrition rates that might have influenced or biased the results.

431   We further conducted a sensitivity analysis using multiple imputation, a statistical method used in recent years

432   to account for attrition in cohort studies (Niarchou *et al.*, 2015, Sterne *et al.*, 2009). This replicated our main

433   finding, and if anything suggests that we have underestimated the effects.

434

435   There were also some limitations. Firstly, we lacked data on clinical diagnoses of depressive episodes using

436   interview methods, which some might argue would be more informative. Parenting was also measured using

437   self-reports, which might not be accurate due to biased reporting of positive parenting and inter-association with

438   fathers reporting high depressive symptoms and higher conflict parenting. Parenting is often measured using

439   observational methods of parent-child interactions (Aspland and Gardner, 2003). However, in both cases

440   conducting studies using observational and interview methods with such a large sample size would be

441   expensive, time-consuming, and impractical. Thus, the study of the influence of depressive symptoms is useful

442   as results can later be tested experimentally using smaller clinical samples. Secondly, the coefficient effect sizes

443   of the associations were small. Previous studies investigating mediation effects using large cohort studies have

444   also reported small effect sizes of maternal and paternal depressive symptoms on child outcomes (Giallo *et al.*,

445   2014a, Giallo *et al.*, 2014b, Malmberg and Flouri, 2011). Given that the MCS consisted of a normal population

446   of fathers, clinically relevant high levels of depressive symptoms would have been underestimated due to the

447   likelihood of depressed fathers being less motivated to participate and therefore might have resulted in small

448   effect sizes. A smaller scale study consisting of a clinical sample of depressed fathers may yield larger effect

449   sizes. This is something for future studies to investigate. However, given the huge challenges with recruiting

450   depressed fathers to participate in research with their children (Garber *et al.*, 2011, Pilowsky *et al.*, 2014, Sherr

451   *et al.*, 2006), the findings from large cohort studies such as the MCS offers useful insight into the possible

452   associations in this field of limited literature (Fagan, 2014, Niarchou *et al.*, 2015). These findings, if replicated

453   with a clinical population, could suggest targets for development of clinical interventions.

454

455   We also assumed causal direction due to the data originating at different time points across the child's life. We

456   are assuming linear relationships when in fact the interrelationships between parental mental health, parenting

457   and children's development is likely to be complex and these factors may amplify and feedback on each other.

458   Therefore, our findings need to be replicated experimentally to draw firm conclusion about causal direction.

459   This could only be done in by using treatment trials for paternal depression which provide an opportunity to see

460   if father-child conflict and child emotional/behavioural problems are reduced among fathers who respond

461   compared to those who do not respond to treatment.

462

463   Finally, we acknowledge that there are more statistically advance techniques for testing mediation using Cross-

464   Lagged Panel Modelling (CLPM) and Latent Growth Mediation (LGM) Modelling (Selig and Preacher, 2009).

465   These techniques account for autoregressive controls, reverse causality and trends (slopes and intercepts)

466   between associations (Cole and Maxwell, 2003, Maxwell and Cole, 2007, Maxwell *et al.*, 2011). These methods

467   have been used to investigate moderation and mediation in maternal depression, mothers' parenting and

468   children's behavioural outcomes (Beauchaine *et al.*, 2005, Belsky *et al.*, 2007, Eisenberg *et al.*, 2005). However,

469   these statistical techniques require all variables to be available at all time-points (Selig and Preacher, 2009),

470   which was not the case in the MCS, restricting the analysis method we could utilise. Specifically with regards to

471   our research question, it would be important to investigate family context factors that may change over time

472   such as maternal and paternal depressive symptoms. Thus, future research work could expand the statistical

473   analysis of this paper by using longitudinal multivariate analysis with more statistically advanced techniques to

474   build on the findings of this paper once appropriate samples are available.

475

476   Despite some of the limitations, the findings of this study add to theoretical understanding of indirect effects of

477   fathers' postnatal depressive symptoms to their children's outcomes. Postnatal paternal depressive symptoms

478   were associated with boys' emotion regulation problems at 7 years old via higher father-child conflict at 3 years

479   old. This association still remained significant after accounting for maternal depressive symptoms, child

480   temperament, SES and marital conflict (at all time points). There are some specific implications that can be

481   taken from the current study to inform parenting interventions. For example, parenting interventions could help

482   with managing conflict parent-child relationships between depressed parents and their children. This may have

483   potential to break the intergenerational transmission of risk. Parenting interventions involving fathers have been

484   found to lessen behavioural problems in children mainly due to the change in fathers' parenting (Wilson *et al.*,

485   2014), therefore involving depressed fathers in such interventions maybe beneficial. Like maternal depression,

486   studies have shown paternal depression to have a cost on public health care services (Edoka *et al.*, 2011), but

487   intervention programs are still primarily targeted at mothers (Panter-Brick *et al.*, 2014). In light of our findings

488   we would encourage more research with fathers and involvement of fathers in parenting programs of depressed

489   parents.

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517   **Contribution of each author statement:**

518   **Dr Selina Nath**: Conception and design, data analysis, interpretation of data, write-up of article, revising it

519   critically for important intellectual content and final approval of the version to be published.

520   **Dr Ginny Russell**: Conception and design, provided guidance with data analysis, interpretation of data and

521   analysis, revising it critically for important intellectual content and final approval of the version to be published.

522   **Prof Willem Kuyken**: Interpretation of data and analysis, revising it critically for important intellectual content

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