Reciprocal Influence of Depressive Symptoms Between Mothers and Fathers During the First Postpartum Year: A Comparison Among Full-Term, Very Low, and Extremely Low Birth Weight Infants

1 Reciprocal influence of depressive symptoms between mothers and
2 fathers during the first postpartum year: a comparison among full-
3 term, very low and extremely low birth weight infants

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12 **Abstract**

13 **Background:** Perinatal depression (PND) in mothers and fathers of very low and extremely low birth
14 weight (VLBW and ELBW) infants has not been studied extensively. In particular, no studies
15 investigated the reciprocal influence of depressive symptoms during the first 12 months postpartum.
16 This study aimed at exploring the impact of the severity of prematurity on maternal and paternal
17 PND during the first postpartum year; specifically, we used an Actor–Partner Interdependence Model
18 (APIM) to test the interdependence of both partners on depressive symptoms.

19 **Methods:** 177 mothers and 177 fathers were recruited, divided in 38 couples with ELBW infants, 56
20 with VLBW and 83 of Full-Term (FT) infants. PND was evaluated by the Edinburgh Postnatal
21 Depression Scale (EPDS) at 3, 9 and 12 months postpartum (corrected age for preterm infants).

22 **Results:** Maternal depressive symptoms at 3 months were positively related to those at 9 and 12
23 months, in the 3 groups. Conversely, paternal depressive symptoms assessed at 3 months were
24 positively related to those measured at: 9 months for ELBW group, 12 months for VLBW group, 9
25 and at 12 months for FT condition. Furthermore, a significantly positive partner effect was observed,
26 regarding the influence of 3 month-maternal depressive symptoms on paternal depressive symptoms
27 at 9 months, but only in the case of VLBW group.

28 **Conclusion:** Prematurity represents a very specific scenario in the transition to parenthood, leading
29 to specific reactions in mothers and fathers, especially in high-risk condition. Results should be
30 deepened given the relevance of their clinical implications.
31

1   Introduction

Perinatal depression (PND) is a serious mental disorder, characterized by onset during pregnancy and/or within a year after childbirth (Patel et al., 2012) and symptoms like mood lability, insomnia, disorganized behaviour, irritability and agitation (Monzon et al., 2014). The risk of PND is widely recognized in mothers, with an overall prevalence of about 17% (Gavin et al., 2005; Hahn-Holbrook et al., 2018; Shorey et al., 2018), but recent literature observed a relevant prevalence also in fathers, which estimated rate is about 10% (Paulson and Bazemore, 2010; Cameron et al., 2016).

The prevalence of PND could be particularly significant in high-risk contexts, such as in the situation of a preterm birth.

Prematurity, the condition of all births occurring before the 37th week of pregnancy (World Health Organization, 2012), represents an unexpected and stressful event for the parents, who might experience feelings of guilt, grief and recurrent worries about their baby's survival and health (Miles et al., 2007; Mehler et al., 2011; Shah et al., 2011; Gray et al., 2012; Lasiuk et al., 2013; Helle et al., 2015; Pace et al., 2016; Pisoni et al., 2019). The stress experienced can reach such a high intensity to represent a traumatic experience, in some cases satisfying the criteria to diagnose a post-traumatic stress disorder (Pierrehumbert et al., 2003; Kersting et al., 2004; O'Donovan and Nixon, 2019).

Both preterm infants' mothers and fathers may also experience high levels of depressive symptoms that could persist (Miles et al., 2007; Vigod et al., 2010; Pace et al., 2016). Indeed, recent studies found a range of prevalence of PND in preterm babies' mothers of 15-27% in the first 3 months (Agostini et al., 2014; Helle et al., 2015; Neri et al., 2015; Pisoni et al., 2019), and of 14-21% at 9 and 12 postpartum months (Miles et al., 2007; Cheng et al., 2016; Quist et al., 2019), confirming that maternal PND after a preterm birth may be significantly more frequent compared to mothers of full-term (FT) infants (Vigod et al., 2010; Neri et al., 2015). Recently, an increased interest has been paid also to PND in preterm babies' fathers: nevertheless, to our knowledge, studies are sparse and investigated depressive symptomatology only at 3 months postpartum, reporting 0-6% as a range of prevalence (Mehler et al., 2014; Helle et al., 2015).

The risk of PND may be intensified when prematurity is more severe (Vigod et al., 2010; Barkmann et al., 2018). Nevertheless, studies usually focus on Low Birth Weight-LBW and Very Low Birth Weight-VLBW babies (birth weight <2500 and 1500 grams, respectively) (Treyvaud, 2014; Helle et al., 2015), neglecting the investigation of a more severe preterm birth condition represented by the Extremely Low Birth Weight-ELBW (<1000 grams). This population may increase the occurrence for maternal PND, as shown by previous studies (Agostini et al., 2014; Neri et al., 2015), where a greater risk for PND emerged in ELBW mothers rather than in VLBW ones. Conversely, to our knowledge, no studies have explored paternal PND in the case of ELBW infants.

Another relevant issue in the evaluation of PND in parents of preterm infants regards the possible association between maternal and paternal depression. To our knowledge, studies often have focused separately on mothers or fathers, while the reciprocal influence between partners on depressive symptoms has been neglected. Conversely, the association between maternal and paternal PND has been deeply investigated in parents of healthy full-term infants, but giving somewhat inconsistent findings. Indeed, while many researchers found an association between maternal and paternal PND (Ramchandani et al., 2005; Anding et al., 2016; Narayanan and Naerde, 2016; Vismara et al., 2016; Canario and Figueredo, 2017; Kiviruusu et al., 2020), others observed a predictive role of only maternal (Kerstis et al., 2013; Nishimura et al., 2015; Xu et al., 2016; Da Costa et al., 2019;

75 Fredriksen et al., 2019) or paternal PND on partner's symptomatology (Matthey et al., 2000; Paulson
76 et al., 2016); again, other studies did not find any significant associations (Wynter et al., 2013;
77 Ayinde and Lasebikan, 2017; Ierardi et al., 2019). One reason for the inconsistency of these results
78 may be represented by the heterogeneity of the methodology. In particular, many different statistical
79 analyses have been used in the studies; quite often the statistical methods do not seem appropriate for
80 assessing the interdependence, and the direction of the relations found between members of dyads
81 (i.e. correlational analysis, MANOVA or Linear Regression). In this context, a promising statistical
82 approach could be represented by the Actor-Partner Interdependence Model (APIM; Cook & Kenny,
83 2005; Kenny et al., 2006). Using Structural Equation Modelling, APIM treats data from both dyad
84 members as nested scores within the same group (i.e., the parental couple), providing both the extent
85 to which one partner's independent variable score influences his/her dependent variables score (actor
86 effect) as well as the other partner's dependent variables score (partner effect). Although different
87 methodological and data-analytic approaches are useful in the study of dyads (i.e. Multiple
88 Regression, Multilevel Modelling), Structural Equation Modelling is one of the most widely used
89 data-analytic techniques in social and behavioural sciences. To our knowledge, no study assessed the
90 reciprocal influence of perinatal depressive symptoms between mothers and fathers using these
91 statistical models.

92 Another methodological issue regards the research design. Indeed, many studies on PND usually
93 have a cross-sectional design, assessing mothers and fathers in one step: to our knowledge, only few
94 studies investigated the evolution or the trajectories of maternal and paternal PND until 6 or 12
95 months postpartum (Escriba-Aguir and Artazcos, 2011; Paulson et al., 2016; Ayinde and Lasebikan,
96 2017; Da Costa et al., 2019; Fredriksen et al., 2019; Narayanan and Naerde, 2019; Volling et al.,
97 2019). This lack is particularly evident in literature on preterm parents, where only two studies
98 investigated parental PND longitudinally (Meheler et al., 2014; Pace et al., 2016).

99   Given that the perinatal period ranges from conception to the end of the first postnatal year, reflecting
100 the interval for the arrival of the baby and parental adjustment, the parental affective state should be
101 assessed in a longitudinal perspective.

102 For the above-mentioned reasons, there is a need of developing more research comparing maternal
103 and paternal PND, assessing both the influence of severity of prematurity and longitudinal effects.

104 Therefore, this study aimed at investigating the impact of severity of preterm birth on maternal and
105 paternal depressive symptoms at 3, 9, and 12 months of infant's age (corrected for preterm infants).
106 We hypothesized to find more intense symptoms of PND in the case of a more severe premature birth
107 (ELBW), compared to VLBW and FT conditions, especially in mothers (than fathers) and in the first
108 months postpartum. Also, we aimed at exploring whether the symptoms of PND of each partner at 3
109 months were associated to own and partner's symptoms at 9 and 12 months; specifically, we aimed
110 to measure interdependence within ELBW, VLBW and FT mothers and fathers applying an APIM
111 model.

112 We chose to observe parental PND at the specific time points of 3 and 9 months, considered two
113 milestones for infant development and, as consequence, important moments for parental adjustment;
114 furthermore, we added the assessment of parental PND at 12 months, in order to evaluate parental
115 PND through all the perinatal period.

116

117 **2   Methods**

2.1 Participants and procedure

The study participants were 354 parents (177 couples). Eighty-three couples were parents of full-term infants, with a birth weight >2500 g and gestational age >36 weeks (FT group); the remaining 94 were parents of preterm infants. According to infant birth weight, they were differentiated in 56 couples with VLBW infants (weight between 1000 and 1500 g) and 38 couples with ELBW infants (weight <1000 g).

ELBW and VLBW groups were recruited at Neonatal Intensive Care Unit (NICU) of Bufalini Hospital (Cesena, Italy), while FT group was recruited at the antenatal classes held at Health Services in the same town. Exclusion criteria were: previous or present psychiatric illness, lack of fluency in Italian, severe neonatal pathologies.

All the assessments took place in Cesena at "Anna Martini" Laboratory (Department of Psychology, University of Bologna) at 3, 9 and 12 months postpartum (T1, T2 and T3, respectively) (corrected age for preterm infants). After providing the written informed consent, all parents fulfilled an *ad hoc* questionnaire (regarding socio-demographic and infant variables) and a self-report questionnaire for the assessment of depressive symptoms. The study was approved by the Ethical Committee of the Department of Psychology (University of Bologna).

2.2 Measures

The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) is the most widely used instrument for the assessment of perinatal depressive symptomatology. It is a self-report questionnaire, composed of 10 items, exploring the presence of depressive symptoms during the previous 7 days. The EPDS was developed for use by postnatal women (Cox et al., 1987) and has been implemented in international research for the detection of perinatal depressive symptoms (i.e., Evans et al., 2001; Bowen et al., 2012). Up to now, the EPDS has been translated into more than 60 languages (Cox, 2019). The questionnaire has been subsequently validated for the detection of perinatal depression in men (i.e., Matthey et al., 2001; Ramchandani et al., 2005; Escriba-Aguir and Artazcoz, 2011).

As recently underlined by the main author (Cox, 2019), the EPDS deliberately does not assess a number of common depressive symptoms that are also common features of typical perinatal adjustment; this increases the possibility of detecting individuals who truly exhibit a depressive state across the perinatal period. The EPDS also includes some indicators of anxiety and omits somatic symptoms of typical depression. For this reason, studies of the factor structure have identified at least two factors, one represented by a "depressive core" and the other focused on "anxiety" (Matthey, 2008; Matthey et al., 2013).

All the items are scored from 0 to 3, providing a total score ranging from 0 to 30, allowing for derivation of both continuous scores (a high score indicates the probable presence of depressive symptoms) and/or dichotomous scores (referring to a cut-off value which enables identification of individuals with depressive symptoms of clinical relevance). In this latter case, for the Italian version of EPDS, Italian validation studies suggested an optimal cut-off of 9/10 for women (Benvenuti et al., 1999) and 12/13 for men (Loscalzo et al., 2015). The version for men has been more recognized as a reliable and valid measure for the detection of distress, rather than proper depression, supporting the findings by previous international studies (Matthey et al., 2001; Massoudi et al., 2013). This state of

160　distress would be mainly characterized by unhappiness and anxiety and less by the most common
161　depressive symptomatology.

162

163　**2.3　Data Analysis**

164　Firstly, according to our first aim, Repeated Measures ANOVA was run to compare the level parental
165　PND according to the birth weight (ELBW, VLBW vs FT), parental gender (mothers vs fathers), and
166　time of assessment (3, 9, and 12 months of age). Moreover, the frequencies of depressed parents
167　among ELBW, VLBW and FT groups at the 3 times of assessment were investigated by Chi-square
168　analysis.

169　Secondly, preliminary analyses were carried out to justify the need for further investigation of the
170　relation between maternal and paternal depressive symptomatology via dyadic data analysis. One
171　fundamental principle with dyadic data is that members of a dyad cannot be considered completely
172　independent one from the other because they share and/or develop similarities in some of their
173　psychological attributes (Kenny et al., 2006). Specifically, correlation analyses between the
174　depression levels in mothers and fathers at T1, T2 and T3 were conducted.

175　To account for the interdependence of dyadic data, we tested two Actor-Partner Interdependence
176　models (APIM). APIM analyses were carried out for exploring, separately for each infant birth
177　weight group, the relation between one parent's levels of depressive symptoms at T1 on his/her own
178　levels of depressive symptoms at T2 and at T3 respectively (that is, actor effect), as well as on the
179　other partner's levels of depressive symptoms at T2 and at T3 respectively (that is, partner effect).

180　APIMs were estimated using path analysis (Maximum Likelihood estimation method) that is a
181　special case of Structural Equation Models without latent variables. All the analyses were performed
182　using Lavaan software (Rosseel, 2012; Stas et al., 2018). In order to test empirically the
183　distinguishability of dyad members by parental gender, an omnibus test of distinguishability has been
184　done for both T1->T2 model and T1->T3 model. The coefficients have been tested using Z tests. The
185　APIM test consists of a two-step approach. In the first step, the saturated APIM model looks for
186　significant actor and partner effects. In the second step, the saturated APIM with K parameters (ratio
187　of the partner to actor effect) is computed separately for each parent of the dyad to provide
188　information about the type of dyadic pattern that characterize the effects reported in the model
189　(Kenny and Ledermann, 2010). Step 2 was not performed if the absolute standardized values of the
190　actor effects were less than 0.10; indeed, weak actor effects combined with strong partner effects
191　would suggest the presence of a partner-only pattern (Fitzpatrick et al., 2016). The regular
192　bootstrapping method was used to calculate confidence intervals of k values. Cases with missing data
193　were handled using Full Information Maximum Likelihood estimation (Enders and Bandalos, 2001).
194　Because the standard APIM is a saturated model, it is just-identified and therefore has only one
195　unique solution. A just-identified model has trivially perfect fit; therefore, information about model
196　fit (e.g., RMSEA, CFI, etc.) is uninformative for the standard APIM and is not reported (Kenny,
197　2012). Instead, model evaluation is based on the magnitude and significance of the path estimates.

198

199　**3　Results**

200　**3.1　Descriptive Characteristics**

201 Descriptive analyses showed an overall homogeneity among the 3 birth weight groups, except for
202 parity and maternal education variables (Table 1): VLBW mothers were primiparous in a lower
203 percentage, compared to FT and ELBW ones; also, ELBW mothers showed a lower educational level
204 compared to VLBW and FT mothers. To evaluate the effect of parental educational level, marital
205 status, parental age and parity on EPDS scores, a series of Repeated Measures Analysis of Variance
206 was performed considering time of assessment (3, 9 and 12 months) as a within-subjects factor, birth
207 weight (ELBW, VLBW and FT groups), parental gender and specific confounder variables (parental
208 educational level, marital status, parental age and parity) as between-subjects factors. The results
209 showed a non-significant interaction effect for educational level ($F_{(4,620)}$=.89; p=.47), for parental age
210 ($F_{(6,626)}$=1.22; p=.30) and for parity ($F_{(4,628)}$=.77; p=0.54). A significant interaction effect was found
211 considering the variable marital status in the model ($F_{(4,622)}$=2.55; p=.04); to better evaluate the
212 marital status effect on EPDS scores, a separate Repeated Measures ANOVA was performed for each
213 birth weight group. Results showed a significant effect of marital status by parental gender by time of
214 assessment for the FT group ($F_{(2,153)}$=3.12; p=.04), while no significant interaction effect was found
215 for the ELBW group ($F_{(2,63)}$=.92; p=.40) nor for the VLBW group ($F_{(2,93)}$=2.75; p=.07). Taking into
216 account these results, we included the marital status as a confounder variable in the APIM models
217 only for FT group, and, following the parsimony principle, the variable was not included in the
218 APIM models for ELBW and VLBW groups.

219 Moreover, significant differences among groups emerged for the variables strictly linked to the
220 condition of preterm birth, as expected: birth weight, gestational age, type of delivery and twinning
221 (Table 1).

222

223 **3.2   Depressive symptoms according to severity of birth weight, time of assessment and**
224 **parental gender**

225 Repeated Measures ANOVA showed a significant effect of the interaction between birth weight and
226 time of assessment ($F_{(4,646)}$=3.43, p=.01): specifically, ELBW parents showed the highest EPDS score
227 at T1 with a considerable decrease of depressive symptoms at T2 and T3. Conversely, despite EPDS
228 mean scores of VLBW and FT groups are lower at 9 and 12 months than those at 3 months, this
229 decrease is slight and less evident than that shown by ELBW (Table 2).

230 No significant effects were found when we considered the interaction among birth weight, time of
231 assessment and parental gender ($F_{(4,646)}$=1.09, p=.36).

232 When we considered the categorical scores of EPDS (depressed vs. non-depressed), a significantly
233 higher frequency of depressed parents emerged at T1 in the ELBW group compared to those of
234 VLBW and FT groups (χ^2=14.01, p=.01) (Table 2). This result emerged also when analyses were run
235 separately for mothers (χ^2=9.40, p=.01) and fathers (χ^2=7.43, p=.02) (Table 2).

236 No significant differences emerged among the 3 birth weight groups at T2 and T3 (Table 2), neither
237 in the total sample, nor in mothers' and fathers' separate samples.

238

239 **3.3   Reciprocal influence of depressive symptoms between mothers and fathers**

240   Most of the correlations among maternal and paternal EPDS at T1, T2 and T3 were significant, for
241   each birth weight group (Table 3). Overall, a high correspondence emerged between mothers' and
242   fathers' EPDS scores measured at the same time of assessment. Moreover, mothers' and fathers'
243   depression levels were correlated with their own as well as their partner' depression among the
244   different times of assessment. Results indicated that actor effect, both for mothers and fathers, as well
245   as partner effect, could be estimated.

246   An omnibus test of distinguishability has been done for both T1->T2 model and T1->T3 model to
247   test empirically the distinguishable of dyad members by parental gender. The results of the omnibus
248   test of distinguishability suggest that in our sample the members of the dyad can be considered
249   statistically distinguishable (T1-T2: $Chi^2(6)$=20.54; p=.01; T1-T3: $Chi^2(6)$=20.54; p=.01). Therefore,
250   in this study, we conclude that dyad members were distinguishable based on the variable gender.

251   The results of APIM models based on the different birth weight groups are shown in Figure 1, 2 and
252   3. Model 1 and 2 represent, respectively, the evaluation of actor-partner effects estimated on
253   depressive symptoms measured from T1 to T2 (Model 1:T1D->T2D) and those from T1 to T3
254   (Model 2:T1D->T3D).

255

256   3.3.1   ELBW group

257   *Model 1*

258   A significant actor effect was found for both mothers (b=.45, p=.02) and fathers (b=.54, p=.01). No
259   significant partner effect was found from fathers to mothers (b=.14, p=.35) nor from mothers to
260   fathers (b=.12, p=.39). The k values interpretation suggests that for both mothers (k=.32, 95% CI [-
261   .27; 3.86]) and fathers (k=.22, 95% CI [-.16; .81]) an actor-only model is plausible (Figure 1A).

262   *Model 2*

263   A significant actor effect was found for mothers (b=.29, p=.02), but not for fathers (b=.17, p=.34).
264   No significant partner effect was found from fathers to mothers (b=.03, p=.86) nor from mothers to
265   fathers (b=.06, p=.68). Interpretation of k values suggests an actor-only model both for mothers
266   (k=.09, 95% CI [-2.94; .88]) and fathers (k=.38, km=95% CI [-.69; 4.38]) (Figure 1B).

267   3.3.2   VLBW group

268   *Model 1*

269   A significant actor effect was found for mothers (b=.66, p=.01), but not for fathers (b=-.03, p=.78). A
270   significant partner effect resulted both for fathers towards mothers (b=-.21, p=.03) as well as for
271   mothers towards fathers (b=.19, p=.01), meaning that fathers as well as mothers, having a highly
272   depressed partner at T1, reported themselves a higher level of depressive symptoms at T2. However,
273   the k values interpretation suggests an actor-only model (k=0) for mothers: the k value for mothers
274   was equal to -.31 with a 95% confidence interval ranging from -.53 to .13. Therefore, K parameter
275   for fathers to mothers partner effect was not performed, because the absolute standardized value of
276   the actor effects for fathers was less than 0.10 (Beta=-.03), suggesting a partner-only pattern effect
277   (Fitzpatrick et al., 2016).

278   *Model 2*

279   A significant actor effect emerged for both mothers (b=.57, p=.01) and fathers (b=.39, p=.01). No
280   significant partner effect was found from fathers to mothers (b=-.04, p=.73) nor from mothers to
281   fathers (b=.12, p=.17). The k values interpretation suggests that for both mothers and fathers an
282   actor-only model is plausible (k=-.07, 95% CI [-.42; .8]; k=.30, 95% CI [-.27; .65], respectively),
283   (Figure 2B).

284

285   **3.3.3   FT group**

286   Based on the results performed to analyze the impact of possible confounder variables, the marital
287   status has been added at the two subsequent APIM models as between-dyad covariate.

288   *Model 1*

289   Results showed a significant actor effect for both mothers (b=.51, p=.01) and fathers (b=.62, p=.01).
290   No significant partner effect was found from fathers to mothers (b=-.005, p=.97) nor from mothers to
291   fathers (b=.07, p=.50). The k values interpretation suggests that for both parents an actor-only model
292   is plausible (k=-0.01, 95% CI [-.36; .70]; k=.11, 95% CI [-.19; .83], respectively). Marital status did
293   not significantly influence EPDS score for mothers (b=.57, p=.32), nor for fathers (b=-.70, p=.20),
294   (Figure 3A).

295   *Model 2*

296   A significant actor effect has been found for both mothers (b=.38, p=.01) and fathers (b=.64, p=.01).
297   No significant partner effect was found from fathers to mothers (b=.03, p=.74) nor from mothers to
298   fathers (b=-.11, p=.27). Interpretation of k values suggests an actor-only model for both mothers and
299   fathers (k=.06, 95% CI [-.31; .60]; k=-.17, 95% CI [-.38; .13], respectively). The covariate did not
300   significantly influence the EPDS score for mothers (b=.42, p=.41), nor for fathers (b=-.55, p=.30),
301   (Figure 3B).

302

303   **4   Discussion**

304   This study aimed to explore the impact of the severity of prematurity on parental PND during the
305   first year after childbirth. One strength of this study was the focus on both mothers and fathers and,
306   specifically, on the reciprocal influence of depressive symptoms between partners in a high-risk
307   context represented by the parental adjustment after a preterm birth. To our knowledge, no previous
308   studies have investigated this topic.

309   First, we compared depressive symptoms in ELBW, VLBW and FT parents during the first year
310   postpartum. Prematurity is widely recognized as a relevant risk factor for parental PND (Miles et al.,
311   2007; Vigod et al., 2010; Pace et al., 2016) and our study confirmed significantly higher levels of
312   postnatal depressive symptoms in the first months, but only for parents of more severe preterm babies
313   (ELBW). In the other preterm group, VLBW, parents showed low and stable levels of depressive
314   symptoms from 3 to 12 months, similar to FT parents. This result stresses the relevance to distinguish
315   among different preterm populations in research and clinical intervention. Indeed, parents' mental

316 state may be especially impaired in case of higher severity of prematurity, and this is supported by
317 our previous studies (Agostini et al., 2014; Neri et al., 2015, 2020). For ELBW parents, the first
318 postpartum trimester can represent a highly vulnerable period due to baby's health issues and the
319 parental adjustment after discharge from NICU and these factors do play a key role in increasing the
320 risk for PND (Pignon, 2017; Grunberg et al., 2019).

321 An unexpected result concerns the similarity between mothers and fathers regarding both levels and
322 frequency of PND in all birth weight groups, according to the time of assessment. While previous
323 literature has widely underlined a higher level of depression and a higher prevalence, in the perinatal
324 period, of depressed mothers compared to fathers (Matthey et al., 2000; Vismara et al., 2016;
325 Chhabra et al., 2020), we did not find significant differences. This result may suggest that the
326 parental adjustment after a preterm birth similarly characterizes both parents, as fathers also may be
327 more actively engaged (Provenzi et al., 2016; Stefana and Lavelli, 2017), reducing gender
328 differences.

329

330 The second aim of the study was to fit an APIM to investigate, for each birth weight group, whether
331 and how the level of depression at 3 months of each partner was associated to own level of
332 depressive symptoms (that is, actor effect) and to the partner's levels of depressive symptoms (that is,
333 partner effect) at 9 and at 12 months postpartum.

334 According to actor effects, we found a significant association between mothers' depressive
335 symptoms at 3 months postpartum and those experienced at both 9 and 12 months: this result
336 emerged for every birth weight group, that is mothers of preterm and full-term infants, suggesting
337 that the first postpartum months play a crucial role for the depressive risk during the subsequent
338 months. When fathers were considered, actor effects on outcomes at both 9 months and 12 months
339 were observed only for the FT group. Taken together, these results could open up the possibility of
340 identifying sub-groups of mothers and fathers with a higher risk of chronicity since the first
341 postpartum trimester, in line with recent literature (Baron et al., 2017; Santos et al., 2017; Barkmann
342 et al., 2018), enhancing the possibility to promptly implement screening programs as well as
343 therapeutic support for parents. These actions would decrease the risk of negative consequences of
344 chronic depression on infant's physical and mental health.

345 Conversely, for preterm fathers, significant actor effects were found only for the association between
346 scores at 3 and 9 months, in case of ELBW infants, and between 3 to 12 months for VLBW group.
347 These findings suggest some considerations. In the case of ELBW group, it may be possible that the
348 severity of the condition makes fathers more vulnerable to depressive symptomatology also at 9
349 months, especially in case of PND during the first months. Conversely, no significant associations
350 were observed at 12 months, a time point usually characterized by infant's achievement of new
351 important skills (i.e. deambulation and/or first words), allowing him/her to be more autonomous. It
352 may be possible that, due to a change in fathers' representation of their infant, from a "fragile" baby
353 hospitalized in the NICU to a more healthy and competent infant, fathers may feel reassured and
354 more comfortable in their parenting role, with a positive effect on their affective state.

355 Regarding the case of VLBW group, the actor effect that we observed in VLBW fathers represents a
356 quite unexpected result. While the association between PND scores at 3 and 12 months would
357 suggest a long-term effect of early symptomatology, the absence of a significant effect at 9 months
358 undermines the plausibility of this explanation. Taken together, these results showed an unclear

359 profile of PND in VLBW fathers, suggesting that also other variables could influence paternal EPDS
360 scores both at 9 and 12 months. Given the lack of studies on PND in preterm infants' fathers, we
361 recommend to develop further studies to deeply explore the effect of risk factor in the maintaining
362 stable, improving or worsening of PND in these fathers.

363 When partner effects were considered, a significant association emerged in VLBW group, where
364 paternal PND at 9 months was significantly influenced by maternal depression at 3 months (partner
365 effect). Some studies have underlined how the prolonged hospitalization of the baby, and quite often
366 of the mother, may weigh on fathers, especially in the case of VLBW, because of the active role is
367 expected from them in supporting the partner and taking care of the baby (Provenzi et al., 2016;
368 Stefana and Lavelli, 2017). In this context, having a depressed partner could represent an additional
369 factor of pressure for fathers, leading to an increase in distress and depressive symptoms (Chhabra et
370 al., 2020).

371 In all other conditions no significant partner effect between maternal and paternal PND emerged. The
372 absence of partner effect in ELBW group may suggest that the higher severity of these infants may
373 represent a traumatic event, where both parents experience more frequently overwhelming negative
374 feelings. For this reason, parents might react by emotionally distancing themselves, and becoming
375 less sensitive to affective states of their partners, with a subsequent absence of significant partner
376 effect.

377 In our study, a similar reaction could be hypothesized for mothers of VLBW infants. The present
378 results may suggest that VLBW fathers have an active involvement in the care of their infant and
379 their partner, while mothers, as those of ELBW infants, are often more overwhelmed by feelings of
380 sadness, guilt, and failure, as already underlined by literature (Shah et al., 2011; Loomotey et al.,
381 2020), may be highly self-absorbed in their suffering and more detached from their partner.

382 Taken together, these results seem to confirm that ELBW and VLBW parents may differ in the way
383 they cope with the potentially traumatic experience of a preterm childbirth. Furthermore, even if we
384 did not find any influence of parents' gender, these results may suggest that mothers and fathers are
385 characterized by specific reactions and adaptations to their infant's level of prematurity.

386 Finally, it should be noted that also the results on FT parents showed no reciprocal influence between
387 mothers and fathers. Although we found significant correlations between maternal and paternal
388 EPDS scores, confirming previous literature (Ramchandani et al., 2005; Anding et al., 2016; Vismara
389 et al., 2016; Canario and Figueredo, 2017; Kiviruusu et al., 2020), the interdependence between
390 partners did not emerge anymore when we used a more appropriate statistical model (APIM).
391 Furthermore, it is to note that maternal and paternal PND were usually investigated using cross-
392 sectional research studies (Anding et al., 2016; Vismara et al., 2016; Canario and Figueredo, 2017),
393 while in this study the APIM was performed in a longitudinal design.

394 In summary, the results seem to suggest a specificity of maternal and paternal affective responses to
395 preterm birth, where the influence of a partner's symptomatology on the other's symptoms is only
396 partially present (Johansson et al., 2012; Molgora et al., 2017; Canzi et al., 2019).

397 Some limits of the study may be acknowledged. First, the results need to be confirmed on larger
398 samples, also considering a similar size among groups. Second, in the present study we assessed
399 PND through a self-report questionnaire (EPDS): given the limitations of this kind of measure, it may
400 be useful to replicate the study using a clinical interview, in order to diagnose the depressive
401 condition. We may add some more detailed considerations on the use of EPDS. The international

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402   literature on the psychometric characteristics of this instrument has underlined how, regarding the
403   fathers' population, the EPDS would show a different factor structure from the EPDS used on
404   mothers. In fact, as reported by previous studies (Matthey, 2008; Massoudi et al., 2013), the EPDS
405   for fathers seems more appropriate in detecting a general level of distress given by anxiety,
406   unhappiness and worry. In the Italian version for fathers by Loscalzo et al. (2015), this aspect has
407   been confirmed by a factorial structure characterized by a most prevalent factor, concerning items on
408   unhappiness and anxiety, and only a small portion of the variance explained by a "depressive core".
409   These characteristics of EPDS could possibly explain why, in our samples, we found very low
410   prevalence rates of clinically depressed fathers. As already put in evidence by Matthey & Agostini
411   (2017), all these findings support the evidence that: 1) probably this kind of general distress is a more
412   typical expression of emotional maladjustment in men in the first postpartum months, compared to
413   women; 2) considering that the EPDS is the same for both genders, it may be less suited for the
414   identification of perinatal depression in fathers; 3) there is the need to further analyze the
415   psychometric properties of the EPDS for men.

416   Taking into account these limitations on the use of EPDS, we underline also the fact that, up to now,
417   the EPDS is the only validated measure available for both mothers and fathers and specifically aimed
418   at detecting the perinatal depressive symptomatology; besides, using the same instrument for both
419   genders, we enable in this study the comparison between the two samples and the comparison with
420   all the massive international literature published on EPDS since 1987.

421   Another limitation of the study was that we evaluated parental PND longitudinally, but no specific
422   analyses were run to identify the trajectories of symptomatology, as suggested by recent literature
423   (Paulson et al., 2016; Fredriksen et al., 2019; Narayanan and Naerde, 2019; Volling et al., 2019).
424   Also, in our study we did not investigate anxious symptoms, which are known to occur often in
425   comorbidity with depression and may represent the difficulies in parental adjustment after a preterm
426   birth (Chabbra et al., 2020; Mutua et al., 2020).

427   Future studies are needed to confirm the results also controlling for the effect of other variables, such
428   as specific characteristics of parental couples (e.g. quality of dyadic relationship, social support),
429   which may interact with parental PND (Don et al., 2012; Rollè et al., 2017). Besides, it would be
430   relevant to study the possible implications of maternal and paternal PND on the quality of caregiving.

431   Globally, this study suggests that the preterm birth represents a very specific scenario in the transition
432   to parenthood, leading to possibly different affective reactions in mothers and fathers for what
433   concerns depressive symptomatology. Given the paucity of the research on the reciprocity between
434   maternal and paternal PND in prematurity, these results may shed new light on this field but would
435   benefit of a confirmation by further studies.

436

437 **AUTHOR CONTRIBUTIONS**
438 EN prepared the study design, organized the sample recruitment, collected data, and contributed to
439 the writing of all sections of the manuscript. SG and FG performed statistical analysis, prepared the
440 tables, and contributed to write the manuscript's methods, results and references sections. MB and
441 MS contributed to prepare the study design and supervised data collection and the research team. FA
442 prepared the study design, supervised all the phases of the research study and contributed to the
443 writing of all the sections of the manuscript.
444 All authors reviewed and approved the manuscript for publication.
445
446
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448

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673 Table 1. Parents and infant characteristics according to categories of birth weight.

	ELBW (n=38)	VLBW (n=56)	FT (n=83)	F/χ^2
Parental characteristics				
Maternal Age				2.95
Mean (SD) *in years*	34.54±5.15	35.14±5.47	33.07±4.87	
Paternal Age				2.00
Mean (SD) *in years*	36.95±5.11	37.49±5.75	35.68±5.25	
Maternal Education, n (%)				7.33*
Primary and Secondary school	9 (25%)	4 (7.3%)	8 (9.6%)	
High school and University	27 (75%)	51 (92.7%)	75 (90.4%)	
Paternal Education, n (%)				5.93
Primary and Secondary school	14 (38.9%)	9 (16.4%)	20 (24.4%)	
High school and University	22 (61.1%)	46 (83.6%)	62 (75.6%)	
Marital status, n (%)				.69
Married	20 (54.1%)	32 (57.1%)	50 (61.7%)	
Other	17 (45.9%)	24 (42.9%)	31 (38.3%)	
Parity, n (%)				17.24**
Primiparous	30 (78.9%)	33 (58.9%)	73 (89%)	
Multiparous	8 (21.1%)	23(41.1%)	9 (11%)	
Infant characteristics				
Gender, n (%)				3.34
Male	19 (50%)	36 (64.3%)	41 (49.4%)	
Female	19 (50%)	20 (35.7%)	42 (50.6%)	
Birth weight				1173.87**
Mean (SD) *in grams*	818.89±122.63	1305.50±145.22	3489.87±456.66	
Gestational age				987.24**
Mean (SD) *in weeks*	27.29±1.99	30.21±2.11	40.04±1.09	
Type of delivery, n (%)				40.46**
Spontaneous	10 (28.6%)	14 (26.4%)	63 (75.9%)	
Caesarean section	25 (71.4%)	39 (73.6%)	20 (24.1%)	
Twinning, n (%)				21.19**
Yes	4 (10.5%)	16 (28.6%)	2 (2.4%)	
No	34 (89.5%)	40 (71.4%)	81 (97.6%)	

674 * p≤.05

675 **p≤.01

676

677   Table 2. EPDS mean and categorical scores according to birth weight, time of assessment and parental gender

	BW x Time of Assessment			BW x Time of Assessment x Parental Gender						F	
				Mothers			Fathers				
										BW x Time of Assessment	BW x Time of Assessment x Parental Gender
	T1	T2	T3	T1	T2	T3	T1	T2	T3		
EPDS Mean scores[a]										3.43**	1.09
ELBW	6.64 ±.49	4.84 ±.44	3.87 ±.41	7.83 ±.70	5.71 ±.62	4.11 ±.58	5.46 ±.70	3.97 ±.62	3.63 ±.58		
VLBW	4.92 ±.42	4.10 ±.37	4.00 ±.35	5.66 ±.59	4.44 ±.52	4.32 ±.49	4.19 ±.60	3.75 ±.53	3.69 ±.50		
FT	4.94 ±.33	4.43 ±.29	3.92 ±.27	5.19 ±.45	4.76 ±.40	4.19 ±.38	4.70 ±.47	4.10 ±.41	3.65 ±.39		
EPDS > cut-off[b]										$\chi2$	
ELBW	20(26.3)	8(10.5)	5(6.6)	15(39.5)	6 (15.8)	5 (14.3)	5(13.2)	2 (5.3)	0 (0.0)	14.01**	/
VLBW	15(13.4)	6(5.4)	9(8.0)	10(17.9)	6 (11.8)	8 (14.5)	5(8.9)	0 (0.0)	1 (1.9)	1.38	/
FT	14(8.4)	12(7.2)	7(4.2)	13(15.7)	8 (9.6)	6 (7.2)	1(1.2)	4 (4.9)	1 (1.3)	1.98	/

678   Legend: BW= birth weight; T1=3 months; T2=9 months; T3=12 months.

679   [a] Values are mean±SD.

680   [b] Values are n (%).

681

682   * p≤.05
683   **p≤.01

684 Table 3. Pearson correlation analysis on EPDS scores at T1, T2 and T3 in mothers and fathers
685 according to birth weight
686

			Mothers			Fathers		
			EPDS T1	EPDS T2	EPDS T3	EPDS T1	EPDS T2	EPDS T3
ELWB		EPDS T1	1	.55**	.38*	.48**	.49**	.21
	Mothers	EPDS T2		1	.64**	.38*	.54**	.27
		EPDS T3			1	.20	.28	.55**
		EPDS T1				1	.77**	.30
	Fathers	EPDS T2					1	.33
		EPDS T3						1
VLWB		EPDS T1	1	.67**	.61**	.36**	.33*	.36**
	Mothers	EPDS T2		1	.84**	.05	.39**	.39**
		EPDS T3			1	.17	.44**	.44**
	Fathers	EPDS T1				1	.08	.57**
		EPDS T2					1	.47**
		EPDS T3						1
FT		EPDS T1	1	.56**	.46**	.33**	.25*	.12
	Mothers	EPDS T2		1	.61**	.18	.37**	.28*
		EPDS T3			1	.18	.29**	.31**
	Fathers	EPDS T1				1	.60**	.67**
		EPDS T2					1	.73**
		EPDS T3						1

687 * p≤.05
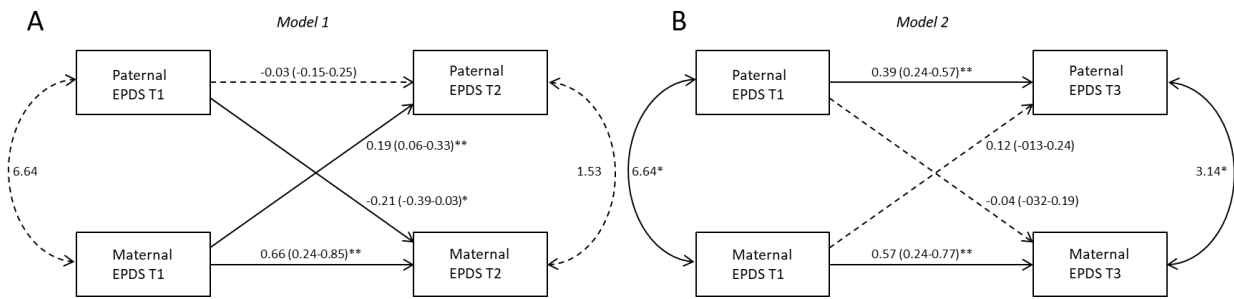
688 **p≤.01

689

690   Figure 1: Actor-partner interdependence models for depression in ELBW group.
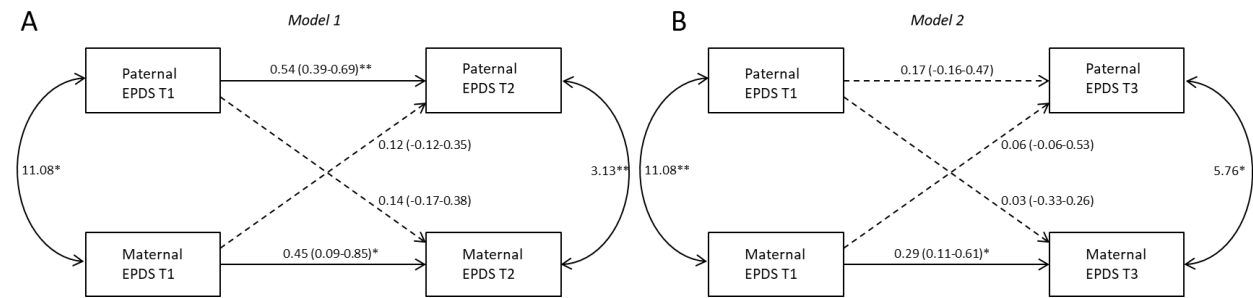
691

692   95% CI are reported in parentheses; *p≤.05; **p≤.01.

693   *Note*. (A) Model 1: T1D->T2D, (B) Model 2: T1D->T3D. Black lines represent significant paths,
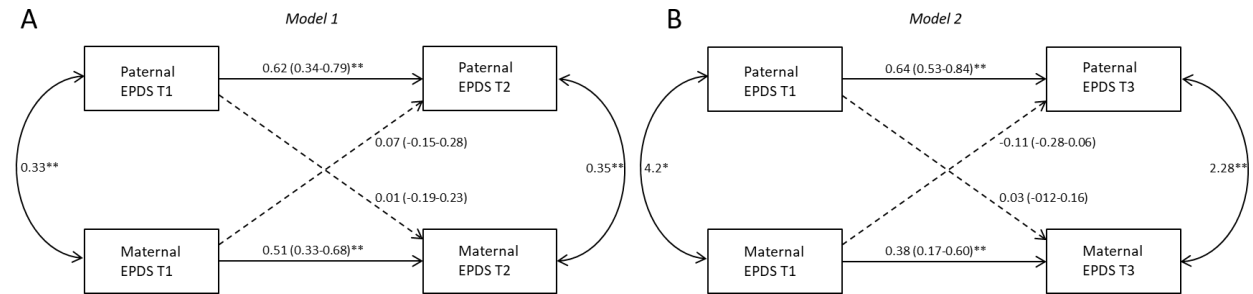694   dashed lines represent non-significant paths.

695

696   Figure 2: Actor-partner interdependence models for depression in VLBW group

697

698   95% CI are reported in parentheses; *p≤.05; **p≤.01.

699   *Note*. (A) Model 1: T1D->T2D, (B) Model 2: T1D->T3D. Black lines represent significant paths,
700   dashed lines represent non-significant paths.

701

702   Figure 3: Actor-partner interdependence models for depression in FT group

703

704

705   95% CI are reported in parentheses; *p≤.05; **p≤.01.

22

706   *Note*. (A) Model 1: T1D->T2D, (B) Model 2: T1D->T3D. Black lines represent significant paths,
707   dashed lines represent non-significant paths.