Predictors of Postpartum Depression in Partnered Mothers and Fathers from a Longitudinal Cohort

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Abstract

Postpartum depression (PPD) is a growing mental health concern in new mothers and fathers. The purpose of this study was to determine the predictors of depression at 3 months postpartum, comparing depressed couples to couples with only one depressed partner or no depressed partner, using data from the Alberta Pregnancy Outcomes and Nutrition study. Data from mothers and fathers were collected during the second trimester and at 3 months postpartum. Results showed predictors of PPD in mothers to be low household income, high prenatal depressive symptoms, and postnatally, low social support and higher number of stressful life events. Fathers had similar predictors, including low household income, high prenatal depressive symptoms, and postnatally low social support and smoking. Compared with non-depressed couples, factors that predicted PPD in *both* mothers and fathers in couples included low income, high prenatal depressive symptoms in mothers and low prenatal social support reported by fathers.

Keywords

Postpartum depression
Couples depression
Maternal
Paternal

Introduction

Postpartum depression (PPD) is a mental disorder characterized by depressed mood, loss of interest or pleasure in daily activities, and at least three other symptoms, including psychomotor agitation or retardation, insomnia or hypersomnia, reduced concentration and decisiveness, fatigue or loss of energy, suicidal ideation and mental confusion [American Psychiatric Association (APA) 2003]. While PPD is not actually a disorder recognized by the Diagnostic and Statistical Manual (5th Edition) (APA 2003), it may be diagnosed as major depressive disorder with postpartum onset. PPD symptoms must be experienced over a 2 week period and produce a noteworthy impact on daily functioning. The onset of PPD is typically during the first 12 weeks postpartum (Cooper and Murray 1998).

Affecting approximately 15% of new mothers (Gavin et al. 2005), the negative effects of PPD on women and their children’s development are well established

(Letourneau et al. 2012a, b; Murray and Cooper 1996). Increasingly, PPD is recognized to also affect fathers, either directly by experiencing it themselves, or indirectly in supporting and coping with their partner's symptoms (Paulson and Bazemore 2010). The greatest lifetime risk for depression for both women and men is the first year after their child's birth (Dave et al. 2010). Approximately 10% of fathers will experience depression in the first year postpartum (Paulson and Bazemore 2010). For both women and men, the rate of depression in the postpartum period is greater than the overall population rates. The American national average for depression in men is 6–7% according to the Centre for Disease Control [Centers for Disease Control Prevention (CDC) 2012] and for women is 6% according to Statistics Canada data (CDC 2012; Dave et al. 2010). It has been estimated that when mothers experience PPD, 24–50% of their partners (typically fathers) may also experience depression in the postpartum period (Goodman 2004). Unlike mothers, where onset of PPD is the most severe in the first 6 months postpartum (Vliegen et al. 2014), the course of depression in fathers is not yet well understood. Compared with mothers, some research has found that the highest incidence of depression in fathers is at 12 months postpartum (Areias et al. 1996; Matthey et al. 2000), while other studies have demonstrated a more similar pattern to mothers with the highest incidence in the first 6 months after the birth of their child (Ballard et al. 1994; Paulson and Bazemore 2010).

Well documented negative outcomes of mothers' PPD on children span across cognitive, emotional, social, and physical domains (Cornish et al. 2005; Grace et al. 2003; Murray et al. 1996; O'Hara 2009; Patel et al. 2003). Cognitive development including language and scores on intelligence tests are affected adversely by a mothers' PPD (Grace et al. 2003). Meta-analytic results correlated general children's psychopathy, internalizing and externalizing behavioral problems, and negative affect with exposure to mothers' PPD (Goodman et al. 2011). Children of mothers who experienced PPD also demonstrate less ability to handle stress and engage with peers (Kersten-Alvarez et al. 2012). As well, children of mothers who experienced PPD were more likely to have affective and anxiety disorders in early adolescence (Halligan et al. 2007). Less well documented are adverse child outcomes associated with depression in fathers. Fathers' prenatal depressive symptoms were predictive of their children's internalizing (e.g. anxiety, depression) and externalizing (e.g. aggression, hyperactivity) behavioral problems at 2–3 years of age (Paulson et al. 2009; Ramchandani et al. 2008). A population cohort study also found an association between fathers' PPD and psychiatric disorder

in their children 7 years later (Ramchandani et al. 2008), demonstrating the long lasting impact fathers' PPD can have on children. Only one study was identified that examined the association between PPD experienced by both mothers and fathers and children's development: PPD in both partners predicted more negative perceptions of child temperament at 3 months (Kerstis et al. 2013). In other research, mothers' depression and couple conflict mediated two-thirds of the overall association between fathers' depression and child outcomes at 3.5 and 7 years of age (Gutierrez-Galve et al. 2015), suggesting a need to understand predictors of both mothers' and fathers' depression.

For mothers, predictors of PPD include prenatal depression and anxiety, stressful life events during pregnancy, low self-esteem, childcare stress, lower family income, lower occupational status, marital relationship issues, low social support, past history of psychopathy and being overweight or obese (Beck 2001; Brugha et al. 1998; Goyal et al. 2010; LaCoursiere et al. 2006, 2010; Logsdon and Usui 2001; Matthey et al. 2000; O'Hara and Swain 1996; Seguin et al. 1999; Webster et al. 2000). The risk factors for fathers developing PPD symptoms are less well known, but have been linked with their partners' (mothers') depressive symptoms (Bielawska-Batorowicz and Kossakowska-Petrycka 2006; Deater-Deckard et al. 1998; Kim and Swain 2007; Matthey et al. 2000; Pinheiro et al. 2006; Wee et al. 2011). For example, a meta-analysis of 43 studies revealed that mothers' PPD symptoms were positively correlated ($r = .31$) with fathers' PPD symptoms (Paulson and Bazemore 2010). Other factors suspected of association with fathers' PPD include increasing societal expectations, demands and financial responsibilities (Kim and Swain 2007), a history of depression or experiencing depressive symptoms in the prenatal period (Bielawska-Batorowicz and Kossakowska-Petrycka 2006; Deater-Deckard et al. 1998; Kim and Swain 2007; Matthey et al. 2000; Pinheiro et al. 2006; Wee et al. 2011), and low marital or relationship satisfaction (Bielawska-Batorowicz and Kossakowska-Petrycka 2006; Cummings et al. 2005; Dudley et al. 2001). Marital quality is also a factor as men in stepfamilies and partners of single mothers have higher levels of depressive symptoms compared with men in traditional two-parent intact families (Deater-Deckard et al. 2014). Similar to mothers (O'Hara 2009), fathers' depressive symptoms are associated with lower education, more stressful life events, less social support, smaller social networks, more aggression within their partnerships and partners' depression (Deater-Deckard et al. 2014; Don and Mickelson 2012). In addition, similar to depression in the general population, other risk factors for fathers' depression

include behavioral activities such as drug use (Grant 1995), alcohol use (Regier et al. 1990), and smoking (Anda et al. 1990). Thus, to determine predictors of maternal and paternal PPD, these risk factors are important covariates to be considered in any analyses.

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Few studies have investigated the predictors of co-occurring depression in mothers and fathers (Kerstis et al. 2013), and to our knowledge none have examined partnered couples. In a systematic review of PPD in fathers, depressive symptoms in one partner led to an increase in symptoms in the other (Wee et al. 2011). This potential "couple comorbidity co-occurrence" of depression is yet to be understood, with more research needed to better define this phenomenon. Research focusing on the onset and joint course of depression in parents has also been suggested (Paulson and Bazemore 2010) as well as recommendations that more studies include both mothers and fathers to better understand the impact of PPD in a family (Goodman 2004).

The *purpose* of this study was to determine the predictors of postpartum depressive symptoms in couples categorized as: (1) couples where neither partner was depressed; (2) couples where only the mother was depressed; (3) couples where only the father was depressed; and (4) couples where both partners were depressed at 3 months postpartum. To this end, we addressed the following questions:

1. What are the characteristics of depressed mothers and fathers compared to non-depressed mothers and fathers? 2. What are the predictors of depressed mothers and fathers postpartum?
3. What are the predictors of depressed couples?

Methods

The data for the current study comes from the Alberta Pregnancy Outcomes and Nutrition (APrON) study. APrON is a longitudinal pregnancy cohort that recruited pregnant women, who were 16 years of age or older, at <27 weeks of gestation, and lived in the cities of Calgary or Edmonton, Alberta, Canada. While pregnant women were the initial recruits, their babies and partners (biological fathers of the babies) were also participants in the APrON study. Details about the cohort study (rationale and methods) have been published elsewhere (Kaplan et al. 2014).

The APrON study was approved by the Conjoint Health Research Ethics Board at the University of Calgary, and the Health Research Ethics Board at the University of Alberta. Mothers and fathers each provided consent forms.

Sample

At the end of recruitment in June 2010, the APrON study had enrolled 2189 mothers and 1417 fathers. For the purpose of this study, data from mother-father partnered pairs, including married and common-law biological parents were used. The number of partnered mothers and fathers available for study was 1043; however, only 846 couples had prenatal and postnatal depression data available for analysis. Of this 846, 78.5% (n = 664) were non-depressed couples, 9.5% (n = 80) were couples in which mothers were depressed and fathers were not, 9.8% (n = 83) were couples in which fathers were depressed and mothers were not, and 2.3% (n = 19) were couples in which both mothers and fathers were depressed.

Data Collection

The data collection process differed for mothers and fathers, as well as the number of questions asked in that mothers were asked more questions more frequently than fathers. The full list of the types of data collected (e.g. questionnaires and time-points) has been published elsewhere (Kaplan et al. 2014). Women were recruited in their first or second trimester, and follow-up data were collected in each remaining trimester, then at 3, 6, 12, 24, and 36 months postpartum. Fathers provided data once during the women's pregnancy and then again at 3 months postpartum. Completed forms and questionnaires by fathers were returned to the APrON study office by mail or brought in by the mother. For the purpose of this study, we used data on partnered mothers and fathers, from the first questionnaire obtained in either the first or second trimester, as well as the questionnaire obtained at 3 months postpartum.
The questionnaires for both mothers and fathers asked similar questions about socio-demographics, depressive symptoms using the Edinburgh Postpartum Depression Scale (EPDS) (Bergink et al. 2011; Cox et al. 1987; Edmondson et al. 2010; Matthey et al. 2001; Pop et al. 1992), life events using the Stressful Life Events Questionnaire (SLEQ) (Bergman et al. 2007), social support from Statistics Canada's Social Support Survey (Statistics Canada 2001) and questions regarding the use of alcohol, drugs and smoking, that were developed specifically for the APrON study. Sociodemographic questions pertained to

family income, education, age were also collected. The body mass index (BMI) was calculated using participants' self-reported pre-pregnancy height and weight [BMI weight = kg/height^2 (m)] and categories were then created for underweight (BMI < 18.5), normal (BMI ≥ 18.5 and BMI < 24.9) and overweight/obese (BMI ≥ 25.0) using international standards (Cole et al. 1995). The EPDS is a 10-item self-administered scale measuring depressive symptoms, and requires about 5 min to complete. For women, the EPDS has been found to have high sensitivity (83.6%) and specificity (88.3%) for identifying those at risk of, or potentially suffering from, either antenatal or PPD at a threshold score of 10 (Pop et al. 1992). The EPDS has a moderate to good reliability and test–retest reliability and has a good to moderate correlation with other depression measures (Boyd et al. 2005). For mothers, we used the widely accepted cut-off of EPDS ≥ 10, "at least probable minor depression" (Matthey et al. 2000). Using this cut-off provided a prevalence rate for depression in our study that was consistent with meta-analytic prevalence data (2003). For fathers, consensus is lacking on the best cut-off to use, with some suggesting that the cut-off should be the same (Edmondson et al. 2010) or lower (as low as 4) (Matthey et al. 2001, 2006) than for mothers. The cut-off of EPDS ≥ 10 has a sensitivity of 89.5% and a specificity of 78.2% (Murray and Cooper 1996); however in our study, we elected to use a cut-off for fathers (EPDS ≥ 9) just slightly lower than for mothers, to conservatively account for the variation in recommendations in the literature. Moreover, at this cut-off, the prevalence rate of fathers' depression was relatively consistent with meta-analytic prevalence data (Paulson and Bazemore 2010). For clarity, we use the terminology "depressed" for mothers who scored EPDS ≥ 10 and fathers with EPDS ≥ 9.

The SLEQ asked participants to indicate whether or not they experienced any of seven stressful life events including: (1) a close friend/family member had a serious accident/illness; (2) you were separated/divorced; (3) a close friend or relative died; (4) you had a serious argument with your partner; (5) your partner was emotionally cruel to you; (6) your partner was physically cruel to you; (7) you were sexually abused. Responses were "yes" or "no" with a total possible score of 7 and higher scores indicating more stressful life events. In addition to the number of events, perceptions of the impact of stressors were assessed by asking parents to indicate whether the event affected them "a little = 1" or "a lot = 2". Scores for each item response were summed to attain an overall perceived impact score (Bergman et al. 2007).

The Social Support questionnaire consisted of four questions addressing emotional, instrumental, informational and affirmational support respectively, including: (1) do you have someone you can confide in, or talk to, about your private feelings or concerns? (2) Do you have someone you can really count on to help you in a difficult situation? (3) Do you have someone you can really count on to give you good advice when you are making important personal decisions? (4) Do you have someone who makes you feel loved and cared for? (Galambos et al. 2004) Responses ranged from "none of the time" to "all of the time", and was coded on a Likert-type scale from 0 to 4. Cronbach's alpha for the measure has been evaluated at 0.8 (Galambos et al. 2004). It should be noted that when responding, mothers would likely be thinking of support provided by their environment, including the child's father as her closest companion, and similarly fathers would be thinking of support provided by their environment, including the child's mother.

Data Analysis

Descriptive statistics are reported using means (standard deviations) or median (interquartile ranges), as well as frequencies (e.g. proportions). To determine prevalence of depression within the mother-only depressed couples, father-only depressed couples, and dual depressed couples we calculated the frequency of each type of depressed couples as a ratio of the total number of couples.
We assessed for association using χ^2 tests with categorical variables, and Pearson's (or Spearman's for nonparametric data) correlations for continuous variables. Multivariate logistic regression was used to determine predictors of mothers' and fathers' symptoms of postpartum depressive (i.e. EPDS ≥ 10 and ≥ 9 respectively), controlling for covariates.
A multi-categorical variable was created to identify the state of the couple with respect to depressive symptoms according to the cut-offs, that is 0 = neither mother nor father at or above cut-offs for depressive symptoms ("non-depressed couple"), 1 = mother at or above cut-off and father below cut-off ("depressed mother, non-depressed father"), 2 = father at or above cut-off and mother below cut-off ("non-depressed mother, depressed father"), 3 = both father and mother at the above cut-off for depressive symptoms ("depressed couple"). In this case, the multinomial response variable led us to use the extension of logistic regression to accommodate the ordering of levels, the proportional odds model. To determine if this model was appropriate for multivariate analysis, we tested the assumption of the common slope for the

proportional odds model. The score test for the null hypothesis of constant slope, $\chi^2 = 69.5$, df = 20, p = 0.0001. Therefore, the null hypothesis of common slope is rejected, so the proportional odds assumption does not hold. Because we were unable to use the proportional odds model, we instead used the baseline category logit model (BCL) for nominal responses. This model pairs each response category with a baseline category, often the last one or the most common one to describe the effects of predictors that vary according to the response paired with the baseline.

To determine the predictors of couples' PPD symptoms, bivariate logistic regression models were fitted separately for each outcome of depression in mothers and fathers. To identify the predictors of each type of depressed couple we used a stepwise procedure to select covariates in the BCL model. The selection of variables proceeded as follows; first, unadjusted bivariate model was fitted for each predictor (separate for each outcome). Variables that were significant or close to significance (i.e. 0.06–0.09) were then entered into the full model. Non-significant variable were then removed from the full model to a reduced (final) model. All analyses employed a 0.05 level of significance (two-tailed). All statistical analyses were performed using STATA11 software.

Results

Maternal and Paternal Characteristics

Of the 1043 mother-father couples, the average age was 31.0 (SD 4.0) for women and 33.0 (SD 5.0) for men. A majority of couples (61.1%) had a household income >$100,000. More mothers than fathers had a university or higher education (76.0% compared to 60.9%, respectively). Almost two-thirds (63.9%) of the men had a BMI that was considered "overweight" or "obese" whereas 32% of the women were considered "overweight" or "obese". Fathers had higher rates of smoking and drug use compared with mothers. Alcohol use in mothers was 4.1% prenatally, and 50.9% postnatally. 15.2% of mothers had scores above the mothers' EPDS cut-off score (i.e. EPDS ≥ 10) *prenatally* and 14% of fathers scored above the fathers' EPDS cut-off score (i.e. EPDS ≥ 9). The proportion of mothers and fathers above their respective *postnatal* EPDS cut-off scores were approximately the same 11.8 and 12.1%, respectively. Twice as many fathers reported having ≥2 stressful life events prenatally compared with mothers (22.2 vs. 11.0% respectively), while both partners had similar social support scores in the prenatal and postpartum periods (Table 1).

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Table 1
Demographic, substance use, and mental health characteristics of mothers and fathers

	Mothers (n = 1043)	**Fathers (n = 1043)**
Demographic		
Age [Mean (±SD)]	31 (±4.0)	33.8 (±4.6)
Household income [n (%)]	n = 1031	n = 1031
$100,000/year or more	630 (61.1)	630 (61.1)
$70,000–99,999/year	230 (22.3)	230 (22.3)
$40,000–69,999/year	131 (12.7)	131 (12.7)
<$39,999/year	40 (3.9)	40 (3.9)
Education [n (%)]	n = 1035	n = 750
Post graduate	267 (25.8)	141 (18.8)
University	520 (50.2)	316 (42.1)
Trade, technical	170 (16.4)	201 (26.8)
High school or less	78 (7.5)	92 (12.3)
# Children born alive [n (%)]	n = 1020	
0	589 (57.8)	–
1	342 (33.5)	–
≥2	89 (8.7)	–
Born in Canada [n (%)]	n = 1041	n = 1025
Yes	822 (79.0)	795 (77.6)
No	219 (21.0)	230 (22.4)
Ethnicity [n (%)]	n = 1040	n = 357
Caucasian	867 (83.4)	272 (76.2)
Non-Caucasian	173 (16.6)	85 (23.8)
BMI [n (%)]	Pre-pregnancy (n = 956)	n = 1017
Underweight	31 (3.2)	11 (1.1)
Normal	624 (65.3)	356 (35.0)
Overweight/obese	301 (31.5)	650 (63.9)
Substance use		
Smoking [n (%)]		
Prenatal	n = 1027	n = 1012
Yes	10 (1.00)	85 (8.4)
No	1017 (99.0)	927 (92.6)
Postpartum	n = 949	n = 851

Table 1
Demographic, substance use, and mental health characteristics of mothers and fathers

	Mothers (n = 1043)	**Fathers (n = 1043)**
Yes	16 (1.7)	49 (5.8)
No	933 (98.3)	802 (94.2)
Alcohol [n (%)]		
Prenatal	n = 1024	n = 967
Yes	42 (4.10)	895 (92.6)
No	982 (95.9)	72 (7.4)
Postpartum	n = 949	n = 850
Yes	483 (50.9)	710 (83.5)
No	466 (49.1)	140 (16.5)
Drugs [n (%)]		
Prenatal	n = 1025	n = 988
Yes	2 (0.20)	89 (9.0)
No	1023 (99.8)	899 (90.9)
Postpartum	n = 949	n = 851
Yes	7 (0.70)	32 (3.8)
No	942 (99.3)	819 (96.2)
Mental health		
Stressful life events (mental health)		
Prenatal [n (%)]	n = 1037	n = 1017
0	677 (65.3)	537 (52.8)
1	246 (23.7)	254 (25.0)
≥2	114 (11.0)	226 (22.2)
Postnatal [n (%)]	n = 955	n = 848
0	662 (69.3)	564 (66.5)
1	208 (21.8)	183 (21.6)
≥2	85 (8.9)	101 (11.9)
Depressive symptoms [n (%)]	n = 1039	n = 1024
EPDS ≥ 10—prenatal	158 (15.2)	139 (13.6)
EPDS < 10—prenatal	881 (84.8)	885 (86.4)
	n = 963	n = 850
EPDS ≥ 10—postpartum	114 (11.8)	103 (12.1)
EPDS < 10—postpartum	849 (88.2)	747 (87.9)

Table 1
Demographic, substance use, and mental health characteristics of mothers and fathers

	Mothers (n = 1043)	**Fathers (n = 1043)**
Social support [mean (±SD)]		
Prenatal	n = 1039 14.6 (±2.4)	n = 1024 13.9 (±2.9)
Postpartum	n = 955 14.6 (±2.2)	n = 846 13.8 (±3.1)
Anxiety		
Prenatal	n = 804 5.98 (±4.4)	n = 793 1.88 (±3.1)
Postpartum	n = 806 1.77 (±2.7)	n = 588 1.9 (±3.3)
n's vary because of missing values for some variables		

Comparison of Depressed and Non-Depressed Mothers and Fathers

The cohort's characteristics were further compared by postpartum EPDS cut-off scores, i.e. mothers EPDS ≥ 10 vs. EPDS < 10 and fathers EPDS ≥ 9 vs. EPDs < 9 (Table 2). A higher proportion of women with EPDS ≥ 10 had lower household income, were overweight/obese, and had greater number of children, (all p's < 0.05). A higher proportion of men with EPDS ≥ 9 smoked ($p < 0.05$). In both mothers and fathers, individuals with postpartum EPDS above their respective cut-offs reported more stressful life events, lower social support, and higher mean anxiety scores during prenatal and postpartum periods, as well as higher prenatal EPDS mean scores (all p's < 0.05).

Table 2
Comparison of characteristics of mothers and fathers by postpartum EPDS cut-off scores

	Mothers		**Fathers**	
	EPDS < 10 (n = 849)	**EPDS ≥ 10 (n = 114)**	**EPDS < 9 (n = 747)**	**EPDS ≥ 9 (n = 103)**
Age [mean (±SD)]	31 (±4.0)	31.5 (±4.5)	33.8 (±4.6)	33.9 (±4.8)
Household income [n (%)]				
$100,000/year or more	531 (63.4)	56 (49.6)	531 (63.4)	56 (49.6)
$70,000–99,999/year	191 (22.9)	24 (21.2)	191 (22.9)	24 (21.2)
$40,000–69,999/year	91 (10.9)	26 (23.0)	91 (10.9)	26 (23.0)
<$39,999/year	25 (3.0)	7.0 (6.2)†	25 (3.0)	7.0 (6.2)†
Education [n (%)]				

Table 2
Comparison of characteristics of mothers and fathers by postpartum EPDS cut-off scores

	Mothers		**Fathers**	
	EPDS < 10 (n = 849)	**EPDS ≥ 10 (n = 114)**	**EPDS < 9 (n = 747)**	**EPDS ≥ 9 (n = 103)**
Post-graduate/	222 (26.3)	28 (24.8)	100 (18.9)	11 (13.8)
University	431 (51.1)	49 (43.4)	232 (43.9)	30 (37.5)
Trade/technical	134 (15.9)	28 (24.8)	133 (25.1)	25 (31.2)
High school/less than high school	56 (6.6)	8 (7.1)	64 (12.1)	14 (17.5)
Ethnicity [n (%)]				
Caucasian	720 (85.1)	94 (82.5)	194 (77.6)	29 (74.4)
Non-Caucasian	126 (14.9)	20 (17.5)	56 (22.4)	10 (25.6)
BMI [n (%)]				
Underweight	24 (3.1)	4 (3.9)	7 (0.96)	2 (2.00)
Normal	526 (67.2)	63 (60.5)	262 (35.9)	33 (33.3)
Overweight/obese	233 (29.7)	37 (35.6)	461 (63.2)	64 (64.7)
Born in Canada				
Yes	681 (80.4)	85 (74.6)	580 (79.2)	81 (79.4)
No	166 (19.6)	29 (25.4)	152 (20.8)	21 (20.6)
# Children born alive [n (%)]				
0	491 (58.5)	53 (47.3)	–	–
1	275 (32.8)	46 (41.1)	–	–
≥2	73 (8.7)	13 (11.6)†		
Smoking [n (%)]				
Prenatal	9 (1.1)	1 (0.9)	48 (6.6)	14 (14.1)†
Postpartum	14 (1.7)	2 (1.8)	39 (5.2)	10 (9.7)
Alcohol [n (%)]				
Prenatal	38 (4.7)	3 (2.7)	654 (93.8)	89 (92.7)
Postpartum	424 (50.7)	59 (52.7)	627 (84.1)	82 (79.6)
Drugs [n (%)]				
Prenatal	2 (0.24)	0 (0.00)	53 (7.46)	10 (10.10)
Postpartum	6 (0.72)	1 (0.89)	27 (3.61)	5 (4.85)
Stressful life events [n (%)]				
Number of events				
Prenatal				

Table 2
Comparison of characteristics of mothers and fathers by postpartum EPDS cut-off scores

	Mothers		Fathers	
	EPDS < 10 (n = 849)	**EPDS ≥ 10 (n = 114)**	**EPDS < 9 (n = 747)**	**EPDS ≥ 9 (n = 103)**
0	562 (66.6)	59 (51.7)	393 (54.2)	40 (39.2)
1	199 (23.6)	33 (29.0)	190 (26.2)	24 (23.5)
≥2	83 (9.8)	22 (19.3)†	142 (19.6)	38 (37.3)†
Postnatal				
0	601 (71.3)	61 (54.5)	514 (68.9)	50 (49.0)
1	175 (20.8)	33 (29.5)	159 (21.3)	24 (23.5)
≥2	67 (7.9)	18 (16.0)†	73 (9.8)	28 (27.5)†
Prenatal EPDS [mean (±SD)]	4.9 (±3.6)	8.8 (±4.4)†	3.9 (±3.0)	8.3 (±3.9)†
Social support				
Prenatal [mean (±SD)]	14.8 (±2.2)	13.6 (±2.8)†	14.1 (±2.7)	12.3 (±3.3)†
Postpartum [mean (±SD)]	14.8 (±2.0)	13.2 (±3.0)†	14.0 (±2.9)	11.3 (±4.0)†
Anxiety				
Prenatal [mean (±SD)]	5.7 (±4.3)	7.5 (±4.1)†	1.5 (±2.4)	4.5 (±4.8)†
Postpartum [mean (±SD)]	1.2 (±1.8)	6.0 (±4.3)†	1.25 (±1.9)	6.8 (±5.8)†

†$p < 0.05$

Factors Associated with (Postpartum) Depressed Mothers and Fathers

To determine the predictors of depressed mothers or fathers in the postpartum period, bivariate logistic regression models were fitted separately for each parental outcome (i.e. EPDS cut-off). The selection of variables proceeded as follows; first, unadjusted bivariate model was fitted for each predictor (separate for each outcome). All predictors that were statistically significant (p value <0.05) were then included in separate multivariable model. The final reduced models for each outcome are presented in Table 3, and these variables were then included in the BLC model.

Table 3
Predictors of maternal postpartum EPDS ≥ 10 and paternal postpartum EPDS ≥ 9 by multivariate logistic regression

Variables	**OR (95% CI)**	**p value**
Predictors of maternal postpartum EPDS ≥ 10		
Household income (ref: $70,000–99,999 year or more) <$69,999	1.93 (1.17–3.17)	0.009

Table 3

Predictors of maternal postpartum EPDS ≥ 10 and paternal postpartum EPDS ≥ 9 by multivariate logistic regression

Variables	OR (95% CI)	p value
Prenatal EPDS (ref: no)	3.96 (2.49–6.30)	0.000
Postnatal social support	0.83 (0.77–0.90)	0.000
Postnatal SLE event	1.29 (0.95–1.74)	0.099
Predictors of paternal postpartum EPDS ≥ 9		
Household income (ref: $70,000–$99,999 or more)	2.71 (1.54–4.78)	0.001
Pre-natal EPDS (ref: no)	9.11 (5.40–15.4)	0.000
Postnatal stressful life events	1.36 (1.01–1.85)	0.044
Postnatal social support	0.87 (0.82–0.93)	0.000
Postnatal smoking (ref: no)	2.42 (1.17–5.02)	0.018

For mothers, low household income (OR 1.93, 95% CI 1.17–3.16, p = 0.009), prenatal EPDS ≥ 10 (OR 3.96, 95% CI 2.49–6.30, p < 0.001), and postpartum social support (OR 0.83, 95% CI 0.77–0.90, p < 0.001) were associated with postpartum EPDS ≥ 10. For fathers, household income <$60,000 (OR 2.71, 95% CI 0.77–0.90, p = 0.001), prenatal EPDS ≥ 9 (OR 9.11, 95% CI 5.40–15.4, p < 0.001), postpartum stressful life events (OR 1.36, 95% CI 1.01–1.85, p = 0.044), postnatal smoking (OR 2.42, 95% CI 1.17–5.02, p = 0.02), and postpartum social support (OR 0.87, 95% CI 0.82–0.93, p < 0.001) were associated with postpartum EPDS ≥ 9.

Predictors of Postpartum Depressed Couples by Category

In the BLC regression, the baseline group was the non-depressed couples, with which the other three groups were compared (see Table 4).

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Table 4

Estimated baseline (Logit) category model of postpartum depression by couple categories

Predictors	Depressed couple vs. non depressed couple	Depressed fathers vs. non depressed couple	Depressed mothers vs. non depressed couple
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Maternal postnatal social support	0.86 (0.73, 1.01)	1.03 (0.90, 1.17)	**0.82 (0.74, 0.91)**
Family income	**2.24 (1.38, 3.64)**	**1.51 (1.10, 2.01)**	1.17 (0.88, 1.55)
Maternal prenatal EPDS	**3.11 (1.06, 9.14)**	0.71 (0.31, 1.64)	**4.29 (2.45, 7.51)**

Table 4

Estimated baseline (Logit) category model of postpartum depression by couple categories

Predictors	Depressed couple vs. non depressed couple	Depressed fathers vs. non depressed couple	Depressed mothers vs. non depressed couple
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Postnatal paternal stressful life events	1.61 (0.87, 2.96)	1.32 (0.93, 1.89)	**1.44 (1.03, 2.93)**
Prenatal paternal social support	**0.86 (0.75, 0.98)**	**0.87 (0.81, 0.94)**	1.03 (0.94, 1.13)
Prenatal paternal smoking	0.65 (0.08, 5.35)	**3.45 (1.55, 7.67)**	1.33 (0.55, 3.23)
Paternal prenatal EPDS	3.11 (0.97, 9.78)	**13.2 (7.19, 24.2)**	1.34 (0.62, 2.87)

Depressed Mother, Non-depressed Father

Compared with the non-depressed couples, maternal postnatal social support decreased the odds of PPD (OR 0.82, 95% CI 0.74–0.91) among depressed mothers in couples, controlling for all other factors. This means that postnatal social support for a couple is a protective factor associated with a lowered probability of depression within mother-only depressed couples. Maternal prenatal depression (EPDS ≥ 10) (OR 4.29, 95% CI 2.45–7.51), and paternal postnatal stressful life events (OR 1.44, 95% CI 1.03–2.93) are associated with an increased odds of depression in depressed mothers in couples compared with non-depressed couples, controlling for all other factors. This means experiencing stressful life events during pregnancy and stressful events experienced by the partner (father) after delivery were risk factors for depression in depressed mothers in a couple.

Depressed Father, Non-depressed Mother

Compared with non-depressed couples, low household income (OR 1.51, 95% CI 1.10–2.01), prenatal paternal depression (EPDS ≥ 9) (OR 13.2, 95% CI 7.19–24.2), and prenatal paternal smoking were associated with PPD in fathers (OR 3.45, 95% CI 1.55–7.67), controlling for all other factors. However, paternal prenatal social support (OR 0.87, 95% CI 0.81–0.94) decreased the odds of PPD in father-only depressed couples.

Depressed Couple (Mother and Father)

Compared with non-depressed couples, low household income (OR 2.24, 95% CI 1.38–3.64) and prenatal maternal depression (EPDS ≥ 10) (OR 3.11, 95% CI 1.06–9.14) were associated with an increased odds of depression in depressed

couples, after controlling for the covariates. Prenatal paternal social support (OR 0.86, 95% CI 0.75–0.98) decreased the odds of PPD in depressed couples.

Discussion

This study is among the first to examine partnered couples to determine predictors of depression in either or both mothers and fathers. We found that the number of couples with PPD symptoms in both mothers and fathers was lower than the prevalence reported in the literature, with 2.3% of APrON couples (measured at 12 weeks postpartum) compared with 5.4% measured at 2 weeks after birth in other research (Anding et al. 2016). Consistent with the literature, more APrON mothers reported having prenatal and postnatal depressive symptoms compared with fathers (Escribà-Agüir and Artazcoz 2011; Paulson and Bazemore 2010). Predictors of high PPD symptoms in mothers included low household income, high prenatal depressive symptoms and postnatally, low social support (from fathers, presumably) and higher number of stressful life events experienced. For fathers similar predictors were identified, including low household income, high prenatal depressive symptoms, low postnatal social support (from mothers, presumably) and smoking.

Compared with non-depressed couples (where neither mothers nor fathers had high depressive symptoms postnatally), factors associated with high PPD symptoms in couples in which *either* mother or father experienced high PPD symptoms included: having lower household income, lower postnatal support to mothers, higher depressive symptoms in mothers prenatally, more postnatal stressful life events experienced by fathers, more prenatal smoking and depressive symptoms experienced by fathers and lower prenatal social support provided to fathers. It is noteworthy that so many factors were experienced by either the couple (i.e. income) or fathers (prenatal smoking, depressive symptoms and social support, and postnatal stressful life events prenatal), compared with mothers (prenatal depressive symptoms and postnatal social support) in predicting high PPD symptoms postnatally in either mothers or fathers postnatally. These data suggest fathers' PPD salience in setting the course or the outcomes of the couple postnatally.

Compared with non-depressed couples, factors that predicted PPD in *both* mothers and fathers in couples included low income, high prenatal depressive symptoms in mothers and low prenatal social support reported by fathers. Presumably, fathers are considering that their partners (children's mothers) are

providing low levels of social support prenatally. Not only are prenatal symptoms and experiences more predictive of postnatal symptoms in these couples, but mothers' symptoms of depression persist while fathers symptoms of depression evolve from feelings of low social support. How these variables interact would be worthy of qualitative study.

The low prevalence of PPD in both members of the couple may be a timing issue of the PPD assessment at 12 weeks postpartum of the APrON cohort. Fathers' PPD is known to occur later than mothers, with a more variable prevalence rate. For example, Paulson's meta-analysis reports substantial heterogeneity among studies with regards to rates of fathers' depressive symptoms with an overall meta-estimate of fathers' depression of 10.4% (95% CI 8.5–12.7%), but 25.6% (95% CI 17.3–36.1%) during the 3–6 month postpartum period (Paulson and Bazemore 2010).

The prevalence rate of mothers', fathers', and both parents' co-occurring PPD symptoms has varied by study. A review by Goodman reported that in the first postpartum year, the incidence of fathers' depression ranged from 1.2 to 25.5% in community samples and from 24 to 50% among men whose partners were experiencing PPD (Goodman 2004). We are also unable to rule out the possibility that our observed low prevalence of co-occurring depressive symptoms in both mothers and fathers in couples may be a result of greater drop-out of couples in which both mother and fathers are depressed. As well, different studies have used different outcome measures (e.g. EPDS vs. Beck Depression Inventory), which could account for the difference in rates.

Findings from the current study suggest that depression should be assessed prenatally as well as postpartum and that assessments should include both expectant mothers and their partners (i.e. fathers). Policy and program guidelines have typically emphasized the assessment of depression in the postpartum period, given the well documented association between mothers' depression and children's health/development (Letourneau et al. 2012a, b). Studies of both mother and fathers reveal little resistance to screening and rather interest in being screened for depression (Letourneau et al. 2007, 2012a, b).

For both mothers and fathers within the couple, stressful events and social support are strong predictors of PPD. This finding is also in-line with the literature (Kamalifard et al. 2014). Furthermore, lower income as a predictor of PPD is likely to be a contributor to stressful events, given that financial uncertainty is associated with depression (Goyal et al. 2010). Fathers' support for mothers is known to affect mothers' pregnancy experiences (Giesbrecht et

al. 2013) and findings from this study suggest that assessment of stress and provision of appropriate couple support may be useful in preventing PPD in mothers and fathers.

There are a number of strengths associated with this study. Namely, this is one of the first papers to examine influences on the occurrence of depressive symptoms in both mothers and fathers. Given the growing recognition of the influence of both mothers and fathers to children's development, especially when parents are depressed (Letourneau et al. 2012a, b), this paper points to areas for assessment and intervention to promote the mental health of childbearing families. Moreover, the large sample offers the opportunity to undertake robust statistical modelling. Finally, the ability to examine partnered couples is a definite strength.

This longitudinal cohort study also has some limitations. The EPDS is a screening tool and thus does not diagnose depression therefore misclassifications may occur using the cut-off scores. While the low prevalence of depressive symptoms experienced by both mothers and fathers in couples may be a consequence of participant drop-out, nonetheless the observed variance was sufficient in detecting difference between couples with and without PPD. The sociodemographic characteristics of the APrON cohort were skewed towards higher education and higher income couples, thus findings may underestimate the prevalence rates of high depressive symptoms compared with more normative samples. Moreover, only partnered, presumably co-parenting couples were included in the current study and thus the findings may only be generalizable to similar, higher income, higher education, intact families.

In conclusion, this study is one of the first to examine the predictors of PPD symptoms in couples. The repeated findings of the importance of fathers' symptoms and experiences in predicting depressive symptoms in either mothers or fathers postnatally, points to the need to fully include fathers in prenatal care for childbearing families. In general, prenatal experiences were robust predictors of PPD symptoms, suggesting a need for greater emphasis on prenatal screening and support for childbearing families. Next, research is needed to determine the negative impact of parental PPD in couples on the development of their children. Little information exists about the effects of fathers' depression on children, but even less data is available on the effects of high depressive symptoms occurring in both parents. Future research should evaluate and compare the impact of depressive symptoms in either or both mothers and fathers on infant and child development.

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Compliance with Ethical Standards

Conflict of interest

The authors declare that they have no conflict of interest.

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