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ORIGINAL ARTICLE

Predictors of postnatal mother-infant bonding: the role of antenatal bonding, maternal substance use and mental health

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Abstract The emotional bond that a mother feels towards her baby is critical to social, emotional and cognitive development. Maternal health and wellbeing through pregnancy and antenatal bonding also play a key role in determining bonding postnatally, but the extent to which these relationships may be disrupted by poor mental health or substance use is unclear. This study aimed to examine the extent to which mother-fetal bonding, substance use and mental health through pregnancy predicted postnatal mother-infant bonding at 8 weeks. Participants were 372 women recruited from three metropolitan hospitals in Australia. Data was collected during trimesters one, two and three of pregnancy and 8 weeks postnatal using the Maternal Antenatal Attachment Scale (MAAS), Maternal Postnatal Attachment Scale (MPAS), the Edinburgh Antenatal and Postnatal Depression Scale (EPDS), the Depression and Anxiety Scales (DASS-21), frequency and quantity of substance use (caffeine, alcohol and tobacco) as well as a range of demographic and postnatal information. Higher antenatal bonding predicted higher postnatal bonding at all pregnancy time-points in a fully adjusted regression model. Maternal depressive symptoms in trimesters two and three and stress in trimester two were inversely related to poorer mother-infant bonding 8 weeks postnatally. This study extends previous work on the mother's felt bond to her developing child by drawing on a large sample of women and documenting the pattern of this bond at three time points in pregnancy and at 8 weeks postnatally. Utilising multiple antenatal waves allowed precision in isolating the relationships in pregnancy and at key intervention points. Investigating methods to enhance bonding and intervene in pregnancy is needed. It is also important to assess maternal mental health through pregnancy.

Keywords Maternal bonding · Pregnancy · Postnatal · Mental health · Substance use

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Introduction

The mother's felt bond to her infant is critical to infant health and wellbeing. It is thought to underlie her sensitivity to the needs of the fetus and infant, establishing the foundations for a strong relationship which in turn benefits the child's social, emotional and cognitive development (Ainsworth et al. 1978; Belsky et al. 1984). Poor maternal-infant bonding has been associated with: maternal risk behaviours, including tobacco and alcohol use; poor health care and diet, including lack of

physical exercise during gestation (Lindgren 2001, 2003; Sedgmen et al. 2006), and negative impacts on the child brain regulatory functions which may affect subsequent mental health (Green and Goldwyn 2002; Patock-Peckham and Morgan-Lopez 2010; Schore 2001; Warren et al. 1997). Disordered mother-infant relationship has been reported in 10–25 % of women referred to psychiatrists (Brockington 1996, 2004). Although bonding during the pregnancy period is documented, bonding across the pre- and postnatal period is not well researched, with bonding typically being assessed at one time point in pregnancy and using small samples.

Antenatal and postnatal bonding

Research has shown an association between antenatal and postnatal bonding: attitudes towards the unborn baby can influence first impressions of the infant (Condon and Dunn 1988); antenatal and postnatal bonding are correlated ($r = 0.38$–0.41) (Damato 2004; Müller 1996); prenatal bonding predicts the early mother-infant relationship (Siddiqui and Hagglof 2000); and, mothers with a higher quality of prenatal maternal bonding are more sensitive and more stimulating in interaction with their 6 months old (De Cock et al. 2011). Van Bussel et al. (2010a, b) were the first researchers to utilise the Maternal Antenatal Attachment Scale (MAAS) at three time points during pregnancy and Maternal Postnatal Attachment Scale (MPAS) postnatally. These measures of bonding developed by Condon (1993) focus exclusively on mothers' thoughts and feelings towards their fetus/infant (Brandon et al. 2009). They found antenatal bonding predicted stronger bonding postnatally (Van Bussel et al. 2010a), however, like others, did not assess potential mediating variables (e.g. mental health or substance use). Although this literature does seem to show a link between antenatal and postnatal bonds, correlations seem to be modest and predict some outcomes and not others. For example, maternal interactive behaviour at 3 months postpartum was not predicted by antenatal representations about the child (Thun-Hohenstein et al. 2008).

Mental health and maternal bonding

There is limited prospective research that considers mental health, particularly stress and anxiety, across the antenatal and postnatal period and its relationship to bonding. Depression is correlated with poor mother-fetal bonding during pregnancy (Alhusen et al. 2012; Goecke et al. 2012; Lindgren 2001; McFarland et al. 2011; Ossa et al. 2012) and bonding postpartum (Damato 2004; Goecke et al. 2012; Ohoka et al. 2014). Women with low-quality fetal bonding tend to report higher levels of anxiety and depression (Hart and McMahon 2006). Women with lower depression scores had higher levels of bonding and bonding had significant direct effects on health practices (Lindgren 2001, 2003). The correlation between postpartum depression and abusive behaviour may also be influenced by bonding difficulties (Choi et al. 2010). As for the mother-child relationship, depressed (versus non-depressed) mothers showed less vocal and visual communications, less corporal interactions and less smiling with their infants at 3 months postpartum (Righetti-Veltema et al. 2002). However, depression is not always correlated with antenatal bonds (Diniz et al. 2015).

Research into anxiety and stress predictors on bonding pre- and postnatal is scarce yielding mixed results. Correlations were not found between trait anxiety and maternal-fetal bonding (Gaffney 1986; Stanton and Golombok 1993). Furthermore, anxiety showed no correlation with maternal-fetal bonding in low or high obstetrical risk women (Mercer and Ferketich 1990) and has not been considered a major component of bonding disorders commonly seen postpartum (Brockington et al. 2001). However, in the context of a prior late pregnancy loss, women have reported experiencing higher level of anxiety in relation to pregnancy concerns as well as decreased prenatal bonding (Armstrong and Hutti 1998). Cranley (1981) reported an inverse correlation between perceived stress and maternal-fetal bonding, but other researchers were unable to replicate this (Curry 1987; Grace 1989; Mercer and Ferketich 1990). Few studies have comprehensively assessed mental health contributions to *postnatal* bonding across the pregnancy and postnatal period and yet symptoms such as anhedonia, low or dysregulated affect, and reduced capacity to view the future positively are likely to interfere with the bonding process.

Substance use and maternal bonding

Maternal drug and alcohol use also have the potential to dampen the capacity of mothers to make an affective connection. Substances may diminish the intensity of feeling towards a fetus or infant and therefore impact on postnatal bonding. 'Abusing' drugs or experiencing domestic violence during pregnancy each have been shown to negatively impact upon maternal bonding (Quinlivan and Evans 2005). Similarly, maternal alcohol use has been associated with poorer mother-infant relationship quality 1 year postbirth (O'Connor et al. 1992); that is, mother's alcohol use is associated with poorer infant mental development and negative effect which, in turn, relates to the mother-infant relationship and infant cognitive performance (O'Connor et al. 1993). Alcohol exposure in mothers prenatally is also strongly related to poorer bonding and negative child affect (O'Connor et al. 2002a, b, c; O'Connor and Paley 2006). Unfortunately, existing studies have small sample sizes, and few consider alcohol and other substances like caffeine or tobacco. This oversight may prove important as, unlike illicit substances, most women tend to

continue using these substances at low levels during pregnancy (Hutchinson et al. 2013).

In summary, mother-fetal bonding, maternal mental health and substance use through pregnancy have been linked to the mother's felt bond to her infant postnatally; however, most studies have been limited by the use of small samples, bonding being assessed infrequently (typically) at one time point during pregnancy and not including the full range of psychological variables and substance use exposures; and this results in incomplete covariate adjustment. There is need for greater methodological rigour including: larger sample sizes; multi-wave assessments across pregnancy and postnatally; and detailed assessment of constructs. Therefore, our work aims to overcome these limitations by examining the associations between antenatal bonding, substance use (caffeine, alcohol and tobacco) and maternal mental health (stress, anxiety and depression) across pregnancy (trimesters one, two, three) in predicting the mother's felt bond to her infant at 8 weeks postpartum, controlling for a range of demographic and other potential covariates. Data are drawn from an innovative Australian longitudinal study which examines a wide range of biopsychosocial factors that relate to the health and development of infants and families.

Method

This project is a part of the Triple B Pregnancy Cohort Study, a longitudinal pregnancy study conducted by the National Drug and Alcohol Research Centre (NDARC) at the University of New South Wales (NSW), and the National Drug Research Institute (NDRI) at Curtin University (WA). The study examines the impact of parental substance use on infant development and family functioning from the time of conception, taking into account the influence of a range of additional factors, including sociodemographic variables, diet and nutrition, psychological and physical health and social support. A total of 1604 women were recruited during pregnancy between 2008 and 2013, as well as their offspring and partners. The current study included a subsample of participants from NSW. Ethics approval for this study was obtained from the human research ethics committees of each participating hospital, the Area Health Services in which the hospitals were located and the University of New South Wales.

Participants

Participants were a subsample of 372 women recruited between November 2010 and June 2012, who had completed all requisite measures at the time of analysis. All families were approached during their pregnancy through the Royal Prince Alfred Hospital (RPA), Royal Hospital for Women (RHW) and Liverpool Hospital. Eligibility criteria included: being pregnant (at any stage from conception to 40 weeks gestation); being aged 16 years or more; having no major medical complications (mother or fetus); residence in NSW; intention of mother or both parents to be the primary caregiver/s; being mentally able to complete study measures (as assessed by the researcher); and possessing sufficient literacy in English. To assess generalisation of findings, comparisons with women who gave birth during the same period of time, but who had not completed all required measures (i.e. recruited but not yet interviewed on all available measures relevant to this study; $n = 485$) showed similar sociodemographic characteristics, with the exception that those included in the sample were more likely to be employed (χ^2 ($df = 2$, $N = 862$) $= 21.66$, $p < 0.01$).

We compared our sample with the Australian population of women giving birth in 2012 (Hilder et al. 2014). The median maternal age for our study was 33.0 years (IQR = 7), while the median maternal age in the Australian population is 30.8 years (Wilcoxon signed rank test, $p < 0.001$). In our study, 1.1 % of women were from an indigenous background, while 2.5 % of women were indigenous in the population (binomial test, $p = 0.044$). In our study, 41.1 % of women were born overseas, while 27.0 % of women giving birth in the population were overseas born (binomial test $p < 0.001$). It was the first pregnancy for 39.7 % of women in our study, while 42.4 % of women in the population gave birth for the first time ($p = 0.162$). The average gestational age at birth in our study was 39.3 weeks, while the population average was 38.8 weeks (t (371) $= 5.86$, $p < 0.001$). The average weight of babies in our study was 3.6 kg, which was similar to the population average of 3.37 kg (t (369) $= 2.02$, $p = 0.044$).

Procedure

Pregnant women were approached by trained researchers in waiting rooms at general antenatal clinics and specialist drug and alcohol antenatal clinics attached to major public hospitals and area health services. Women, partners and children have been followed up prospectively, with maternal data being collected during each trimester, and at 8 weeks and 12 months postbirth. For women who joined the study later in pregnancy, interviews for trimesters one and two were done retrospectively. The data for this study consists of structured interviews and self-completed questionnaires administered across the following four time points: trimester one (T1), trimester two (T2), trimester three (T3) and 8 weeks postnatal.

Measures

Demographic information

Demographic information was collected via structured interview in trimester three (27 weeks birth) while postnatal information was collected at 8 weeks postbirth. Demographic variables included: age, marital status, employment status, gross

annual household income, highest level of education, country of birth, Aboriginal or Torres Strait Islander status, living arrangement, desire to be pregnant and whether it was the mother's first pregnancy (yes/no).

Birth outcomes and postnatal factors

Data on birth outcomes and postnatal factors were collected through structured interview and personal health records (i.e. from the infant's 'blue book', in which birth data were recorded by hospital staff post-birth), at the 8-week follow-up. This included baby's birth weight (kilogrammes), gestational age at birth (weeks), problems during labour (none, one or more problems), breastfeeding problems (none, one, two or more problems) and baby's crying time (minutes per day).

Bonding to the fetus

The mother's felt bond to her baby during pregnancy was assessed using the Maternal Antenatal Attachment Scale (MAAS) (Condon 1993). The 19-item scale focuses on maternal attitudes, feelings and behaviours towards the fetus. It has two dimensions measuring (1) the *quality* of maternal bonding (ten items) and (2) the *intensity* of preoccupation with the fetus (eight items). The quality subscale assesses affective experiences, such as closeness, tenderness and positive feelings about the fetus, a desire to know about it, as well as vivid internal representations of the future baby. The intensity subscale assesses the intensity of preoccupation with the fetus and the intensity of feeling, including the amount of time spent thinking about, talking to, and dreaming about the unborn baby. A 5-point response scale was employed with higher values corresponding to higher antenatal bonding. Generally, higher scores for both the subscales indicate the most adaptive mother-fetal bonding style (Condon 1993). The range of scores for the global total scale was 19–95 with the quality and intensity subscales ranging from 10 to 50 and 8 to 40, respectively. The MAAS is a widely used measure with reliability for the overall instrument reported to be 0.82, measured in the third trimester (Condon 1993). Reliability analyses for the current study yielded Cronbach's alphas of 0.72, 0.68 and 0.76 in trimesters one, two and three, respectively.

Bonding to the infant

The Maternal Postnatal Attachment Questionnaire (MPAS; 19-items) (Condon and Corkindale 1998) was used to measure a mother's reported feelings about her infant at 8-weeks of age. The measure consists of three factors*:* (1) *quality of bonding* (nine items; range, 9–38): confidence and satisfaction in the interaction with the infant; (2) *absence of hostility* (five items; range, 5–22): the absence of hostile or angry feelings towards one's infant; and (3) *pleasure in interaction* (five items; range, 5–19): the desire for physical closeness and happiness in interaction with one's infant (McMahon et al. 1997). Responses were provided on 2-, 4- or 5-point scales. To ensure equal weighting of questions, all response options were recoded to represent a score of 1 (low bonding) to 5 (high bonding). The sum of the 19 items forms the total MPAS scale, with higher scores indicating the most adaptive mother-infant bonding style (Condon and Corkindale 1998). The scale has demonstrated reliability and construct validity (Condon and Corkindale 1998). Cronbach's alpha for the total scale in this sample was 0.75.

Stress and anxiety

The short-form version of the Depression and Anxiety Scales (DASS-21) (LovibondP 1995) were completed at 8 weeks to assess anxiety and stress. The anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety and subjective experience of anxious affect. The stress scale is sensitive to levels of chronic non-specific arousal. It assesses difficulty relaxing, nervous arousal and being easily upset/agitated, irritable/over-reactive and impatient. The DASS-21 subscales each consist of seven items (range, 0–28). Participants rated the extent to which they had experienced each state *over the past week* on a 4-point scale (0 = never, 1 = sometimes, 2 = often and 3 = almost always). The reliability of the instrument was tested using the Cronbach's alpha coefficient of internal consistency and was found to be 0.85, 0.82, 0.84 and 0.83 across trimesters one, two and three and 8 weeks postnatal, respectively. Stress and anxiety were coded into categories for the regression analyses, where 0 = normal to mild symptoms of stress or anxiety, and 1 (elevated) = moderate, severe or extremely severe symptoms.

Depression

The Edinburgh Antenatal and Postnatal Depression Scale (EPDS) were used to assess depression through pregnancy and postnatally. Mothers completed the ten-item Edinburgh antenatal and postnatal depression scales, to detect symptoms of antenatal and postnatal depression (antenatal: T1, T2, T3; postnatal, 8 weeks). The EPDS may be used within 8 weeks postpartum, and it also can be applied for depression screening during pregnancy. The EPDS asks women to respond to each statement based on their mood over the previous seven days. Items of the scale correspond to various clinical depression symptoms, such as feeling guilt, sleep disturbance, low energy, anhedonia, and suicidal ideation. Each item is scored from 0 to 3 with a maximum score of 30. Higher scores indicate more depressive symptoms, and this study analysed this as a continuous scale. Examples of items from the EPDS include 'I have looked forward with enjoyment to things' and 'I have blamed myself unnecessarily when things go wrong'. The reliability of the instrument was tested using the Cronbach's alpha coefficient of internal consistency, which

was found to be 0.87, 0.86, 0.84 and 0.82, respectively, across trimesters one, two and three and 8 weeks postnatal, respectively. Depression was coded into a binary variable for the regression analyses, where 0 (score 0–9) = normal to mild symptoms of stress or anxiety, and 1 (elevated, 9 or above) = moderate, severe or extremely severe symptoms.

Substance use

Quantity and frequency of caffeine, alcohol and tobacco use were collected at each trimester and 8 weeks postnatally. Frequency of substance use was coded in the following way: Everyday, five to six times a week, three to four times a week, one to two times a week, two to three times a month, once a month, once or twice during the 3-month period. Caffeine use each day was recorded in milligrammes; alcohol was recorded in standard drinks, a drink that contains 10 g of alcohol; and tobacco use was recorded as number of cigarettes per day.

Intake guidelines for pregnancy recommend no more than 200 mg of caffeine/day (Finke et al. 2015), therefore for the regression analyses, caffeine was coded as a binary variable (0 = ≤200 mg, 1 = >200 mg). Alcohol was classified into three categories for regression purposes (0 = abstinent, 1 = low-level drinkers and 2 = moderate, binge and heavy drinkers) using the composite method which takes into account the timing, frequency and quantity of consumption (O'Leary et al. 2010). Low-level drinkers were defined as having ≤two standard drinks per typical occasion, never more than four standard drinks on one occasion, and ≤seven drinks per week. Moderate drinkers were women who had >two drinks per typical occasion but never more than four. The binge category refers to women who have >four drinks on any occasion. Heavy drinkers have >seven drinks in a week, and a drinking frequency of at least weekly. Finally, tobacco was coded as a binary variable in the regression analysis (0 = no tobacco use during pregnancy, 1 = tobacco use during pregnancy).

Four assessment points across pregnancy and postnatal are shown in Table 1.

Statistical analysis

All data were analysed with the Statistical Package for Social Sciences (SPSS). Average (mean) bonding scores were calculated at each trimester during pregnancy and postnatally. Descriptive statistics were run for mother-fetal/infant boding, substance use and mental health through pregnancy (trimesters one, two and three) and postnatally (8 weeks). A series of bivariate analyses and correlation analyses were run for each factor with postnatal bonding. We tested the assumptions for multiple linear regression models, and none of the assumptions were violated. A series of three multiple linear regression models for trimesters one, two and three was run with antenatal bonding, substance use and mental health and postnatal bonding (model A, unadjusted). The same series of multiple linear regression models were repeated, controlling for demographic and postnatal factors (model B, adjusted).

Missing data

Person mean substitution (PMS) was conducted to impute missing data for MAAS and MPAS variables in the present research (Huisman 2000). In this procedure, the imputed value for a variable with missing data was applied to cases with <20 % of data missing on the scale and derived from the non-missing items for the case (Hawthorne and Elliott 2005). When PMS was performed on this dataset, 11 participants were excluded due to missing data on the MAAS and MPAS scales.

A relatively large proportion of participants did not disclose their income ($n = 104$, 28 %). There were also a number of participants with missing data for other variables ($n = 46$, 12.4 %). Further detail on the missing data is included in the Electronic supplementary material. The presence of missing data raises the possibility of introducing bias into the results if data is not missing completely at random. In order to address this, multiple regression analyses were carried out using multiple imputations of chained logit and mlogit equations to impute missing data.

Table 1 Study measures across pregnancy and postnatal

	Pregnancy trimester 1	Pregnancy trimester 2	Pregnancy trimester 3	Postnatal 8 weeks
Mother	Demographic information	Demographic information	Demographic information	Postnatal information
	MAAS	MAAS	MAAS	MPAS
	EPDS	EPDS	EPDS	EPDS
	DASS	DASS	DASS	DASS
	Substance use	Substance use	Substance use	Substance use
Infant offspring	–	–	–	Birth outcomes (Blue Book)

In instances where women commenced participation after trimester 1 or 2, pregnancy assessments were completed retrospectively

Results

Descriptive results

Demographic and postnatal

Table 2 summarises the demographic characteristics of the sample. The mean age of the sample was 33 years (range, 18–49). The majority of women were Australian born (59 %), married (69 %) and had completed a university/college education (67 %). In this sample, 49 % of women were working full time when they were pregnant. For over a third of the sample (40 %), this was their first pregnancy and the majority of women in the sample (81 %) reported wanting to become pregnant. On average, infant birth weight was 3.6 kg, and gestational age at birth was 39 weeks. A substantial proportion of the women reported one or more problems during their labour (42 %), while breastfeeding problems (e.g. mastitis) were also common, with women either reporting no problems (25 %) one problem (57 %) or two or more problems (18 %). In this sample, it was found that babies averaged 86 min of crying/day at 8 weeks postnatal.

Study measures

Summary statistics of the measures utilised in this study (MAAS, MPAS, DASS-21 and EPDS) are shown in Table 3.

Caffeine, alcohol and tobacco use

Table 4 details the summary statistics of substance use through pregnancy and postnatally. Frequency and quantity of caffeine scores were combined into a continuous scale, milligrammes per week.

Correlational analysis

A series of correlational analyses, using Pearson's correlation coefficients, were conducted with independent predictor variables and postnatal bonding. Table 5 shows the correlation between total antenatal bonding through pregnancy and postnatal total bonding at 8 weeks. As expected, there was a significant positive relationship between antenatal and postnatal bonding. This relationship increased through pregnancy (r (T1) = .27 (low), r (T2) = .29 (low) and r (T3) = .40 (moderate); $p < 0.01$).

Antenatal substance use was also correlated with postnatal bonding at 8 weeks (Table 6). Caffeine use during trimester two ($r = -.10$, $p < 0.05$) and alcohol use in trimesters one and three (r (T1) = −.11 (low), r (T3) = −.13 (low); $p < 0.05$) were significantly correlated with postnatal bonding. These associations were in the expected direction, that is: caffeine and alcohol use was associated with poorer bonding at 8-weeks postnatal.

Table 7 shows the correlation matrix of mental health (stress, anxiety and depression) through pregnancy correlated with postnatal bonding at 8 weeks. All measures of mental health were significantly negatively correlated with postnatal bonding.

Regression analysis

Multiple regression analyses were conducted using bonding, substance use and mental health through pregnancy (trimesters one, two and three) as independent variables, with postnatal bonding as the dependent variable (see Table 8). Model A included antenatal bonding, substance use and mental health with postnatal bonding. Model B included the same predictors and also adjusted for demographic and postnatal covariates, which included: age (years), country of birth, employment status, household income (before tax), number of previous children, baby's birth weight (kg), gestational age at birth, problems during labour, breastfeeding problems, baby's crying time (min/day). Overall, the amount of variance in postnatal bonding for model A ranged from 11 % (13 % unadjusted) in trimester one to 19 % (18 % unadjusted) in trimester three. When demographic and postnatal variables were included in the model, the amount of variance ranged from 22 % (26 % unadjusted) in trimester one to 29 % (33 % unadjusted) in trimester three.

A separate analysis was run predicting postnatal bonding from demographic and postnatal factors. The results of this analysis indicated that demographic and postnatal factors accounted for a significant proportion of mother-infant bonding variability ($R^2 = 0.15$, $F(14, 357) = 4.42$, $p < 0.001$). No relationship was found between mother-infant bonding and sample characteristics including household income and mother born overseas, as well as some postnatal factors, baby's birth weight, gestational age at birth, presence of one breastfeeding problem and problems during labour. Variables that contributed significantly to the model were: maternal age ($\beta = -.21$, $p < 0.01$), employed part time ($\beta = -2.00$, $p < 0.05$) or homeduties/unemployed/student ($\beta = -2.67$, $p < 0.01$) compared with full time, number of children ($\beta = 2.31$, $p < 0.01$), presence of two or more breastfeeding problems ($\beta = -2.62$, $p < 0.01$) and baby's daily time crying ($\beta = -.02$, $p < 0.001$).

The multiple regression analysis revealed that antenatal bonding significantly predicted postnatal bonding at all time points (t (T1) = 4.90, t (T2) = 6.39 and t (T3) = 7.95; $p < 0.001$) after controlling for demographic and postnatal covariates. Maternal stress, anxiety and depression and its relationship to postnatal bonding at 8 weeks showed significant results for the depression and stress variables. Maternal depression was significantly related to postnatal bonding at all time points in the unadjusted model and when covariates were included into the model maternal

Table 2 Sample demographic and obstetric characteristics

Characteristics at third trimester	Number	Mean (SD)	Percent
Mean age (years)	362	32.59 (*5.00*)	
Marital status			
Married or defacto	357		95.97
No partner or not living with partner	15		4.03
Employment status			
Full time	182		48.90
Part time/casual	90		24.20
Unemployed/student/home duties	100		26.90
Gross annual household income[a]			
124,800 or more	121		47.50
$78,000–124,799	96		37.60
$77,999 or less	38		14.90
Highest level of education completed			
Some high school	27		7.30
High school	52		14.00
Diploma/certificate	45		12.10
Undergraduate/postgraduate university degree	248		66.70
Country of birth			
Australia	219		58.90
Other English-speaking country (OESC)	61		16.40
Non-English-speaking background (NESB)	92		24.70
Indigenous			
Aboriginal and/or Torres Strait Islander	4		1.10
Non-aboriginal Torres Strait Islander	368		98.90
Living arrangement			
Renting	173		46.50
Privately own	176		47.30
Staying with friends/family	19		5.10
Other	3		0.80
Pregnancy characteristics			
Pregnancy feelings			
Wanted to become pregnant	302		81.20
Did not want to become pregnant	14		3.80
Had not thought about becoming pregnant	39		10.50
Other	16		4.30
First pregnancy			
Yes	147		39.70
No	223		60.30
Labour			
Problems during labour			
None	147		57.60
One or more	108		42.40
Postnatal characteristics (8 weeks)			
Baby's birth weight (kg)	370	3.60 (*2.17*)	
Gestation at birth (weeks)	372	39.34 (*1.77*)	
Baby's time crying (min/day)	369	86.34 (*87.15*)	
Breastfeeding problems			
None	63		24.70
One	145		56.90
Two or more	47		18.40

SD standard deviation from the mean

[a] $N = 268$ due to a large number of respondents not wishing to report on this variable

Table 3 Summary statistics of study measures through pregnancy and postnatally

	Number of respondents	Mean	SD	Range	
				Minimum	Maximum
Bonding (global total, antenatal MAAS and postnatal MPAS)					
T1	370	74.94	8.39	50.00	117.00
T2	370	78.60	6.97	56.00	113.00
T3	367	80.68	7.23	56.00	113.00
8 weeks	372	85.20	6.59	57.90	95.00
Stress (DASS-21)					
T1	370	7.85	7.52	0.00	42.00
T2	370	7.52	7.17	0.00	40.00
T3	370	7.99	6.88	0.00	39.67
8 weeks	370	6.24	5.96	0.00	30.00
Anxiety (DASS-21)					
T1	370	3.36	4.71	0.00	38.00
T2	370	3.52	4.40	0.00	32.00
T3	370	4.17	4.75	0.00	36.00
8 weeks	370	1.61	3.03	0.00	28.00
Depression (EPDS)					
T1	371	5.17	4.92	0.00	27.00
T2	371	4.21	4.36	0.00	27.00
T3	371	4.30	3.93	0.00	21.00
8 weeks	368	3.69	3.57	0.00	19.00

depression in trimesters two ($t=-2.35$, $p<0.05$) and three were significant ($t=-3.09$, $p<0.001$). Maternal stress in trimester two was a significant predictor of postnatal bonding at 8-weeks in the adjusted model ($t=-2.14$, $p<0.05$).

Discussion

Bonding

This study used a large sample of women, assessed major predictors, controlled for covariates and found evidence that bonding to the fetus antenatally may lay the groundwork for the mother-child relationship in the early postnatal period. The multiple regression analyses revealed that antenatal bonding predicted postnatal bonding at all time points after controlling for key demographic and postnatal covariates. While past research has focussed on observational and structured interviewing techniques for determining the mother-infant relationship postnatally (Condon and Dunn 1988; Damato 2004; De Cock et al. 2011; Müller 1996; Siddiqui and Hagglof 2000), we were able to demonstrate this relationship in a large sample of Australian women using the MAAS and MPAS. Understanding factors that underpin the postnatal bond is a foundational step in predicting sensitive maternal behaviours related to the development of a secure attachment style (Hamilton 2000; Waters et al. 2000) and protecting against maladaptive mental health in adulthood (Green and Goldwyn 2002; Patock-Peckham and Morgan-Lopez 2010; Schore 2001; Warren et al. 1997). Therefore, the potential importance of the felt bond to the fetus cannot be underestimated. Antenatal care has an important role to play at key points during pregnancy to promote the maternal-fetal bond. Targeted interventions specifically aimed at enhancing and strengthening the development of the maternal-fetal bond should, where appropriate, be integrated into the current model of care pregnant women receive.

Mental health

Maternal depression across all time points predicted mother-infant bonding at 8 weeks, such that higher levels of depression during pregnancy predicted lower postnatal bonding scores. Depression during trimesters two and three remained significant when adjusting for demographic and postnatal covariates. This supports previous research that has found a relationship between antenatal depression and postnatal mother-infant bonding (Goecke et al. 2012). Our research extends these results by considering the relationship in the other direction, predicting postnatal bonding from antenatal depression during three pregnancy time points, in a larger sample of women. A prospective study of 389 women found a significant weak to moderate correlation ($r=0.14$ to 0.39) between the EPDS and mother-to-infant bonding scale scores during pregnancy and the postpartum period (Ohoka et al. 2014). Our study extended on that work by using the MAAS and MPAS while also considering other predictor variables, including substance use and other mental health factors (stress and anxiety). Understanding that antenatal depression impacts on mother-child bonding postpartum, and that depression remains stable throughout pregnancy and postnatally, highlights the importance of identifying women who are experiencing prenatal depression symptoms early. Encouraging these women to undergo treatment and assisting them to find appropriate services are actions that health professionals can take to help pregnant women deal with symptoms of depression. Importantly though, antenatal depression symptoms in the third trimester and bonding each uniquely contributed to variance in postnatal bonding, supporting the contention that bonding problems are not wholly explained by depression and so discrete characteristics of each require attention in a treatment context (Brockington 2004; Choi et al. 2010).

Furthermore, antenatal stress during trimester two was associated with lower postnatal bonding scores at 8 weeks, albeit as a weak effect. Due to mixed results shown in previous research, this represents an opportunity for future exploration. An inverse correlation between perceived stress and maternal-fetal bonding has been found

Table 4 Summary statistics of substance use (caffeine, alcohol, and tobacco) through pregnancy and postnatally

	Number of respondents	Number using substance	Quantity consumed[a]		Range	
	N	*N* (%)	Mean	SD	Min	Max
Caffeine (mg/week[b])						
T1	366	245 (66.94)	468.37	493.93	0.00	3745.00
T2	370	291 (78.65)	447.36	428.05	5.00	3745.00
T3	370	287 (77.57)	525.72	420.69	3.00	2996.00
8 weeks	368	332 (90.22)	633.16	568.70	5.00	3920.00
Alcohol (SD/week)						
T1	369	72 (19.51)	1.47	2.63	0.03	15.75
T2	367	101 (27.52)	1.44	1.95	0.03	10.50
T3	371	111 (29.92)	1.60	1.78	0.05	10.50
8 weeks	372	226 (60.75)	2.64	4.16	0.03	41.25
Tobacco (cigarettes/day)						
T1	371	20 (5.39)	9.18	6.70	0.50	20.00
T2	371	16 (4.31)	9.44	6.03	2.00	20.00
T3	370	15 (4.05)	7.60	5.23	1.00	20.00
8 weeks	372	19 (5.11)	8.92	6.82	0.50	20.00

[a] Quantity of those who consumed the substance

[b] One espresso coffee contains 107 mg of caffeine

(Cranley 1981), while other researchers were unable to reproduce these findings (Curry 1987; Grace 1989; Mercer and Ferketich 1990). There has also been some evidence of neurobiological processes underpinning the influence of parental stress on human bonding relations (Feldman et al. 2011). Other work has linked maternal mood during pregnancy to infant behaviour and temperament outcomes. For example, maternal antenatal anxiety predicted behavioural and emotional problems in children at 4 years of age in a large UK sample (O'Connor et al. 2002a, b, c), while Australian prospective research also found antenatal anxiety was predictive of 'difficult' infant temperament at 4 or 6 months, independent of concurrent depression (Austin et al. 2005). Other prospective work found maternal sensitivity to infant distress moderated the association between maternal prenatal anxiety disorder and infant mental development, independent of prenatal depression (Grant et al. 2010). A review article similarly reported evidence for the link between antenatal stress and anxiety and long-term behaviour of the child, even after controlling for effects of postnatal maternal mood and other confounders (Van den Bergh et al. 2005). Given anxiety and depression appear to remain stable from pregnancy in to the postnatal period, with antenatal anxiety being an important predictor of postnatal anxiety and mood disorders (Grant et al. 2008), further investigation into how stress, anxiety and depression link with a mother's feeling towards her fetus and infant is warranted.

Table 5 Correlation between mother-fetal/infant bonding through pregnancy and postnatally

	MAAS T1	MAAS T2	MAAS T3	MPAS 8-week
MAAS T1	1	–	–	–
MAAS T2	.74**	1	–	–
MAAS T3	.61**	.72**	1	–
MPAS 8 weeks	.27**	.29**	.40**	1

**Correlation is significant at the 0.01 level (two-tailed)

Substance use

In the current study antenatal substance use had no association with the quality of the postnatal bond at 8 weeks. Caffeine was not a significant predictor of mother-infant bonding which is consistent with the extant literature suggesting that caffeine and bonding are not related (O'Connor et al. 2002a, b, c; O'Connor and Paley 2006). While alcohol use in mothers antenatally was significantly related to bonding insecurity in infants at 12 months (O'Connor et al. 1992, 1993) and children at 4–5 years of age (O'Connor et al. 2002a, b, c; O'Connor and Paley 2006), our results found no evidence of alcohol use during pregnancy being associated with postpartum bonding. Given most women tend to continue drinking at low levels during pregnancy (Hutchinson et al. 2013), these findings require confirmation. The results of this study do not provide information about higher levels of alcohol consumption during pregnancy.

Table 6 Correlation between antenatal substance use (caffeine, alcohol, tobacco) and postnatal bonding (8 weeks)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. MPAS	1	–	–	–	–	–	–	–	–	–	–	–	–
2. T1 Caf	−.09	1	–	–	–	–	–	–	–	–	–	–	–
3. T2 Caf	−.10*	.71**	1	–	–	–	–	–	–	–	–	–	–
4. T3 Caf	−.09	.52**	.69**	1	–	–	–	–	–	–	–	–	–
5. 8 weeks Caf	.05	.35**	.43**	.65**	1	–	–	–	–	–	–	–	–
6. T1 Alc	−.11*	.22**	.23**	.22**	.14**	1	–	–	–	–	–	–	–
7. T2 Alc	−.06	.16**	.18**	.18**	.15**	.57**	1	–	–	–	–	–	–
8. T3 Alc	−.13*	.15**	.16**	.24**	.13*	.35**	.42**	1	–	–	–	–	–
9. 8 weeks Alc	−.08	.14**	.13*	.16**	.17**	.41**	.30**	.48**	1	–	–	–	–
10. T1 Tob	−.00	.23**	.24**	.14**	.21**	.33**	.16**	.11*	.00	1	–	–	–
11. T2 Tob	−.01	.22**	.23**	.13*	.21**	.26**	.07	.11*	.06	.77**	1	–	–
12. T3 Tob	.04	.14**	.13*	.13*	.23**	.27**	.08	.12*	.06	.80**	.90**	1	–
13. 8 weeks Tob	.04	.14**	.11*	.13*	.26**	.34**	.19**	.12*	.08	.76**	.79**	.88**	1

*Correlation is significant at the 0.05 level (two-tailed); **correlation is significant at the 0.01 level (two-tailed)

Strengths and limitations

This study extends previous work on the maternal felt bond to her developing child (Condon and Dunn 1988; De Cock et al. 2011; Siddiqui and Hagglof 2000) by drawing on a large sample of Australian women; documenting the pattern of this bond at three time points in pregnancy and at 8 weeks postnatally; and by including an examination of the extent to which antenatal bonding is critical in the formation of the postnatal bond. These results should, however, be interpreted in the context of several limitations. First, the subsample represented a somewhat advantaged group of families in NSW and consisted of predominantly Anglo-Saxon Australians, which possibly reduces generalisability to other more diverse populations. For example, this was a non-clinical sample with limited variability on measures of mental health and substance use, so generalisability to clinical samples is difficult to ascertain. Despite this, comparisons with women who gave birth during the same period of time but who had not completed all requisite measures, showed similar sociodemographic characteristics including age, country of birth, education and employment status. This sample is also similar to the Australian population of women giving birth on a range of demographic factors.

Second, there were limitations in regard to the bonding measures used in the study to assess the mother's felt or perceived bond to her developing child. Whilst these measures have been validated (Condon 1993; Condon and Corkindale 1998; Van Bussel et al. 2010b) and the results appear consistent with both theory and past empirical research,

Table 7 Correlation between antenatal mental health (stress, anxiety, depression) with postnatal bonding (8 weeks)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1. MPAS 8 weeks	1	–	–	–	–	–	–	–	–	–	–	–	–
2. DASS (S) T1	−.26**	1	–	–	–	–	–	–	–	–	–	–	–
3. DASS (S) T2	−.30**	.76**	1	–	–	–	–	–	–	–	–	–	–
4. DASS (S) T3	−.28**	.54**	.61**	1	–	–	–	–	–	–	–	–	–
5. DASS (S) 8 weeks	−.51**	.45**	.48**	.52**	1	–	–	–	–	–	–	–	–
6. DASS (A) T1	−.17**	.59**	.45**	.34**	.31**	1	–	–	–	–	–	–	–
7. DASS (A) T2	−.22**	.42**	.47**	.32**	.35**	.68**	1	–	–	–	–	–	–
8.DASS (A) T3	−.15**	.32**	.33**	.53**	.25**	.45**	.48**	1	–	–	–	–	–
9. DASS (A) 8 weeks	−.31**	.29**	.31**	.31**	.54**	.38**	.50**	.47**	1	–	–	–	–
10. EPDS (D) T1	−.30**	.69**	.50**	.42**	.33**	.56**	.41**	.28**	.23**	1	–	–	–
11. EPDS (D) T2	−.32**	.51**	.69**	.52**	.34**	.40**	.48**	.35**	.34**	.65**	1	–	—
12.EPDS (D) T3	−.35**	.51**	.61**	.72**	.46**	.44**	.45**	.50**	.38**	.52**	.69**	1	-
13. EPDS (D) T 8 weeks	−.47**	.39**	.47**	.47**	.67**	.36**	.42**	.36**	.50**	.42**	.52**	.60**	1

**Correlation is significant at the 0.01 level (two-tailed)

Table 8 Regression analyses predicting mother-infant bonding at 8 weeks postnatal, by trimester ($n = 372$)

	Model A			Model B[†]		
	B	*t*	*p*	B	*t*	*p*
T1						
Bonding	0.17	4.30	0.00***	0.19	4.90	0.00***
Caffeine	−0.99	−0.75	0.45	−2.14	−1.71	0.09
Alcohol						
Abstinent (reference)						
Low	−1.11	−1.25	0.21	−0.91	−1.06	0.29
Moderate, ginge, heavy	−1.71	−0.83	0.41	−0.32	−0.16	0.87
Tobacco	2.55	1.66	0.10	0.65	0.42	0.67
Stress	−1.18	−0.80	0.42	−2.45	−1.74	0.08
Anxiety	−1.13	−0.85	0.40	−0.03	−0.02	0.98
Depression	−3.02	−2.82	0.01**	−1.43	−1.38	0.17
R^2 (R^2_{adj})	0.13 (0.11)			0.26 (0.22)		
F	6.76			5.62		
p	0.00			0.00		
T2						
Bonding	0.23	4.79	0.00***	0.29	6.39	0.00***
Caffeine	−1.11	−0.92	0.36	−2.20	−1.95	0.05
Alcohol						
Abstinent (reference)						
Low	0.08	0.11	0.91	0.62	0.85	0.40
Moderate, binge, heavy	−0.52	−0.31	0.75	0.14	0.09	0.93
Tobacco	1.43	0.89	0.37	−0.46	−0.30	0.77
Stress	−2.19	−1.51	0.13	−2.92	−2.14	0.03*
Anxiety	−1.81	−1.46	0.14	−0.96	−0.81	0.42
Depression	−3.64	−2.86	0.00***	−2.82	−2.35	0.02*
R^2 (R^2_{adj})	0.15 (0.13)			0.33 (0.29)		
F	8.10			7.73		
p	0.00			0.00		
T3						
Bonding	0.33	7.35	0.00***	0.34	7.95	0.00***
Caffeine	1.01	0.95	0.34	0.21	0.21	0.84
Alcohol						
Abstinent (reference)						
Low	−0.87	−1.19	0.24	−0.39	−0.56	0.58
Moderate, binge, heavy	−1.70	−1.04	0.30	−1.25	−0.81	0.42
Tobacco	1.88	1.14	0.25	0.61	0.38	0.70
Stress	0.83	0.54	0.59	0.33	0.23	0.82
Anxiety	1.13	1.05	0.29	0.51	0.50	0.62
Depression	−3.92	−3.17	0.00***	−3.57	−3.09	0.00***
R^2 (R^2_{adj})	0.19 (0.18)			0.33 (0.29)		
F	10.91			7.93		
p	0.00			0.00		

*$p < 0.05$, significance; **$p < 0.01$, significance; ***$p < 0.001$significance

[a] Note: Covariates for model B: age, country of birth, employment status, household income (before tax), first pregnancy, baby's birth weight (kg), gestational age at birth, problems during labour, breastfeeding problems, baby's crying time (min/day)

confirmation of these patterns using clinical observational tools (e.g. emotional availability scales) is recommended. Third, the antenatal and postnatal measures were not directly comparable which makes it difficult to assess differences in antenatal and postnatal bonding. It should be noted also that items on each measure represent a qualitatively different bond. The MAAS represents the felt bond towards the developing *fetus*, while the MPAS represents the felt bond towards the *infant*. Doubt might therefore be raised about the validity of a direct comparison between antenatal and postnatal bonding. It is also less clear what 'low' or 'risky' scores are in relation to bonding, both antenatally and postnatally. Despite these limitations, the strength of this study lies in its longitudinal nature which allowed for the examination of maternal-fetal/infant bonding at several time points, taking into account a number of important confounders.

Conclusions

This study confirms and extends previous research on maternal bonding by showing that higher antenatal bonding, across all three trimesters during pregnancy, predicted higher bonding to the infant at 8 weeks postnatally, after accounting for a range of demographic and postnatal covariates. Multiple antenatal waves during pregnancy allowed the ability to isolate effects and key intervention points. Thus, intervening during pregnancy to promote a healthy bond in the postnatal period when feeding, sleeping and other major routines are being established is important. These findings also contribute to knowledge on bonding by demonstrating that symptoms of depression and stress during pregnancy are associated with bonding at 8 weeks postnatal in a large sample of Australian women. Substance use had no association with bonding postpartum in the adjusted model, although quantity and frequency of use was low in the sample. Identification of stress and depressive symptoms in pregnancy may allow for intervention to reduce these symptoms and improve bonding.

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Compliance with ethical standards

Conflicts of interest We do not have any conflicts of interest affecting the conduct or reporting of this research.

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