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ORIGINAL CONTRIBUTION

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Can Maternal Prenatal Self-Reported and Physiological Distress Predict Postnatal Caregiving Practices?

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Maternal prenatal distress is associated with child outcomes, including health, neurocognitive, and socio-emotional development. Knowledge on underlying mechanisms is limited, yet relevant for prevention and intervention. This study investigated whether maternal prenatal distress predicts specific caregiving practices that are known for their effects on child outcomes. Caregiving practices studied were maternal caregiving quality and the initiation and course of breastfeeding and room-sharing. We hypothesized that more maternal prenatal distress would be associated with altered caregiving practices. Participants were 174 healthy mother-child dyads. During the 37th week of pregnancy maternal self-reported distress was assessed using questionnaires, and physiological stress by collecting saliva cortisol. Maternal caregiving quality was observed in postnatal week 5 during infant bathing. Weekly diaries on breastfeeding and daily diaries on room-sharing were completed during the first 6 postnatal months. In a regression analysis, no associations between maternal prenatal distress and caregiving quality were found. Multilevel analyses indicated that maternal prenatal evening cortisol was positively related to the initiation of breastfeeding and room-sharing. Replications are warranted, but these results suggest that breastfeeding and room-sharing initiation may be part of a mechanism underlying links between maternal prenatal physiological stress and child outcomes. As other prenatal cortisol markers and self-reported distress were not found to be related to the caregiving practices, it is likely that alternative mechanisms (co-)exist in explaining links between maternal prenatal distress and child outcomes. Future replication research including child outcomes and (other) potential mechanisms will inform prevention and intervention programs fostering healthy pregnancies and child development.

INTRODUCTION

Maternal prenatal distress, ie, stress and anxiety [1], can affect child outcomes. For example, exposure to maternal distress during pregnancy has been associated with more illnesses and health complaints, altered physiological and neurocognitive development, and more socio-emotional behavior problems in children [2-7].

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Abbreviations: AAP, American Academy of Pediatrics; APGAR, Appearance, Pulse, Grimace, Activity and Respiration; APL, Alle-daagse Problemen Lijst; BIBO, Basale Invloeden op de Baby Ontwikkeling; BSI, Behavioural Science Institute; CAR, Cortisol Awakening Response; C_x, Cortisol sample number $_x$; ECG, Ethische Commissie Gedragswetenschappen; EPDS, Edinburgh Postnatal Depression Scale; HPA axis, Hypothalamic–Pituitary–Adrenal axis; ICC, Interclass Correlation; KNAW, Royal Netherlands Academy of Arts and Sciences; nmol/L, Nanomol per Litre; ns, non-significant; NWO, Netherlands Organisation for Scientific Research; PES, Pregnancy Experience Scale; PRAQ-R, Pregnancy-specific Anxiety Questionnaire-Revised; STAI, State-Trait Anxiety Inventory.

Keywords: maternal prenatal distress, cortisol, self-report, caregiving quality, breastfeeding, room-sharing

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The links between maternal prenatal distress and child outcomes are part of the phenomenon known as fetal or prenatal programming because effects are often profound and long-lasting [8,9]. Knowledge on underlying mechanisms is limited yet highly relevant as a basis for the development of future prevention and intervention programs promoting public health by fostering maternal pregnancy health and child development.

One potential underlying mechanism associating maternal prenatal distress with child outcomes may be maternal postnatal caregiving practices, as maternal caregiving is known to affect child outcomes in important ways [1]. The current study will focus on the first step of this proposed mechanism, by investigating associations between maternal prenatal distress and caregiving practices. Specifically, we will investigate maternal caregiving quality (eg, sensitivity: the degree to which the mother timely and adequately responds to the needs and signals of the infant, and cooperation: the degree to which the mother refrains from interfering with the infant's ongoing activities and to which she adjusts her behavior towards the infant [10,11]). Maternal caregiving quality has been shown to contribute to a broad range of child developmental outcomes (see [12-18]). Moreover, we will study feeding and sleeping practices as highly relevant maternal caregiving practices. Medical organizations recommend exclusive breastfeeding (ie, providing the infant only breastmilk, and no other liquids or solids) and parent-infant room-sharing (ie, having the infant sleep on a separate surface within the parents' room) for the first 6 months after birth, because of their significant implications for infant outcomes [19,20]. However, parents differ widely in how they engage in these caregiving practices [21-23]. A potential factor that may explain individual variation in the initiation and course of breastfeeding and room-sharing in these first 6 months is maternal prenatal distress, the focus of the current study.

To date, only a few studies associated maternal prenatal distress and caregiving quality and the findings appear to be mixed. For example, studies found negative associations between self-reported maternal feelings of anxiousness, worries/negative affect during pregnancy and maternal expressiveness [24]. Also, prenatally anxious mothers (ie, with heightened symptoms of anxiety and/or depression) responded less to their infants before and after a stressor [25]. However, other studies found that prenatal distress was not associated with maternal sensitivity [26,27], and even that mothers with an anxiety disorder prenatally were more sensitive towards their 7-month-olds [28].

With respect to breastfeeding, studies suggest that prenatal distress is related to less frequent initiation and a shorter duration of breastfeeding [29-34]. However, other studies found no evidence for these associations [32,35], or reported associations in the opposite direction [36]. With respect to parent-infant room-sharing, to our knowledge no studies have been published to date on the topic, so it is unclear whether there is a link with maternal prenatal distress.

In general, most of these previously mentioned studies focused on maternal self-reports of distress and did not include physiological measures of stress. When the mother is exposed to stress, the Hypothalamic–Pituitary–Adrenal (HPA) axis is activated, resulting in the release of multiple hormones, including cortisol [1]. There are at least two reasons to include maternal cortisol concentrations next to self-reported distress in studies on prenatal distress. First, maternal self-reports of distress tend to be only weakly related to maternal cortisol concentrations during pregnancy [7], and second, maternal cortisol concentrations during pregnancy independently predict child outcomes irrespective of maternal self-reports of distress [2]. It is possible that altered maternal cortisol may affect the child by affecting maternal behavior [1], although to date, results are scarce and mixed. For example, one study revealed that women who formula-fed their infant had lower cortisol awakening responses (CARs) in prenatal week 24 (not 30 or 36). No associations between maternal prenatal evening cortisol and breastfeeding were found [35]. Also, prenatal cortisol responses of pregnant women were not predictive of their caregiving quality towards their 6-week-olds [37], and the prenatal CAR and cortisol decline were not correlated with maternal sensitivity towards their 6-month-old infant [38].

Overall, while studies have chronicled links between maternal prenatal distress and caregiving, results are mixed, possibly due to looking at specific or single measurements and measurement moments in time. Moreover, physiological stress associations with caregiving practices remain understudied, while parent-infant room-sharing as outcome has not been studied at all. Therefore, the current study will investigate how maternal prenatal self-reported distress (operationalized as pregnancy-specific and general stress and anxiety), and physiological stress (operationalized as diurnal cortisol concentrations) can predict postnatal: (a) caregiving quality, and the initiation and course of (b) breastfeeding, and (c) room-sharing (ie, having the infant sleep on a separate surface within the parents' room [19,20,39]). Caregiving quality will be measured with observations, breastfeeding and room-sharing will be measured with continuous and detailed diary recordings for the first 6 months postpartum. While we expect more prenatal distress, both self-report and cortisol measures of distress, to be associated with altered caregiving practices, due to the mixed results or absence of previous research, the directionality of these associations will not be specified.

Table 1. Descriptive Statistics of All Study Variables

	N	*M (SD)/n (%)*	*Min*	*Max*
Confounders				
Infant sex, n (%)	174			
Boy		91 (52.3%)		
Girl		83 (47.7%)		
Infant birth weight (grams)	172	3632.12 (465.45)	2645.00	4730.00
Infant number of siblings, n (%)	174			
First born		72 (41.4%)		
One sibling		76 (43.7%)		
Two or more siblings		26 (14.9%)		
Infant age at entering non-parental care (months)	169	4.56 (3.00)	1.00	12.00
Maternal age (years)	174	32.61 (3.77)	21.90	42.90
Maternal educational level	174	6.63 (1.49)	2.10	8.00
Maternal postnatal depression	172	4.94 (3.16)	0.00	14.81
Maternal postnatal stress	173	1.12 (0.38)	0.00	2.25
Maternal postnatal anxiety	173	28.38 (6.37)	20.00	48.78
Predictors – maternal prenatal distress				
Pregnancy-specific stress	174	0.33 (0.21)	0.00	1.03
Fear of giving birth	174	5.33 (2.37)	3.00	12.79
Fear of bearing a child with a disability	174	9.16 (3.34)	4.00	19.28
Stress	174	1.14 (0.46)	0.00	2.51
Anxiety	174	32.19 (8.74)	20.00	58.87
Cortisol decline (nmol/L[a])	148	6.67 (4.37)	-2.80	20.13
Evening cortisol (nmol/L[a])	155	9.57 (2.95)	0.85	23.83
Outcomes – postnatal caregiving practices				
Caregiving quality	173	5.47 (2.02)	1.00	9.00
Breastfeeding (mean % over first 27 weeks)	160	59.99 (39.80)	0.00	100.00
Room-sharing (mean % over first 27 weeks)	159	36.58 (37.33)	0.00	100.00

Note. For all presented variables the outliers were winsorized. [a] nmol/L = Nanomol per Litre

MATERIALS AND METHODS

Participants

Data of the ongoing longitudinal BIBO project (Radboud University), approved by the Institutional Ethical Committee following the Helsinki Declaration (ECG 300107), were used. Mothers were recruited through flyers in midwife practices in two cities and their surroundings. Inclusion criteria were an uncomplicated singleton pregnancy, a good understanding of the Dutch language, no use of drugs nor health problems (physical or mental) during pregnancy, delivery after at least 37 weeks, and an infant 5-minute APGAR score of 7 or higher. APGAR is a quick health test that judges newborns' Appearance, Pulse, Grimace, Activity, and Respiration, each scored on a scale of 0 to 2, with 2 being the best score, and the sum being the total score. In total, 220 mothers enrolled and gave informed consent (see Appendix A for the informed consent form used). Of this group, 46 dyads were excluded from the current study (due to medical reasons, $n = 8$, starting participation after delivery, $n = 20$, or discontinuing the study during the first 3 postnatal months, $n = 18$). This resulted in a group of 174 mother-child dyads (see [2]). See Table 1 for demographical data.

Procedure

This section provides an overview of the study procedures that will be described in detail below. Prenatally, as in previous studies (eg, [2,5]) to measure maternal self-reported distress during pregnancy, mothers filled out paper questionnaires regarding feelings of pregnancy-specific and general stress and anxiety ($M = 35.29$

weeks; *SD* = 1.22). To measure physiological stress, mothers collected several cortisol saliva samples over the day, for two days in a row, during the last trimester of pregnancy, just before giving birth (*M* = 37.37 weeks; *SD* = 1.68). Both the questionnaires and a detailed written instruction on how to collect cortisol saliva samples were sent to the pregnant women simultaneously by mail. They were asked to carefully read the instructions and contact the researchers should any question arise. The saliva collection instructions included information on rinsing the mouth with water before starting collection, how to spit in the flacons, and at what time and under what circumstances to collect the samples (eg, before breakfast/lunch/dinner and before brushing their teeth). Mothers were instructed to register time of sampling (to check compliance) and to store the samples in their home freezer until the researcher collected them during the home visit at infant age 5 weeks. At the university, samples were stored in the freezer at -25ºC.

During a home visit at 5 weeks after delivery, mothers were videotaped while bathing their infant (ie, undressing, bathing, dressing) to observe caregiving quality [11,40]. Families were visited at the time the infant would normally be bathed and the mothers were instructed to bathe their infant as they would normally do. These sessions were filmed unobtrusively and observed afterwards. The age of 5 weeks was chosen because at this age infants are around their crying peak [41] and there is a higher chance of infants showing distress during the interaction. Observations of caregiving quality in interactions with distressed infants are better predictors of children's outcomes than those of interactions with non-distressed infants [42].

During the first 6 months, mothers kept diaries on breastfeeding and room-sharing [43]. Mothers received these diaries with instructions already during pregnancy, so they could start filling it in immediately after birth. Measures of breastfeeding were collected on a weekly basis and measures of room-sharing on a daily basis. The reason for this difference is that breastfeeding shows little daily variability (eg, switching between breast and formula), while parents tend to often switch between sleeping arrangements as a reaction to day-to-day variability in infant fussing/crying (eg, [44]). Furthermore, by measuring breastfeeding only once a week, and room-sharing only from 20:00 and 08:00 hour (ie, recalling the past night every morning), we importantly reduced the burden of filling out diaries for new mothers. Compliance with the diary measures was reviewed during two home visits (at infant age 5 weeks and 5 months).

At 3 and 6 months postnatally, mothers received a paper booklet with surveys on their feelings of distress. After completion, mothers returned these booklets by mail.

Measures

Pregnancy-specific stress: As in earlier research [45], mothers indicated for the 43 pregnancy-specific stressors of the Pregnancy Experience Scale (PES; [45]), the extent to which each resulted in positive and negative feelings (4-point scales). Cronbach's α in our sample was 0.87 for positive and 0.88 for negative ratings. The sum of the negative items' ratings was divided by the sum of the positive items' ratings. Higher scores represent more negative emotional valence towards pregnancy due to pregnancy-specific daily hassles, more stress.

Pregnancy-specific anxiety: In line with previous research in the field of prenatal anxiety (eg, [2,46,47]), mothers answered two subscales of the Pregnancy-specific Anxiety Questionnaire-Revised (PRAQ-R; [46-48]) the fear of giving birth (3-items; [49]) and fear of bearing a child with a disability (4-items; [49]), using 5-point scales. Cronbach's α in our sample was 0.70 for fear of giving birth, and 0.83 for fear of bearing a child with a disability. Sum scores of both scales were calculated. Higher scores represent more fear of giving birth and more fear of bearing a child with a disability.

Stress: As in earlier research in the field of prenatal stress [2], mothers indicated for the 49 daily hassles of the Dutch daily hassles questionnaire: Alledaagse Problemen Lijst –APL, whether they had occurred in the past 2 months, and if so, how much they had bothered them (4-point scales; test-retest reliabilities 0.76-0.87; [50]). The sum of the ratings was divided by the number of reported events. Higher scores represent more experienced negativity due to daily hassles, more stress.

Anxiety: Mothers answered the 20-item State subscale of the State-Trait Anxiety Inventory (STAI; [51,52]) on 4-point scales. Cronbach's α in our sample was 0.93. Sum scores were calculated. Higher scores represent more feelings of anxiety.

Diurnal cortisol concentrations: Mothers collected five saliva samples by passive drooling on two consecutive days, each day at awakening, 30 minutes after awakening, at 12:00, 16:00, and 21:00 hours. Samples were stored at -25ºC and subsequently analyzed by the Laboratory of Endocrinology of the University Medical Center Utrecht (for details, see [4]). To reduce fluctuations in cortisol concentrations, samples collected outside the following time windows were removed: C1 between 6:00 and 10:00 hours and within 15 minutes after awakening, C2 between 25 and 35 minutes after awakening, C3 between 11:30 and 13:30 hours, C4 between 15:30 and 17:30 hours, and C5 between 20:00 and 23:00 hours [2,4,5]. Additionally, samples collected during/after the day of delivery were removed. In total, 98 samples (6.45%; [4,5]) were removed. Previous research has shown that the cortisol decline from morning to evening, and the evening cortisol measure, are predictors of child

outcomes [2]. Therefore, and consistent with previous papers [2,4,5], diurnal cortisol decline (the awakening minus the 21:00 hour sample) and evening cortisol (the 21:00 hour sample) were used as markers of the cortisol diurnal rhythm. These measures were calculated based on mean scores of each of the sample moments over the two collection days [2]. Higher scores represent a steeper diurnal cortisol decline and a higher evening cortisol concentration.

Caregiving quality: To measure maternal caregiving quality as in previous research [53], videotaped maternal caregiving behavior during an infant bathing session (ie, undressing, bathing, dressing) was observed. A bathing session is known to be a mild stressor [54,55], eliciting stress in most infants (eg, fussing, crying, cortisol increases), making this situation highly appropriate to observe maternal sensitivity and cooperation. In addition, because infants are bathed regularly, mother-infant dyads are filmed in their homes during a home visit, and the great majority of mothers are comfortable with the situation, the ecological validity of this measure is high [40,53,56,57]. Two or more independent trained observers (ie, PhD students), who were not familiar with the study goals and the mother-infant dyads, each observed all bathing session videos. These observers were trained by a senior researcher experienced in observing and rating mother-infant interactions on caregiving quality, by using training videos of other studies. After becoming reliable, the observers rated the videos of the current study for maternal sensitivity (ie, the degree to which the mother timely and adequately responds to the needs and signals of the infant) and cooperation (ie, the degree to which the mother refrains from interfering with the infant's ongoing activities and to which she adjusts her behavior towards the infant) [10,11]. The Ainsworth rating scales used range from 1 (ie, not being aware of signals of the infant (low sensitivity) and being highly interfering and physically forceful (low cooperation)) to 9 (ie, being exquisitely attuned to signals of the infant, and responding to them promptly and appropriately (high sensitivity) and being totally geared to the wishes and activity of the infant (high cooperation)). Scores of 5 represent mothers who are inconsistent in their sensitivity or, for cooperation, not so much interfering, but inconsiderate, of the wishes and activities of the infant. The reliability of these rating scales has been extensively proven [58]. Moreover, maternal caregiving quality, rated with these scales, is a good predictor of a range of child outcomes, including behavioral problems and biological markers [59]. Inter-observer reliability after the training and during the scoring was good; intra-class correlations > 0.90 for both sensitivity and cooperation. In concordance with earlier research and our previous studies [11,53,56], and because of the high intercorrelation ($r = 0.82$, $p = 0.001$), the average of the sensitivity and cooperation score was calculated and used in the analyses. This reduces the number of statistical analyses and associated risk of Type I errors. Higher scores represent higher maternal caregiving quality.

Breastfeeding: Mothers reported weekly on the mean number of breast feedings, expressed breast feedings, and formula feedings [43,60]. The weekly percentage of breast feedings of the total number of feedings was calculated. To increase reliability, the weekly percentage breast feedings was only calculated if at least 17 of the 27 diary weeks were filled out. In addition, infants that were bottle-fed with expressed milk were excluded (ie, 90% or more of all daily feedings for 2 weeks or more; $n = 6$; [60]) since being fed pumped milk is different from breastfeeding for several reasons (eg, less skin-to-skin contact between mother and infant; expressed milk could be given by someone else than the mother (eg, father)). Higher scores represent higher weekly percentages of breastfeeding.

Room-sharing: Mothers used a daily diary to indicate in blocks of 30-minutes between 20:00 and 08:00 hours, if their infant was sleeping and if so, where: own room, separate bed in the parents' room, in the parents' bed, or somewhere else [43,60]. Mothers were asked to complete this diary every morning, recalling the sleeping arrangements of the past night. The average weekly percentage room-sharing (ie, sleeping in a separate bed in the parents' room) of the total amount of nighttime sleep was calculated. Nighttime was defined as between 0:00 and 05:00 hours [43,61]. To increase reliability, this score was only calculated if data were available for at least 3 of 7 days within a week and for at least 17 of the 27 weeks. Moreover, in line with the definition of room-sharing (ie, sleeping on a separate surface within their parents' room), infants who slept in the parents' bed (ie, 90% or more of the time for 2 weeks or more; $n = 7$) were excluded [60] because this behavior is different from room-sharing and only a few parents did this ($n = 7$). Higher scores represent higher weekly percentages of room-sharing.

Potential confounders: Infant sex (boy, *0*, girl, *1*), birthweight (grams), number of siblings (first born, *0*, one sibling, *1*, two or more siblings, *2*), age at entering non-parental care (months), maternal age (years), educational level (primary, *1*, to university, *8*), postnatal feelings of depression, stress, and anxiety were measured. Maternal postnatal feelings of depression were assessed using the 10-item Edinburgh Postnatal Depression Scale (EPDS; [62]) at 3 and 6 months (Cronbach's $\alpha = 0.89$ and 0.78, respectively). Maternal postnatal feelings of stress and anxiety were measured using the same stress and anxiety scales as used prenatally, at 3 and 6 months (see above; anxiety Cronbach's $\alpha = 0.93$ and 0.91 at 3 and 6 months, respectively). Average scores of the 3

and 6 month depression (Spearman's *rho* = 0.48, *p* = 0.001), stress (Spearman's *rho* = 0.63, *p* = 0.001), and anxiety (Spearman's *rho* = 0.55, *p* = 0.001) scores were calculated. Higher scores represent more psychological complaints. Postnatal stress and anxiety measures were included to be able to study the specific effects of prenatal stress and anxiety. Postnatal depression was included as a confounder to control for its potential effects on maternal caregiving behavior.

Data preparation and analyses: Missing values were inspected. Overall, 7.83% of the data was missing, partly because of the exclusion of seven bedsharing participants, and partly due to other reasons (eg, invalid logbook data or samples not containing enough saliva). The following outliers (3*SD) were detected and winsorized [63] in maternal prenatal distress variables: pregnancy-specific stress (*n* = 4), fear of giving birth (*n* = 5), fear of bearing a child with a disability (*n* = 2), stress (*n* = 1), anxiety (*n* = 3), diurnal cortisol decline (*n* = 1), evening cortisol (*n* = 2), (b) potential confounding variables: maternal educational level (*n* = 2), maternal postnatal depression (*n* = 2), stress (*n* = 1), and anxiety (*n* = 4). See Table 1 for the number of participants per variable.

To examine associations between maternal prenatal distress and caregiving quality, a hierarchical multiple regression analysis, using listwise deletion for missing values, was conducted. Confounders that were significantly associated with caregiving quality were included in Step 1, followed by the predictors representing maternal prenatal distress in Step 2 [64]. Assumptions were met.

To examine whether maternal prenatal distress was associated with the initiation and course of breastfeeding and room-sharing, two longitudinal regression analyses using mixed-model (multilevel) designs were performed. Since mixed-model (multilevel) analyses are robust for missing data, all valid data points could be included in the model [64]. Breastfeeding and room-sharing were introduced at Level 1, and nested within the mother-infant dyad at Level 2. The interclass correlation (ICC) was calculated, using the null model. The ICC's for breastfeeding and room-sharing were 0.71 and 0.64, indicating that sufficient variability was associated with difference between mother-infant dyads, and that multilevel analyses are appropriate [64]. Subsequently, variables were added hierarchically one-by-one using a build-up strategy. The likelihood ratio test was used to compare each model [65]. Linear time and quadratic time were entered first. Linear time and the intercept were considered as random factors. Thereafter, all confounders were added, followed by the maternal prenatal distress variables, the two-way interactions between time and the maternal prenatal distress variables, and the two-way interactions between time squared and the maternal prenatal distress variables. During the build-up process, within each step the variable with the highest significant deviance score on the -2log likelihood scale was entered first, and only variables that significantly improved the model were retained. In all analyses a *p*-value of < 0.050 is interpreted as significant.

RESULTS

Preliminary Analyses

Descriptive statistics are presented in Table 1. In Table 2, Spearman correlations between all study variables can be found. Spearman correlations were used since all variables, except for maternal age, birthweight, and maternal postnatal stress, were non-normally distributed. No significant associations were found between maternal prenatal distress variables and caregiving quality, all *p's* = ns. Correlations with breastfeeding and room-sharing were calculated for mean scores over all 27 weeks. Less fear of bearing a child with a disability was related to more room-sharing (Spearman's *rho* = -0.16, *p* = 0.047).

Main Analyses

Caregiving quality: The regression model predicting caregiving quality is not significant, see Table 3, $F(7, 139) = 1.70$, $p = 0.114$.

Breastfeeding: The best fitting multilevel growth curve model for the initiation (ie, the initial percentage of breastfeeding after birth, measured by the intercept) and course of breastfeeding is presented in Table 4. Breastfeeding was predicted by time (*Estimate* = -2.05, *SE* = 0.21, $p < 0.001$), the quadratic effect of time (*Estimate* = 0.02, *SE* = 0.01, *p* = 0.001), and maternal prenatal evening cortisol (*Estimate* = 2.90, *SE* = 1.20, *p* = 0.017). The weekly percentage of breastfeeding decreased over time and this decline seemed steepest soon after delivery (see [60,65]). Moreover, higher maternal evening cortisol concentrations were associated with a higher percentage of breastfeedings at intercept (ie, during the first week after delivery).

Room-sharing: The best fitting multilevel growth curve model for the initiation (ie, the initial percentage of room-sharing after birth, measured by the intercept) and course of room-sharing is presented in Table 4. Room-sharing was predicted by time (*Estimate* = -3.79, *SE* = 0.25, $p < 0.001$), the quadratic effect of time (*Estimate* = 0.08, *SE* = 0.01, $p < 0.001$), maternal educational level (*Estimate* = 6.22, *SE* = 2.18, *p* = 0.005), and maternal prenatal evening cortisol (*Estimate* = 3.86, *SE* = 1.24, *p* = 0.002). The weekly percentage of room-sharing decreased over time and this seemed steepest soon after delivery (see [60,65]). Higher maternal educational level and higher maternal evening cortisol concentrations were associated with a higher percentage of room-sharing at intercept (ie, during the first week after delivery).

Table 2. Spearman Correlations Between All Study Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Confounders																		
1. Infant sex	-																	
2. Infant birthweight	-0.25**	-																
3. Infant number of siblings	0.01	0.11	-															
4. Infant age entering non-parental care	0.13	0.05	0.07	-														
5. Maternal age	-0.06	0.12	0.35***	-0.08	-													
6. Maternal educational level	0.07	-0.06	-0.08	-0.05	0.08	-												
7. Maternal postnatal depression	0.01	-0.02	-0.03	0.09	0.06	-0.09	-											
8. Maternal postnatal stress	0.17*	-0.02	-0.05	0.04	<0.01	-0.02	0.39***	-										
9. Maternal postnatal anxiety	0.02	-0.01	-0.01	0.01	0.04	-0.02	0.65***	0.35***	-									
Predictors - maternal prenatal distress																		
10. Pregnancy-specific stress	0.06	-0.01	0.03	0.08	-0.05	0.01	0.43***	0.43***	0.35***	-								
11. Fear of giving birth	0.07	-0.11	-0.21**	0.01	0.04	0.10	0.35***	0.18*	0.36***	0.28***	-							
12. Fear of bearing a child with a disability	0.08	<0.01	-0.15*	-0.13	-0.06	-0.04	0.07	0.13	0.16*	0.20**	0.14	-						
13. Stress	0.21**	0.04	0.04	0.14	0.10	-0.06	0.27***	0.49***	0.19*	0.25***	0.15	0.10	-					
14. Anxiety	-0.02	-0.02	0.03	0.06	-0.02	0.04	0.38***	0.26***	0.54***	0.43***	0.35***	0.13	0.26***	-				
15. Cortisol decline	0.09	-0.04	-0.02	0.12	-0.11	-0.03	-0.08	0.07	-0.01	0.16	-0.04	-0.18*	-0.05	-0.03	-			
16. Evening cortisol	-0.04	-0.01	-0.14	-0.02	0.07	-0.02	-0.03	-0.13	-0.04	-0.19*	0.06	-0.03	-0.07	<0.01	-0.27***	-		
Outcomes – postnatal caregiving practices																		
17. Caregiving quality	-0.04	-0.01	-0.08	<-0.01	0.02	0.10	0.04	0.01	-0.04	0.03	-0.08	-0.12	0.03	-0.08	0.16	<-0.01	-	
18. Breastfeeding (mean % over first 27 weeks)	-0.02	0.06	-0.07	0.15	-0.07	0.15	0.02	0.06	-0.04	0.06	0.02	-0.07	-0.04	0.12	0.02	0.12	0.10	
19. Room-sharing (mean % over first 27 weeks)	-0.02	<-0.01	0.17*	0.10	0.18*	0.24**	0.03	-0.02	0.08	0.09	-0.02	-0.16*	-0.07	0.14	<0.01	0.14	0.12	0.39***

Note. For all presented variables the outliers were winsorized. *$p < 0.050$, **$p < 0.010$, ***$p < 0.001$.

Table 3. Hierarchical Regression Model Predicting Caregiving Quality from Maternal Prenatal Distress

	Caregiving Quality[a]		
	B	ß	R^2_{model}
Pregnancy-specific stress	0.14	0.01	0.08
Fear of giving birth	-0.04	-0.05	
Fear of bearing a child with a disability	-0.04	-0.07	
Stress	0.32	0.07	
Anxiety	-0.03	-0.13	
Cortisol decline (nmol/L[a])	0.09	0.20*	
Evening cortisol (nmol/L[a])	0.07	0.09	

Note. Outliers were winsorized, but similar results were found when outliers were included. [a] No confounders were included in the model since no significant associations were found between confounders and caregiving quality. [a] nmol/L = Nanomol per Litre. $^{*}p < 0.050$, $^{**}p < 0.010$, $^{***}p < 0.001$.

DISCUSSION

We investigated how maternal prenatal self-reported and physiological distress predicted: (a) caregiving quality at 5 weeks, and the initiation and course of (b) breastfeeding and (c) room-sharing during the first 6 months. Contrary to our expectations, no associations between maternal prenatal distress and caregiving quality and the course of breastfeeding or room-sharing were found. Maternal prenatal evening cortisol was positively related to the initiation of breastfeeding and room-sharing.

As mentioned before, the results of the scarce earlier studies on maternal prenatal distress and caregiving quality have been mixed (eg, [24-28]). That in our study no associations were found between prenatal distress and caregiving quality is in line with several studies in which prenatal distress was not associated with maternal sensitivity [26,27] and no links were found between caregiving quality and (1) maternal prenatal diurnal cortisol decline [38], (2) maternal prenatal cortisol awakening response [38], and (3) maternal prenatal cortisol response to caring for an unsoothable infant simulator [37]. This may suggest that links between maternal prenatal distress and maternal caregiving quality are not so strong and that other explanatory mechanisms, such as fetal programming through prenatal maternal lifestyle behaviors (ie, diet, sleep) [1] may better explain the often found links between maternal prenatal distress and child development [2-7]. Note, however, that non-significant findings do not prove de absence of a link. Given the importance of high-quality maternal caregiving for healthy child development from birth onwards [12,15], more research on early predictors of caregiving quality is warranted.

Higher concentrations of evening cortisol at the end of pregnancy were positively associated with the initiation of breastfeeding. This is not in line with an earlier study that did not find differences between breastfeeding and bottle-feeding mothers in their prenatal evening cortisol concentrations at 24, 30, and 36 weeks [35]. However, this same study did reveal that women who formula-fed their infant had lower cortisol awakening responses in prenatal week 24. An explanation for our breastfeeding results may be that there is a third factor in play, such as caregiving choices made by mothers by the end of pregnancy, affecting both evening cortisol and initiation of breastfeeding. For example, mothers planning to breastfeed their infant may experience higher physiological stress towards the end of pregnancy due to worries regarding the success of their breastfeeding choice. Also, a biological mechanism may explain the link between heightened pregnancy cortisol and initiating breastfeeding. Earlier research states that maternal cortisol in pregnancy may be necessary for the development of secretory activation needed for breastfeeding [35,66]. However, more research is needed to understand the links between different diurnal cortisol measures in various periods of pregnancy and breastfeeding initiation [35]. We did not find support for associations between maternal prenatal self-reported distress and the initiation or course of breastfeeding nor for associations between physiological stress and the course of breastfeeding. These results may suggest that prenatal physiological stress is especially predictive of breastfeeding initiation through biological mechanisms. Note that these explanations remain speculative and more research is needed to replicate these findings. Given the importance of breastfeeding for healthy child development and the fact that exclusive breastfeeding is recommended for the first 6 months by the American Academy of Pediatrics (AAP; [20]), knowledge on early predictors of breastfeeding initiation will foster future intervention and prevention programs.

Higher maternal evening cortisol at the end of pregnancy was also positively associated with the initiation

Table 4. Estimates for the Best Fitting Multilevel Models Predicting Breastfeeding and Room-sharing from Maternal Prenatal Distress

	Breastfeeding		Room-Sharing	
	Estimate	*SE*	*Estimate*	*SE*
Fixed effects				
Intercept	47.17	29.87	-36.27	31.61
Time linear	-2.05	0.21***	-3.79	0.25***
Time quadratic	0.02	<0.01**	0.08	0.01***
Confounders				
Infant age at entering non-parental care	0.42	1.20	0.71	1.07
Infant birthweight	<0.01	<0.01	0.01	0.01
Maternal postnatal depression[a]	-0.46	1.08	1.37	0.95
Infant number of siblings			-13.89	9.08
Maternal educational level[a]			6.22	2.18**
Predictors - maternal prenatal distress				
Cortisol decline (nmol/L[b])[a]	0.31	0.77	0.75	0.73
Evening cortisol (nmol/L[b])[a]	2.90	1.20*	3.86	1.24**
Random effects				
Intercept	1610.22	203.43***	1952.12	254.69***
Time	3.49	0.45***	3.80	0.50***
Deviance	30075.51		30609.66	

Note. [a] For presented variables the outliers are winsorized, but similar results were found when outliers were included. [b] nmol/L = Nanomol per Litre. *p < 0.050, **p < 0.010, ***p < 0.001.

of parent-infant room-sharing. Earlier research showed that persistent co-sleeping has been linked to marital and co-parenting distress [67]. Possibly, these feelings of distress already exist prenatally, affecting both physiological stress and the choice for room-sharing. However, we did not find support for links between self-reported maternal prenatal distress and room-sharing initiation. Alternatively, earlier research uncovered an association between higher maternal prenatal evening cortisol concentrations and lower quality of self-reported maternal prenatal sleep as well as a shorter gestational length [68]. Possibly, lower prenatal sleep quality and a shorter gestational length result in mothers wanting to keep their infant closer at night after birth, (ie, to prevent fragmented sleep or to be able to monitor the newborn better), resulting in more initiation of room-sharing. In addition, earlier research showed that higher levels of early afternoon maternal prenatal cortisol are related to a more difficult infant temperament, specifically more maternal reported negative reactivity [69]. Possibly, a more difficult temperament in turn also leads to more room-sharing to be able to soothe the infant more easily at night. We did not find support for links between prenatal distress and the course of room-sharing. Given the importance of room-sharing for healthy child development and the recommendation of the AAP to practice parent-infant room-sharing for the first 6 months [39], more research is needed to better understand what predisposes parents to engage in lengthy parent-infant room-sharing or not.

An asset of this study is the broad range of measures used. For maternal distress, both self-reported and physiological measures were used. For caregiving practices, observations and extensive diaries were used, with breastfeeding and room-sharing measured weekly and daily, respectively, for 27 weeks. Additionally, by controlling for postnatal self-reported maternal distress, we were able to focus specifically on the role of prenatal self-reported distress. Limitations of the study are that, since a correlational design was used, no causal conclusions can be drawn. Also, because the sample consisted of mostly highly educated mothers (possible partly due to the recruitment methods and inclusion/exclusion criteria), findings may be less generalizable to broader populations. Although we took many potential predictors and confounders into account, other factors such as maternal depression, experiences of mild pregnancy-related

complications and of the birthing experience, could have played a role and should be investigated in the future. Furthermore, while diaries and maternal recall are often used to assess breastfeeding/room-sharing practices [60,65,70], the specific diaries used in this study have not yet been validated by nightly video observations or wearables. In the present study, caregiving quality was observed during a bathing session, which is known to be an ecologically valid mother-infant interaction that elicits mild stress in infants [54,55]. However, maternal caregiving quality to infant distress can be different to maternal caregiving quality to infant non distress, raising a generalizability question [71]. Lastly, it is important to note that this study only investigated the first step of the proposed mechanism of how caregiving practices may underlie the often-observed relations between maternal prenatal distress and child outcomes. Hence, it is not possible to draw conclusions about an actual mediating role of caregiving practices.

To move the field further, next to replicating the current design, broadening the concept of distress (eg, by including depression), adding other maternal prenatal mental (eg, caregiving choices, birthing experiences) and physical (eg, mild pregnancy complications, sleep quality) variables would greatly enrich our knowledge about relevant predictors of caregiving. Postnatally, measures of the mother's physical and psychological recovery from giving birth should also be included as they may importantly impact a mother's caregiving capacities [72,73]. Moreover, also infant factors, like sleeping patterns and temperament [74], and partner factors, such as paternal ideas about caregiving and physical and psychological support for the mother, may affect maternal choices and caregiving practices [75,76]. Broadening the study design to include these potentially relevant explanatory variables will help obtain a more complete picture of early life caregiving dynamics. Finally, including child outcomes will be an important next step in determining the potential mediation role of maternal caregiving practices in the association between maternal prenatal distress and child outcomes.

Overall, the current study indicates that maternal prenatal evening cortisol is predictive of the initiation of breastfeeding and room-sharing. These results may suggest that breastfeeding and room-sharing initiation may be part of a mechanism underlying links between maternal prenatal physiological stress and child outcomes. Although replications and extensions of this study are warranted, the fact that a physiological stress marker at the end of pregnancy was associated to maternal caregiving behavior following delivery, is intriguing and inviting for future psychobiological studies on underlying mechanisms. Results of such investigations may help inform preventive interventions aimed at fostering healthy pregnancies and child development in the future. Note that given that other prenatal cortisol markers and self-reported distress were not found to be related to the caregiving practices under investigation, and no support for associations between maternal prenatal distress and caregiving quality or the course of breastfeeding and room-sharing is found, it is likely that alternative, possibly complementary, mechanisms such as maternal health, lifestyle behaviors, and placental functioning [1], (co-) exist in explaining links between maternal prenatal distress and child outcomes.

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Author Contributions: **SSHS**: Contributed substantially to the conception and design of the work and interpretation of data for the work; Drafted the work and revised it critically for important intellectual content; Approved the final version to be published; Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. ORCID iD: 0000-0002-4483-0255.
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CdW: Contributed substantially to the conception and design of the work; Revised the work critically for important intellectual content; Approved the final version to be

published; Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. ORCID iD: 0000-0002-0921-1811.

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Appendix A: Informed Consent form - ***Agreement Bibo study***

Herewith declares

Name and surname: …….

Address:..…….……...

Zip code/Town:……..……..…..……..

Phone number:……..…….

Date of birth:…….……...……

to have been informed orally and/or in writing about the study "**Basale Invloeden op de Baby Ontwikkeling**".

The goal of the study has been explained to me and I declare to participate voluntarily. It is also clear to me that I can stop my participation at any time without giving any reasons.

Signature: ……..... Date:……..

Permission use video material

I provide the department of developmental psychology permission to show video material made during the experiment (please tick as appropriate, ticking is not obligatory!):

□ To illustrate the research (to fellow professionals)
□ For educational purposes (to students)

It is clear to me that no personal data will be disclosed to third parties in this process.

Signature: ……..... Date:……..

Permission approach follow-up research

It is possible that the researchers would like to carry out a follow-up study after the Bibo study is completed. In view of this, we ask your permission to approach you after the study for a possible follow-up study. Your permission to be approached does not mean that you consent to a follow-up study, but it does mean that you have no objection to being approached for a follow-up study by the researchers involved after the study has ended.

I provide the involved researchers permission to approach me for a follow-up study after the study has ended.

Signature: ……..... Date:……..

Declaration of confidentiality of personal information

The researchers declare that personal data of participants will never be shared with others than the responsible researches, nor will data of individual participants collected in this study be shown to third parties. The researchers declare that any analysis of data by third parties will be done anonymously on the basis of a subject number. The link between this number and personal data is only known by the researchers involved.

On behalf of BIBO

.....
(name researcher)