Mothers' Perceptions of Quality of Family-Centered Care and Environmental Stressors in Neonatal Intensive Care Units: Predictors of and Relationships with Psycho-emotional Outcomes and Postpartum Attachment

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Abstract

Objectives Maternal attachment to promote role development in mothers of preterm infants is critical for babies' optimal growth and development. However, few models specify how neonatal intensive care units (NICUs) and their environments work to foster postpartum attachment (PPA) after preterm birth. We investigated relationships of quality of family-centered care and NICU environmental stressors with maternal PPA, to determine whether these are mediated by mothers' psycho-emotional response and whether pathways to PPA are moderated by developmental immaturity (gestation, birthweight).

Methods A cross-sectional study using structural equation modeling was conducted on 294 mothers of premature infants with experience in NICUs in over 49 tertiary hospitals in 12 cities or provinces of South Korea. Data were collected using Korean versions of instruments including the Quality of Family-centered Care, Parental Stressor Scale: NICU, and Maternal Postpartum Attachment Scale.

Results Maternal self-representation was a key predictor of PPA ($\beta = .68$), accounting for 42.2% of variance. Multi-group analysis indicated that NICU environmental stressor sensitivity ($\beta = .26$) and maternal self-representation ($\beta = .67$) were predictive of PPA in mothers of moderately preterm and low birthweight (32–36 weeks' gestation, 1500–2499 g birthweight) infants. Quality of family-centered developmental care ($\beta = .11$) and NICU environmental stressor sensitivity ($\beta = -.16$) had significant indirect effects on PPA through psycho-emotional responses.

Conclusions for Practice Healthcare professionals should be aware of the importance of family-centered interventions focusing on psychosocial support and family participation in baby care, based on their environmental role in promoting PPA.

Keywords Postpartum attachment · Preterm infant · Neonatal intensive care unit · Family-centered developmental care · Maternal representation

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Significance

What is already known on this subject? Mothers of premature infants may face challenges in establishing attachment with their preterm or low birthweight infants in the NICU; however, limited evidence exists.

What this study adds? Maternal self-representation had a strong association with postpartum maternal attachment and mediated the relationship between quality of family-centered developmental care, NICU environmental stressors, and psycho-emotional distress. Differences in factors that could impact maternal attachment after preterm birth, according to babies' birthweight and gestation, were examined. Healthcare professionals can successfully promote

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attachment development in NICU mothers through a family-friendly environment, a relationship-based culture, and by providing psychosocial support.

Introduction

Maternal postpartum attachment (PPA) is a psychosocial developmental process initiated when a mother recognizes her role of child care following childbirth (Kim and Tak 2018). A mother who is sensitive and responsive to her infant establishes sustainable affection or a strong emotional bond with them and vice versa (Kim and Tak 2018; Wolke et al. 2013). Maternal attachment is a dominant factor improving maternal role development in mothers of preterm/low birthweight infants (Kim et al. 2018) at high risk of sequelae including neurobehavioral abnormalities and cognitive impairments, and disorganized attachment relationships (Wolke et al. 2013; Pennestri et al. 2015). Although optimal growth and development of fragile infants after leaving the neonatal intensive care unit (NICU) are largely determined by their mothers' attachment, the trauma of preterm birth and admission to the NICU interrupt normal attachment development (Hasanpour et al. 2017; López-Maestro et al. 2017).

Recent reviews suggest that family-centered developmental care and a family-supportive NICU environment can recreate the disrupted process of attachment development (Altimier 2015; Altimier and Phillips 2016; Craig et al. 2015). Nevertheless, uncertainty remains on how NICU care and the NICU environment foster maternal attachment after preterm birth. This study provides empirical evidence to understand the mechanism of atypical attachment in mothers of preterm/low birthweight infants, and presents a framework integrating theory and models including the cognitive-motivational-relational theory of emotion (Lazarus 1991a, b), an internal working model (Bowlby 1982, 1988), and a neonatal integrative developmental care model (Altimier and Phillips 2013, 2016) (Fig. 1).

A hypothetical model for the process of PPA was developed, guided by Lazarus's theory of emotion and the aforementioned models in nursing and psychological science. Traumatic events or environmental stimuli such as having a preterm infant admitted to the NICU motivate cognitive appraisal of the NICU care and environment. Adaptive coping behavior or action on PPA can be synchronized through individual emotional responses to the traumatic crisis (Fig. 2). The quality of family-centered development is regarded as a determinant of psycho-emotional distress, through supporting maternal adaptation to NICU environmental challenges (Altimier 2015; Altimier and Phillips 2013, 2016), while the experience of hospitalization in the NICU and related environmental stressors may impact PPA development (Aftyka et al. 2017; Altimier 2015; López-Maestro et al. 2017; Pennesti et al. 2015). For the socio-emotional developmental health outcome of maternal PPA in mothers of preterm children, psycho-emotional distress—which can be affected by family-centered developmental care and a supportive NICU environment (Altimier 2015; Altimier and Phillips 2016; Hall et al. 2017a)—was addressed as an important mediating factor. With the possibility of distortion or reintegration by antecedents such as psycho-emotional distress (Hall et al. 2017a, b), and NICU environmental stressors (Altimier and Phillips 2013, 2016),
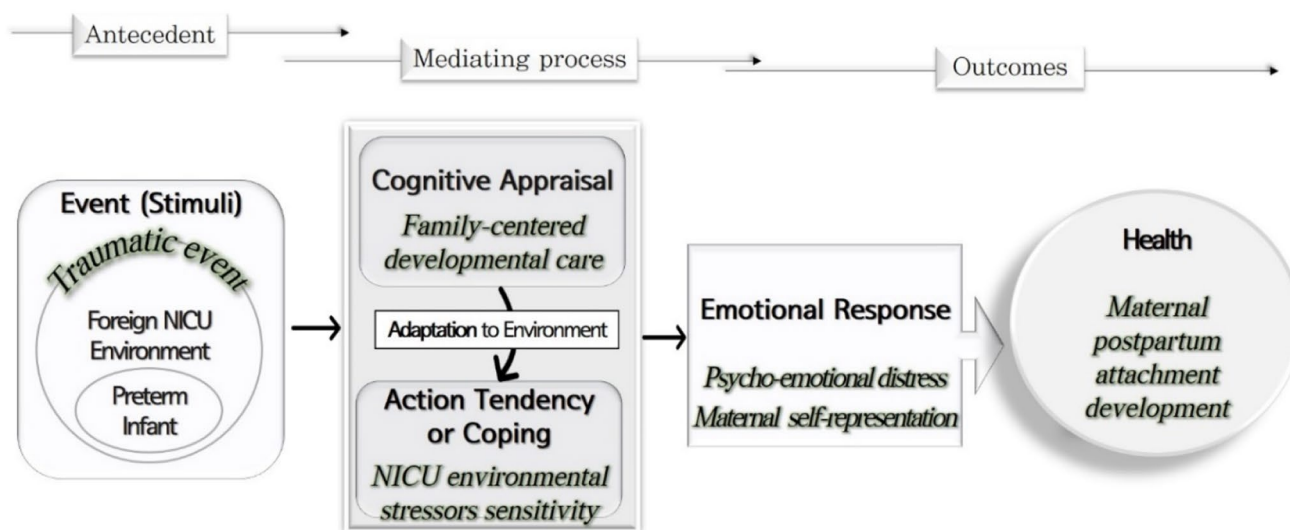

Fig. 1 Conceptual framework of the study based on the cognitive-motivational-relational theory of emotion (Lazarus 1991a, b), internal working model (Bowlby 1982), neonatal integrative developmental care model (Altimier and Phillips 2013, 2016)
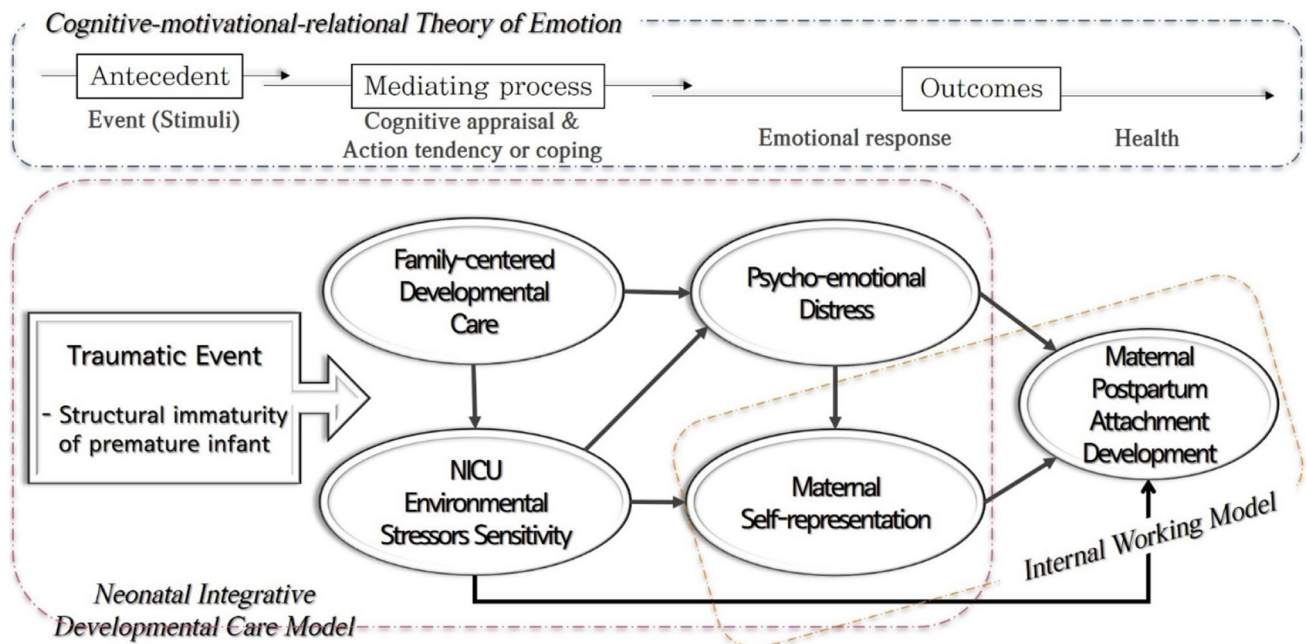
Fig. 2 Theoretical model for the study

positive self-representation (maternal identity and perception of the baby) was considered key for establishing PPA in mothers of preterm/low birthweight infants (Bowlby 1982, 1988; Spinelli et al. 2015). Little research has proposed the mechanism of PPA for those who have experienced traumatic events such as preterm birth and NICU hospitalization of the infant. This study aimed to develop a suitable model specifying how NICUs and their environments work to foster PPA after preterm birth.

Using structural equation modeling, the hypothetical model was tested to identify direct and indirect effects of cognitive appraisal factors (quality of family-centered developmental care; NICU environmental stressor sensitivity), emotional response factors (psycho-emotional distress; maternal self-representation) and the health outcome (maternal PPA). Very preterm (< 32 weeks) or very low birthweight (< 1500 g) infants are at high risk of disorganized attachment, despite sensitive parenting by mothers (López-Maestro et al. 2017; Wolke et al. 2013); we assessed whether developmental immaturity (gestation, birthweight) modifies the model, using multi-group analysis.

Methods

Study Design

A correlational cross-sectional study using structural equation modeling was implemented to understand the mechanism of atypical attachment in mothers of preterm/low

birthweight infants with experience in the NICU. Direct and indirect effects of maternal, NICU care and environmental factors on PPA were identified. Multi-group analysis was performed to compare model results in very preterm/very low birthweight (VP/VLBW) and moderately preterm and moderately low birthweight (MP&MLBW) infants.

Participants

Mothers of preterm/low birthweight infants hospitalized in South Korean hospital NICUs for more than seven days were targeted. Mothers (within 18 months postpartum) of infants born before 37 weeks of gestation or weighing less than 2.5 kg, without documented congenital anomalies and lethal conditions necessitating life-prolonging treatment, were eligible to participate. Mothers within 18 months postpartum were specifically addressed; maternal PPA refers to a strong affectional connection between mother and infant during the first 18 months (Bowlby 1982, 1988). Eligible mothers were recruited from four hospitals in Seoul, Daejeon city and Gyeonggi province by convenience sampling from November 2017 to January 2018. Besides face-to-face data collection, snowball sampling was performed via three online community portals used by parents of preterm/low birthweight infants. All subjects who volunteered and gave consent to participate in this study were provided with links to access web- or smartphone-based surveys. Of 344 eligible mothers (13 from face-to-face recruitment in four hospitals, 331 from online community portals), the analytic sample comprised 294 (85.5%). Thirty-four were excluded because

of incomplete or inappropriate data, and 16 did not meet inclusion criteria (14 babies not preterm/low birthweight, 1 woman gave birth in the United States of America, and 1 infant died after treatment). Data from 294 mothers (13 from hospitals, 281 from online) from seven cities and five provinces in South Korea were analyzed. This study was approved by the ethics committee of our university (approval number: HYI-17-141-2). Prior to inclusion, all participants gave informed consent; the right to withdraw at any time, anonymity, and confidentiality were made known to them.

Measurements

Family-Centered Developmental Care

Family-centered developmental care is comprehensive holistic care performed in the NICU to develop parent-infant attachment (Hall et al. 2017a, b; Ramezani et al. 2014). To measure how mothers of preterm/low birthweight infants admitted to NICU perceive family-centered care (FCC), the Quality of FCC scale (Raiskila et al. 2016) was translated and adapted to Korean, in accordance with World Health Organization guidelines (World Health Organization 2017). Mothers rated 8 questions related to staff active listening, and parent participation in baby care and decision making, from 1 (Not at all) to 7 (Very much) for key aspects of FCC. The scale indicated satisfactory internal consistency, and convergent and discriminant validity (Cronbach's $\alpha = .86$; construct reliability [CR] = .97; average variance extracted [AVE] = .81).

NICU Environmental Stressor Sensitivity

NICU environmental stressor sensitivity is an indicator of cognitive appraisal or adaptive needs of mothers related to environmental stressors surrounding infants in a NICU (Cheng and Wu 2014; Kim et al. 2008; Miles et al. 1993). The Korean version of the Parental Stressor Scale: NICU (Lee et al. 2007), a 16-item questionnaire for mothers, was used to assess subjective evaluation of stressors caused by the physical and psychosocial environment of the NICU. Mothers rated items on three subscales (NICU environment, parental role alteration/mother's relationship with baby, infants' appearance and behavior) from 0 (No stress) to 4 (Too much stress). This showed satisfactory internal consistency and validity (Cronbach's $\alpha = .70$–$.82$; CR = .98, AVE = .95).

Psycho-emotional Distress

Psycho-emotional distress broadly encompasses negative feelings such as depression, anger, guilt, helplessness, trauma and fatigue (Zuk and Talmi 2014). In this study,

psycho-emotional distress was referred to as mood disturbance and posttraumatic stress disorder. Mood disturbance was measured using the Korean version of the Profile of Mood State-Brief (K-POMS-B), which has been validated in the Korean population (Yeun and Shin-Park 2006). This 30-item questionnaire has six identifiable mood dimensions (tension; depression; anger; vigor; fatigue; confusion), each with 5 items scored on a 5-point Likert-type scale (0–4). This had good internal consistency and validity (Cronbach's $\alpha = .93$; CR = .99, AVE = .95).

Posttraumatic stress disorder was measured using the Korean version of the Perinatal PTSD Questionnaire (PPQ), which has been validated in Korean mothers of preterm infants (Huth-Bocks et al. 2004). This 14-item scale has a Likert format and assesses emotional distress and traumatic reactions in the 18 months after delivery. Mothers were asked to rate each from 0 (Not at all) to 4 (Often, lasted for more than one month). It showed good internal consistency and validity (Cronbach's $\alpha = .91$; CR = .98, AVE = .93).

Maternal Self-representation

Maternal self-representation is an integrated scheme of a mother's cognitive/emotional representations encompassing a wide range of opinions/ideas, thoughts, feelings, hopes, and overall expectations about herself, her child, and the relationship with her child (Wolke et al. 2013; Bowlby 1982, 1988; Park et al. 2016). In this study, maternal self-representation was referred to as maternal identity and perception of the baby. Maternal identity was measured using the Korean version of the Semantic Differential Scale-Myself as Mother (Kim et al. 2018), an 11-item questionnaire to assess how they feel as mothers. This 7-point semantic differential scale consists of bipolar adjective pairs (e.g. graceful vs awkward, kind vs cruel). This had satisfactory internal consistency and validity (Cronbach's $\alpha = .91$; CR = .98, AVE = .85).

Perception of the baby was measured using an adapted Korean version (Kim et al. 2018) of the Semantic Differential Scale-My baby, a 6-item questionnaire (Walker and Montgomery 1994). Mothers marked numbers close to their emotional responses to their babies (e.g. sweet vs sour, easy vs difficult, peaceful vs belligerent). This has a possible range from 6 to 42, higher scores indicating a more positive perception of the baby. It had satisfactory internal consistency and validity (Cronbach's $\alpha = .80$, CR = .96, AVE = .81).

Maternal Postpartum Attachment

The Korean version of the Maternal Postpartum Attachment Scale (MPAS-K, 14 items), psychometrically validated for use with NICU-experienced mothers (Kim and Tak 2018), was used to assess mothers' emotional attachment to their child during the first 18 months. Mothers

rated each item on three subscales: positive emotions in interactions; perception of less burden of caregiving/parenting; and quality of mother–child interactions. Depending on the items, responses were on 2–5-point scales, with some reverse items (6–12 questions). All responses were recorded with scores from 1 (Poor attachment) to 5 (Strong attachment) to ensure equal weighted values of questions. The MPAS-K had internal consistency and validity (Cronbach's $\alpha = .80$; CR = .94, AVE = .86).

Statistical analysis

Data were analyzed using SPSS Statistics version 23 (IBM Co., Armonk, NY) and IBM SPSS Amos 23. To present sample characteristics and relationships between study variables, descriptive statistics and bivariate Pearson's correlations were calculated. Confirmatory factor analysis was conducted to verify the validity of the scales used. To evaluate convergent validity, standardized factor loadings (> .40), critical ratio (> 1.965, $p < .05$), CR ($\geq .70$), and AVE ($\geq .50$) were verified (Yu 2016). To assess goodness of fit, the χ^2 test, Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Normed Fit Index (NFI), Root Mean Squared Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) were used. A good model should indicate an insignificant p value for the χ^2 test ($\geq .05$), a high GFI, AGFI, TLI, CFI and NFI close to one ($\geq .90$) and a lower SRMR and RMSEA ($\leq .05$) (Yu 2016). The estimated path coefficient and its statistical significance were evaluated using the standardized regression coefficient, standard error, and critical ratio. Statistical significance of the indirect effect was estimated using bootstrapping. Multi-group analysis was performed to compare differences in path coefficients between the VP/VLBW and MP&MLBW groups.

Results

Study Population

A total of 294 mothers of preterm/low birthweight infants with experience in the NICU, from more than 49 hospitals located in 12 cities or provinces in Korea, were analyzed after screening. Table 1 shows the demographic, general and clinical characteristics of participants. There were no prominent differences between the VP/VLBW (n = 188) and MP&MLBW (n = 106) groups other than gestational age, weight (birth and present) and duration of hospitalization.

Correlation Coefficients Among Measurement Variables

There were significant correlations among the scores of MPAS-K and FCC (r = .16, $p = .007$), PPQ (r = − .29, $p < .001$), K-POMS-B (r = − .24, $p < .001$), maternal identity (r = .47, p < .001), and perception of the baby (r = .34, $p < .001$). Multicollinearity was not found: correlation coefficients between variables were .08–.67; tolerance values were over 0.1 (range = .48–.91), and the variance inflation factor was below 10.0 (range 1.10–2.08).

Structural Equation Model

A structural equation model predicting PPA in mothers of preterm/low birthweight infants is shown in Fig. 3. The hypothesized model was appropriate for the data, with χ^2 (30) = 38.35, $p = .14$, GFI = .98, AGFI = .95, RMSEA = .03, SRMR = .04, TLI = .98, CFI = .99 and NFI = .96. This model presents theoretical causal paths between maternal cognitive factors of the NICU experience, psycho-emotional factors, and maternal attachment during the postnatal period, and highlights the role of maternal self-representation as a key predictor of PPA ($\beta = .68$, $p < .001$), accounting for 42% of the variance. Family-centered developmental care ($\beta = − .25$, $p < .001$) or NICU environmental stressor sensitivity ($\beta = .41$, $p < .001$) were found to have a direct effect on psycho-emotional distress, and psycho-emotional distress to affect maternal self-representation ($\beta = − .64$, $p < .001$). Both family-centered developmental care ($\beta = .11$, $p = .002$) and NICU environmental stressor sensitivity ($\beta = − .16$, $p = .032$) appeared to influence PPA indirectly through psycho-emotional distress and maternal self-representation (Table 2).

Multi-group Analysis

To verify the influence of preterm infants' gestational age/birthweight and moderating effects of the variables, multi-group analysis was conducted (Table 3, Fig. 4). The invariance test indicated robust measurement consistency, with a nonsignificant χ^2 difference ($\Delta\chi^2 = 12.07$, df = 6 < 12.59) between the unconstrained model ($\chi^2 = 78.19$, df = 60) and λ constrained model with the same constraints on measurement weights and factor loadings ($\chi^2 = 9.26$ df = 66). The benefit of NICU environmental stressor sensitivity for maternal PPA was observed only in the MP&MLBW group ($\beta = .26$, $p = .037$). The positive correlation of maternal self-representation with PPA was stronger in the VP/VLBW group, with an explained variation of 38.1% ($\beta = .81$, $p = .031$), than in the MP&MLBW group ($\beta = .67$, $p < .001$). In the MP&MLBW group, variation in NICU environmental stressor sensitivity and maternal self-representation explained 59.3% of the variance in PPA.

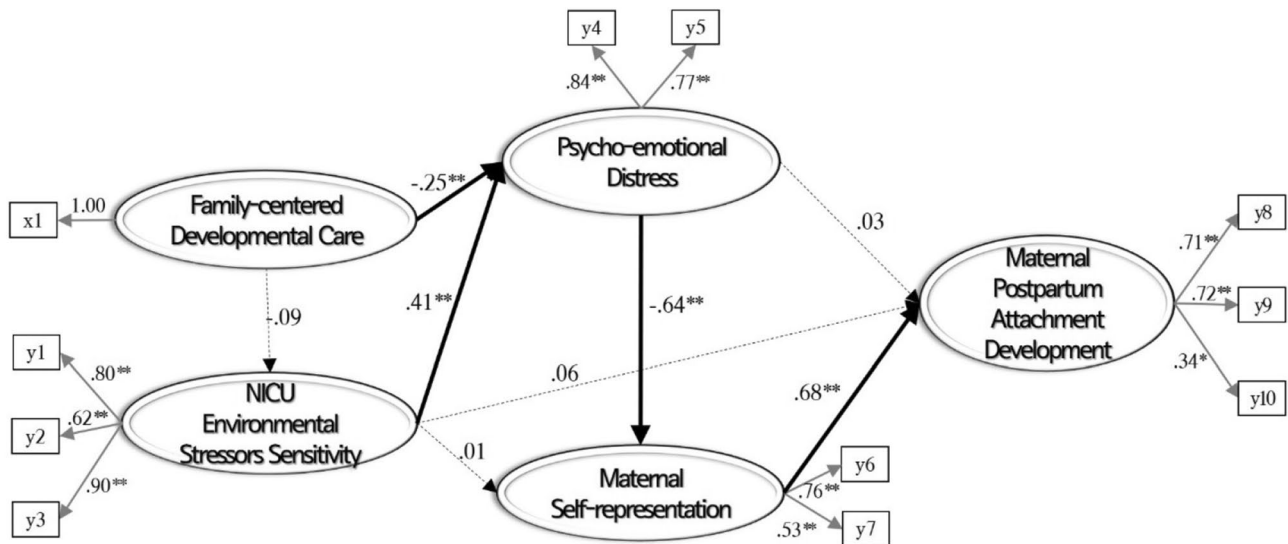**Table 1** Characteristics of the study participants

Characteristics	VP/VLBW (n = 188) n (%)/mean (SD)	MP&MLBW (n = 106)	Total (N = 294)
Maternal factors			
Age at childbirth, mean (SD), years	32.50 (3.87)	32.67 (4.36)	32.56 (4.05)
Married mother, n (%)	185 (98.4)	106 (100.0)	291 (99.0)
Employed mother, n (%)	63 (33.5)	46 (43.4)	109 (37.1)
Planned pregnancy, n (%)	117 (62.2)	63 (59.4)	180 (61.2)
Primiparous mother, n (%)	133 (70.7)	76 (71.7)	209 (71.1)
Delivery mode, n (%)			
Cesarean	136 (72.3)	72 (67.9)	208 (70.7)
Vaginal	52 (27.7)	34 (32.1)	86 (29.3)
Assisted reproductive technology, n (%)	37 (19.7)	17 (16.0)	54 (18.4)
Multiple pregnancy, n (%)	29 (15.4)	14 (13.2)	43 (14.6)
Experiences of kangaroo care in the NICU, n (%)	89 (47.3)	52 (49.1)	141 (48.0)
Experiences of breastfeeding in the NICU, n (%)	92 (48.9)	69 (65.1)	161 (54.8)
Infant factors			
Corrected age, mean (SD), months	5.19 (5.68)	5.13 (4.80)	5.17 (5.37)
Neonate (0–1)	70 (37.2)	29 (27.4)	99 (33.7)
Infant (< 12)	86 (45.7)	64 (60.4)	150 (51.0)
Little toddler (≦18)	32 (17.0)	13 (12.3)	45 (15.3)
Male, n (%)	102 (54.3)	68 (64.2)	170 (57.8)
Gestational age, mean (SD), weeks	28.51 (2.84)	33.95 (1.64)	30.47 (3.60)
Birth weight, mean (SD), grams	1155.39 (380.51)	2128.72 (410.11)	1506.32 (609.79)
Present weight, mean (SD), grams	5324.74 (3094.54)	6424.86 (2689.95)	5722.74 (2996.38)
Hospitalization in the NICU, mean (SD), days	76.47 (54.27)	23.91 (17.80)	57.19 (51.19)
The location of the hospital			
Seoul city	78 (41.5)	42 (39.6)	120 (40.8)
Busan city	14 (7.4)	7 (6.6)	21 (7.1)
Daegu city	15 (8.0)	2 (1.9)	17 (5.8)
Incheon city	9 (4.8)	1 (0.9)	10 (3.4)
Daejeon city	3 (1.6)	3 (2.8)	6 (2.0)
Ulsan city	1 (0.5)	1 (0.9)	2 (0.7)
Gyeonggi province	36 (19.1)	23 (21.7)	59 (20.1)
Gangwon province	3 (1.6)	1 (0.9)	4 (1.4)
Chungcheong province	8 (4.3)	9 (8.5)	17 (5.8)
Jeolla province	8 (4.3)	4 (3.8)	12 (4.1)
Gyeongsang province	11 (5.9)	7 (6.6)	18 (6.1)
Jeju city		3 (2.8)	3 (1.0)
No answer	2 (1.1)	3 (2.8)	5 (1.7)
The number of visitation to the NICU, mean (SD)			
Per week, days	5.79 (1.94)	5.96 (1.78)	5.86 (1.88)
Per days, times	1.26 (0.72)	1.25 (0.43)	1.26 (0.63)

VP very preterm, *VLBW* very low birthweight, *MP* moderately preterm, *MLBW* moderate low birthweight

Discussion

The results of this study enrich our understanding about how subjective perceptions of quality of FCC and NICU environmental stressors could affect maternal attachment following preterm birth and highlight the important roles

of psycho-emotional distress and maternal self-representation in mothers of preterm/low birthweight infants. Guided by Lazarus' theory (Lazarus 1991a, b), we validated the factors of cognitive appraisal, provoked by traumatic experiences (preterm birth, baby's hospitalization), influencing the emotional responses that motivate a health-related

**p< .001; *p< .05; x1=Family-centered developmental care; y1=NICU environment; y2=Parental role alteration/relationships; y3=Infants' appearance and behaviors; y4=Mood disturbance; y5=Post-traumatic stress disorder; y6=Maternal identity; y7=Perception of my baby; y8=Positive emotions in interactions; y9=Perception of less burden of caregiving/parenting; y10=Quality of mother-child interactions. Solid lines represent statistically significant standardized path coefficients while dashed lines represent non-significant standardized path coefficients.

Fig. 3 Path diagram for the hypothetical model

Table 2 Standardized direct, indirect, and total effects for the structural equation model ($N=294$)

Endogenous variable	Exogenous variable	β	S.E	C.R. (p)	Direct effect β (p)	Indirect effect β (p)	Total effect β (p)	SMC
NICU environmental stressors sensitivity	FCC	−.09	.00	− 1.49 (.138)	−.09 (.128)		−.09 (.128)	.01
Psycho-emotional distress	FCC	−.25	.02	− 4.39 (< .001)	−.25 (.004)	−.04 (.116)	−.29 (.004)	.25
	NICU environmental stressors sensitivity	.41	.37	6.15 (< .001)	.41 (.004)	–	.41 (.004)	
Maternal self-representation	FCC					.18 (.006)	.18 (.006)	.41
	NICU environmental stressors sensitivity	.01	.38	0.12 (.902)	.01 (.846)	−.26 (.005)	−.25 (.018)	
	Psycho-emotional distress	−.64	.10	− 5.11 (< .001)	−.64 (.015)	–	−.64 (.015)	
Postpartum attachment	FCC					.11 (.002)	.11 (.002)	.42
	NICU environmental stressors sensitivity	.06	.05	0.72 (.474)	.06 (.411)	−.16 (.032)	−.10 (.173)	
	Psycho-emotional distress	.03	.01	0.17 (.864)	.03 (.992)	−.44 (.010)	−.41 (.005)	
	Maternal self-representation	.68	.02	3.94 (< .001)	.68 (.016)	–	.68 (.016)	

Model fit: $\chi^2 = 38.35$ (df = 30, $p = .141$), $\chi^2/df = 1.28$, GFI = .98, AGFI = .95, RMSEA = .03, SRMR = .04, TLI = .98, CFI = .99, NFI = .96

outcome (PPA). Our empirical evidence indicates that quality of FCC and NICU environment are linked with psycho-emotional distress, such as posttraumatic stress and mood disturbance (Altimier and Phillips 2013, 2016); these factors affect PPA through integration of mothers' representation of mother-self and child (Bowlby 1982, 1988; Park et al. 2016). Therefore, greater psychosocial support from healthcare providers, maternal presence

and interaction with the newborn in the NICU may foster maternal attachment.

Maternal involvement in developmental support for their premature babies has been shown to facilitate not only mothers' adaptation to the NICU environment, but infants' growth and neurobehavioral development (Namprom et al. 2018). Furthermore, previous studies have demonstrated that parents' most preferred interventions included parent

Table 3 Path estimates of the study variables according to the developmental immaturity

Endogenous variable	Exogenous variable	VP/VLBW (n = 188)				MP&MLBW (n = 106)			
		B	β	S.E	C.R. (p)	B	β	S.E	C.R. (p)
NICU environmental stressors sensitivity	FCC	−.01	−.08	.01	−1.05 (.295)	−.01	−.13	.01	−1.27 (.204)
Psycho-emotional distress	FCC	−.07	−.16	.03	−2.30 (.022)	−.23	−.48	.04	−5.18 (<.001)
	NICU environmental stressors sensitivity	2.36	.41	.48	4.88 (<.001)	1.78	.35	.51	3.48 (<.001)
Maternal self-representation	NICU environmental stressors sensitivity	.42	.11	.44	0.95 (.344)	−.40	−.08	−.66	−0.60 (.550)
	Psycho-emotional distress	−.56	−.81	.13	−4.33 (<.001)	−.39	−.40	.15	−2.60 (.009)
Postpartum attachment	NICU environmental stressors sensitivity	−.05	−.08	.07	−0.62 (.534)	.18	.26	.08	2.09 (.037)
	Psycho-emotional distress	.03	.32	.03	0.92 (.355)	−.03	−.26	.02	−1.72 (.086)
	Maternal self-representation	.12	.81*	.05	2.15 (.031)	.09	.67	.02	3.81 (<.001)

Model fit: $\chi^2 = 78.19$ (df = 60, $p = .057$), $\chi^2/df = 1.30$, GFI = .96, AGFI = .90, RMSEA = .03, SRMR = .06, TLI = .97, CFI = .98, NFI = .93

VP very preterm, *VLBW* very low birthweight, *MP* moderately preterm, *MLBW* moderate low birthweight, *B* unstandardized estimates, *β* standardized estimates, *S.E.* standard error, *C.R.* critical ratio

education about the premature infants' development and meeting similar parents (Huenink and Porterfield 2017). Because peer support groups help NICU mothers to integrate a positive maternal identity (Rossman et al. 2015), and to relieve distress through sharing similar experiences/anticipatory guidance (Hall et al. 2017a, b), organizing parent seminars or a family camp program should be considered. Healthcare providers should address social support for individuals, including their relationship with their partner or marital intimacy, while an intimate partner is likely to share positive parenting behavior and ultimately help the maternal caregiving role (Kim et al. 2018). By supporting NICU parents to cope with traumatic events and treating them as key members of their babies' caregiving team, it is possible to increase the probability of PPA and reduce the incidence of attachment disorders.
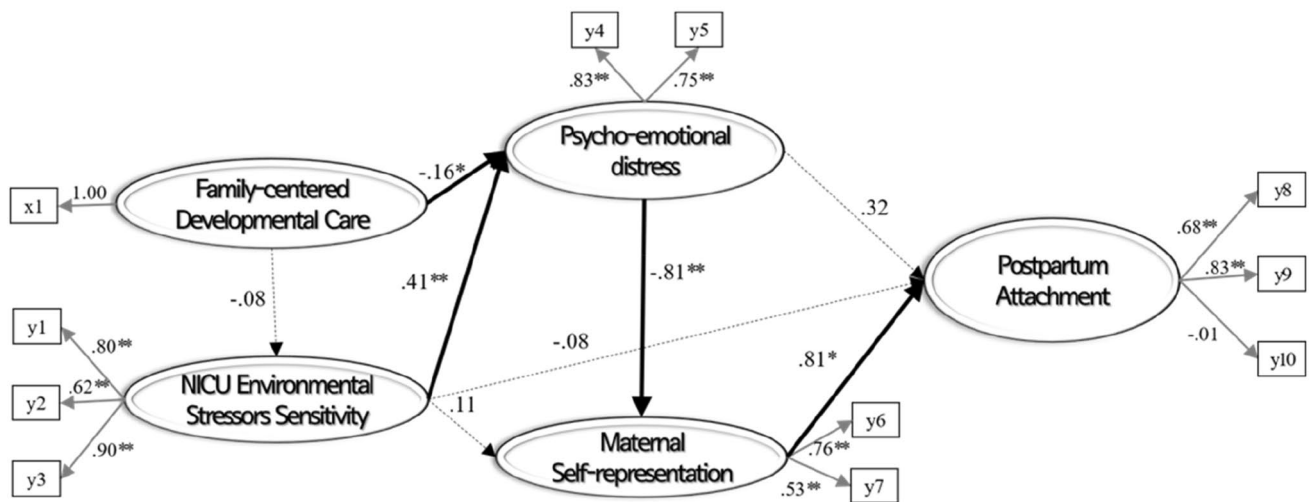
Findings from multi-group analysis suggest that more attention should be given to the NICU environment when dealing with mothers with MP&MLBW children, although further studies are needed to elucidate which aspects of this environment positively affect PPA. Most studies have focused on the negative impact of artificial NICU environments on mother-infant bonding (Pennestri et al. 2015; López-Maestro 2017; Aftyka et al. 2017). However, in our study, mothers' subjective appraisal of NICU environmental stressors was found to be an important predictor of maternal attachment following preterm birth. This parallels previous findings (Kim et al. 2008) suggesting that mothers with children with disabilities showed a slower and passive response (or adaptation) to environmental stressors, that disrupts effective caring behaviors, compared to mothers with normal children. Our results could indicate a correlation between NICU environmental stressor sensitivity and maternal sensitivity (being sensitive and responsive to babies' needs or behaviors), which contributes to optimal growth and

development of preterm/low birthweight infants. In a previous study on VLBW infants (Patki and Antin 2017), most (81.8%) mothers whose babies were born below 1500 g, had antenatal complications (e.g. anemia, premature rupture of membranes, pregnancy-induced hypertension); they might require treatment themselves and be overwhelmed by their babies' survival or health issues. Owing to more severe psycho-emotional distress and possible physiological instability in the VP/VLBW group, the mothers might find it hard to express complaints about the NICU care team.
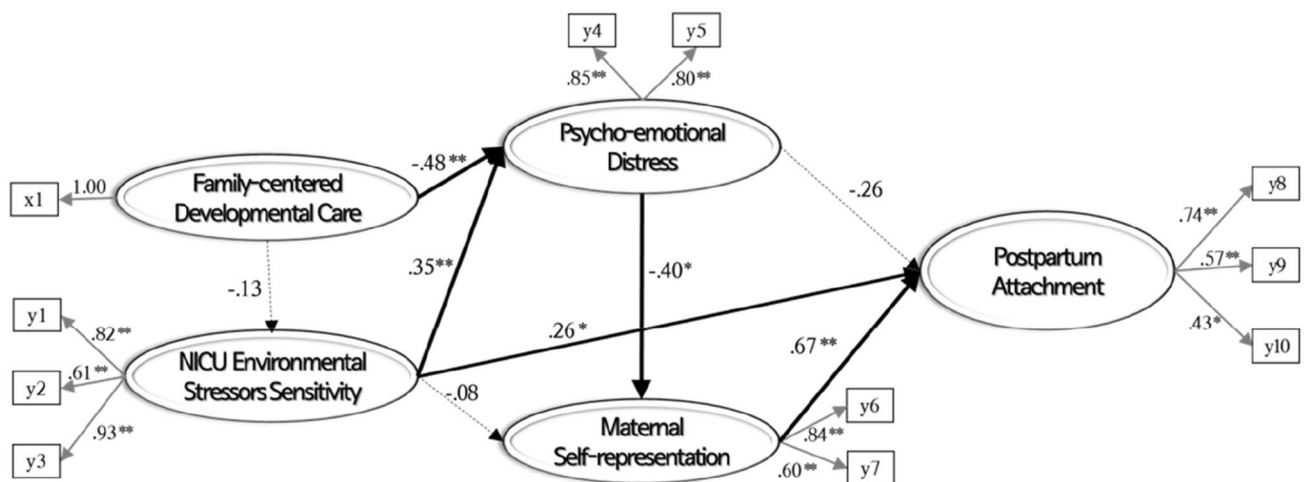
Interestingly, comparing the VP/VLBW and MP&MLBW groups, the weight of maternal self-representation on PPA differed (β = .81 and .67, respectively). This needs to be interpreted carefully. The corrected age of the VP/VLBW group was higher, with more toddlers (12–18 months) than in the MP&MLBW group (17% and 12.3%, respectively). As shown in Supplementary Table 1 and Fig. 1, additional multiple analysis according to age (Supplementary file) showed that the older the preterm children, the more powerful the path estimates of NICU environmental stressor sensitivity and maternal self-representation towards PPA. The attachment process might initially be disturbed by negative feelings, which can delay mothers' acceptance of themselves as a mother and of the premature baby as her own. There is a need for further investigation of effects with other promising factors, such as caring experiences, maternal self-efficacy and parenting stress, in order to understand this mechanism. For these mothers, our findings suggest that clinicians and staff should flexibly assess maternal identity and perception of the baby. Also, prenatal consultation in high-risk pregnancy clinics for preterm labor and guidance on anticipatory information for upcoming traumatic events in the NICU are recommended.

This study may have limitations, akin to those of all cross-sectional studies. The dataset did not fully evaluate

Fig. 4 Final path diagram of the final model for each group

whether predicting variables affect PPA over time by developmental stage of the child. Follow-up longitudinal research or prospective studies specifically designed to guarantee the causality among the cognitive and emotional factors and PPA are required. Our findings cannot be generalized to or be representative of other international settings; the sample consisted of mothers of preterm/low birthweight infants admitted to NICUs in South Korea with potentially varying levels of infrastructure quality. Future studies to analyze the

differences in paths of PPA development according to the age of preterm children, with other related factors such as parenting distress and intimate partner support, are highly recommended. Mothers within 18 months after delivery were targeted for the definition of maternal PPA in this study. Careful interpretation of these results is important, taking into account length of NICU stay and caregiving time at home, while caring experiences, or self-efficacy as primary caregiver, might have contributed to development

of maternal PPA. Despite time for recollection in the web or online survey, use of many self-reporting instruments makes recall bias possible and potential lack of data reliability inevitable. The large discrepancy between number of mothers recruited from hospitals versus from the online portals is attributed to the timing of the survey. It took place after four preterm infants died of bacterial sepsis at Seoul's Ewha Woman's University Medical Center, and data collection was then restricted by managers in hospitals and NICU families were reluctant to participate. A strength of our study is that it included a large sample of emotionally and socially vulnerable mothers from diverse hospitals in different geographical locations in South Korea, via smartphone- and web-based survey techniques.

Conclusion

Positive maternal identity toward oneself as a mother and perception of their preterm/low birthweight infant are important determinants for attachment during the first 18 months. Family-centered developmental care focused on psycho-emotional support for mothers with babies is no longer an option but a necessity during hospitalization. Clinicians or staff should be aware that their attempts to respond to environmental needs related to NICU stressors lead to attachment in mothers with MP&MLBW babies.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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