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Parent Participation in the Neonatal Intensive Care Unit: Predictors and Relationships to Neurobehavior and Developmental Outcomes

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Abstract

Objective—To 1) define predictors of parent presence, any holding, holding in arms, and skin-to-skin care in the NICU and 2) investigate the relationships between parent participation and a) early neurobehavior and b) developmental outcomes at age 4 to 5 years among preterm infants.

Methods—Eighty-one preterm infants born ≤32 weeks estimated gestational age were prospectively enrolled within one week of life in a level III-IV NICU. Parent (maternal and paternal) presence and holding (including holding in arms and skin-to-skin care) were tracked throughout NICU hospitalization. Neurobehavior at term equivalent age and development at 4 to 5 years were assessed using standardized assessments.

Results—The median number of days per week parents were documented to be present over NICU hospitalization was 4.0 (IQR=2.4–5.8) days; days held per week 2.8 (IQR=1.4–4.3) days [holding in arms days per week was 2.2 (IQR=1.2– 3.2) days and parent skin-to-skin care days per

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Contributor Statement: Roberta Pineda oversaw all aspects of the project, conceived of the idea to investigate the relationships of parent participation to outcome, provided significant edits of intellectual content, oversaw all neurobehavioral assessments in the NICU and 3–5 year follow up, and coordinated with all authors for edits and approval of the final manuscript. Joy Bender wrote the initial draft of the manuscript, provided intellectual contributions and approved the final manuscript submitted. Bayley Hall and Lisa Shabosky collected data on parent presence, holding and skin-to-skin from the medical record, aided in collection of outcomes at 3–5 years of age, analyzed the data, updated tables in the manuscript, and approved the final manuscript. Anna Annecca analyzed data, updated tables and the final draft of the manuscript. Joan Smith provided intellectual contributions, provided insights into documentation of parent participation factors in the medical record, and approved the final manuscript for submission. All authors had full access to the data.

week was 0.2 (IQR=0.0–0.7) days]. More parent presence was observed among mothers who were Caucasian, married, older, or employed and among those who had fewer children, familial support and provided breast milk ($p<0.05$). More holding was observed in infants with fewer medical interventions ($p<0.05$) and among those who were Caucasian, had a father who was employed, had fewer children and family support ($p<0.05$). More parent holding in the NICU was related to better reflex development at term age ($p=0.02$). More parent skin-to-skin care was related to better infant reflexes ($p=0.03$) and less asymmetry ($p=0.04$) at term and better gross motor development ($p=0.02$) at 4–5 years.

Discussion—Social and medical factors appear to impact parent presence, holding, and skin-to-skin care in the NICU. Parent holding is related to better developmental outcomes, which highlights the importance of engaging families in the NICU.

Keywords

neonatal intensive care unit; preterm; parent engagement; participation; development; holding; skin-to-skin care; presence; visitation; outcomes; environment; attachment

Introduction

It is well-understood that preterm infants have high rates of developmental problems, including cognitive delays, language impairments, and behavioral problems [1–3]. The rate of developmental delay, however, cannot be fully explained by medical complications or cerebral injury alone. Early experiences in the neonatal intensive care unit (NICU) can also alter developmental trajectories [4–7].

The NICU environment can be stressful for the preterm infant. Infants may be exposed to loud noises and bright lights that interrupt sleep and occur during a vulnerable period of brain development [7]. Further, infants are often exposed to repetitive and painful, but necessary, medical interventions while in the NICU [5]. Environmental stressors can cause physiologic changes, such as increased heart rate, blood pressure, and respiratory rate, as well as decreased oxygen saturation levels [8, 9]. The increased energy expenditure to overcome these changes can alter physiological function, slow healing, and negatively impact the organization of the central nervous system [9].

The NICU environment can also be overwhelming for parents. The role of the primary caregiver can be altered by the infant's need for advanced care provided by NICU personnel [10]. This can result in high levels of stress, depression, and anxiety in parents of NICU infants [11, 12], which can negatively impact the way in which they engage with the infant [13]. In addition, many parents are challenged by needing to balance daily activities with parenting an infant outside the home, needing to return to work sooner in order to save time to stay with the baby at NICU discharge, and/or having other children to care for at home. Barriers to parenting a high-risk infant in the NICU can negatively influence parent engagement with the preterm infant during the months of NICU hospitalization, resulting in shorter, less frequent visitation [14–16]. However, parent engagement in the NICU is vital.

The relationship between parent-child attachment and developmental outcomes is well understood [17, 18]. For the very preterm infant, the parent-child relationship begins in the NICU. The relationship is established and developed when the parent is present in the NICU, holds the infant, and learns how to identify and respond to the needs of the infant [19–21]. In addition, parent presence and infant holding in the NICU is related to improved neurobehavioral outcome at term equivalent age, observed prior to discharge from the NICU [22]. Although the importance of parenting is well-established, there are few studies that have investigated the impact of early parenting in the NICU on outcomes in early childhood.

Parent participation in the NICU, which includes parent presence and infant holding, can promote feelings of usefulness and can improve attachment. Parents can also help to improve the ability of the infant to cope with NICU stressors [23–26] and provide appropriate, meaningful sensory stimuli and human contact. While the effect of being held has not been a focus of current research, there is a growing body of evidence related to the effects of skin-to-skin care. Skin-to-skin care, which involves placing the unclothed infant directly on the parent's bare chest, is related to decreased acute pain responses, improved weight gain, improved infant growth and development, reduced hypothermia, earlier discharge, better cognitive outcomes in childhood, and enhanced nurturing and parent-child interactions [23, 25–31]. Additionally, high maternal involvement in the NICU has been related to superior cognitive and language outcomes in early childhood [32]. Despite efforts in implementing family-centered care and engaging parents in the NICU, suboptimal rates of parent presence and engagement have been reported in the United States [22].

While parenting in the NICU can be challenging, there is a paucity of research that has identified factors that impact parent participation and whether parent participation in the NICU is related to short and long-term outcomes. The aims of this study were to 1) define predictors of parent presence and holding (including holding in arms and skin-to-skin care) in the NICU and 2) investigate the relationships between parent participation in the NICU and early neurobehavior as well as developmental outcome at age 4 to 5 years.

Methods

This study consisted of 81 preterm infants born ≤32 weeks estimated gestational age who were prospectively enrolled in the year 2011 as part of an overarching study investigating the effects of neonatal positioning [4]. Infants were enrolled within the first week of life. Infants with a known congenital anomaly and those who were not expected to live were excluded. This study was approved by the Human Research Protection Office of Washington University in St. Louis, and parents signed informed consent. During hospitalization, parent presence and holding (including holding in arms and skin-to-skin care) were tracked. At term age, infants received neurobehavioral testing in the NICU, using the NICU Network Neurobehavioral Scale (NNNS) and Dubowitz Optimality Scale. At 4 to 5 years of age, parents completed a parent-report measure of child developmental outcome, the Ages and Stages Questionnaires-third edition (ASQ-3).

Participants were recruited from the NICU at St. Louis Children's Hospital, a 75-bed level III-IV NICU. At the study site, parents could be present 24 hours per day while the infant

was in the NICU. Holding the infant was supported, provided the infant could maintain physiological stability during handling. Parents were encouraged to hold infants on mechanical ventilation, but holding was not encouraged during times when the infant was on oscillatory ventilation and/or when chest tubes were in place. However, practices varied based on the comfort level of nurses, the medical team, and the parents. Nurses fostered parent participation through instruction on caregiving and developmentally appropriate interactions, and documentation in the medical record included when a parent visited and whether the infant was held in arms or held skin-to-skin. Documentation was routinely done at each care time, which typically occurred every 3 hours, or was completed after each 12-hour shift.

Parent Participation

For the purposes of this study, parent participation was defined as parents being present and/or engaging in holding (including holding in arms or performing skin-to-skin care) in the NICU. Parent presence, infant holding, and infant skin-to-skin care were captured from documentation in the electronic medical record. From this documentation, the average number of days per week a parent was present as well as the average number of days per week a parent held the infant, ‘any holding’, were calculated. In addition, the average number of days per week the infant was held in arms and average number of days per week the infant was held skin-to-skin were calculated separately from ‘any holding’. Separate tabulations were done for mothers and fathers, as well as combined to represent total days per week a parent was present and/or held the infant.

Medical and socio-demographic factors were collected for descriptive purposes, to identify factors that relate to parent participation, and to enable control for social and medical risk when investigating relationships between parent participation and outcomes.

Medical Factors

Infant medical factors collected included: sex, delivery type (Caesarean vs. vaginal), whether the infant was a multiple, estimated gestational age (EGA) at birth, Apgar scores at one minute and five minutes, days of oxygen therapy [which included days of ventilation, days of continuous positive airway pressure (CPAP), and days of delivery of oxygen via nasal cannula], presence of necrotizing enterocolitis (NEC; all stages), confirmed sepsis, and cerebral injury (defined as Grade III-IV intraventricular hemorrhage or cystic periventricular leukomalacia on cranial ultrasound), length of stay, postmenstrual age at discharge, whether breast milk was received by the infant at discharge, and assigned room type (private room vs. open ward). Room type was investigated due to previous findings related to more parent visitation among infants in private rooms [33]. From these descriptives, high medical risk was defined as having EGA < 28 weeks or cerebral injury.

Socio-Demographic Factors

Socio-demographic factors that were collected included race (Caucasian or non-Caucasian), marital status (single or married), maternal age, insurance type (public vs. private), maternal and paternal employment status, number of siblings in the home, distance traveled to the hospital, and familial support (documentation of extended family visiting an average of one

or more days per week). From these descriptives, social risk was defined as maternal age <21 years or having public insurance.

Neurobehavioral Outcome

Neurobehavior was assessed at 35 weeks postmenstrual age or when medically stable, whichever occurred last, using the NNNS and Dubowitz Optimality Scale. A single trained and certified examiner (author, RP) completed the NNNS and Dubowitz Optimality Scale assessments. The NNNS is a 115 item test with 13 summary scores: Habituation, Orientation, Hypertonicity, Hypotonicity, Arousal, Lethargy, Asymmetry, Sub-optimal Reflexes, Excitability, Tolerance of Handling, Stress, Quality of Movement, and Self-Regulation [34]. However, the Habituation scale was not used for this study, due to the need for a quiet environment during the assessment as well as infants routinely not being in a sleep state upon examiner arrival. Reliability on the NNNS is ensured during a 5-day training course, and it has content validity and clinical utility [35]. The Dubowitz Optimality Scale is a 34 item test with 7 summary scores: Posture, Tone, Tone Patterns, Reflexes, Movement, Abnormal Signs, and Orientation [36]. The Dubowitz has excellent clinical utility and scale construction, adequate standardization, and content and criterion validity [35]. Although reliability can be poor on the Dubowitz, all scoring was conducted by a single evaluator.

Developmental Outcome

At age 4 to 5 years, the ASQ-3 was completed by parents. The ASQ-3 is a parent-report measure used to assess development in children between the ages of 1 to 66 months [37]. For this study, parents completed the ASQ-3 between 48 months and 56 months. The tool consists of 5 subscales: Communication, Gross Motor, Fine Motor, Problem Solving, and Personal-Social. Scores are generated for each subscale and range from 0 to 60. Scores are then translated into 3 percentile groups: below average, average, and above average. Subscale scores were used as outcome variables in this study. The ASQ-3 has strong test-retest reliability [37]. The ASQ-3 was chosen for follow-up, because it could be sent out to parents for completion without the need for infants to return for standardized testing. In addition, it has been shown to provide comparable results to the Bayley Scales of Infant and Toddler Development, 3rd edition [38].

Statistical Analysis

Relationships between medical and sociodemographic factors and parent presence (average days present per week) and any holding (average days held either in arms or skin-to-skin per week) were investigated using linear regression models. Relationships between medical and sociodemographic factors and average days per week held in arms and average days per week held skin-to skin were also investigated separately. Parent presence and any holding (as well as held in arms and skin-to-skin care separately) were investigated for associations with neurobehavioral outcome at term equivalent age and developmental outcome at 4 to 5 years of age using univariate linear regression models as well as multivariate models, controlling for social and medical risk. All analyses were run using $\alpha<0.05$.

Results

One hundred infants were enrolled as part of the overarching study; however, 11 of them were hospitalized at a sister site and therefore excluded. Four infants expired and 4 withdrew, leaving 81 infants who were included in this study. All (100%) had neurobehavioral testing prior to NICU discharge. Thirty-five (43%) had developmental outcome defined by the ASQ-3 at age 4 to 5 years.

Medical and socio-demographic characteristics of the cohort are summarized in Table 1.

Patterns of parent presence, any holding, as well as held in arms and skin-to-skin care are summarized in Table 2.

Predictors of Parent Participation

See Table 3 for medical and socio-demographic factors that were related to parent presence, any holding, held in arms and skin-to-skin care. There were no other factors investigated, other than those listed in the table, that were related to parent presence, any holding, held in arms and skin-to-skin care.

Relationships Between Parent Participation in the NICU and Outcome

See Table 4 for relationships between parent engagement in the NICU, neurobehavioral outcome, and developmental outcome at 4 to 5 years of age. More holding was related to better reflex development on the NNNS (p=.02), less asymmetry on the NNNS (p=0.03) and better gross motor development (p=0.03) and fine motor development (p=0.048) on the ASQ-3.

Relationships between holding and reflex development (p=0.02) remained significant, after controlling for social risk and medical risk. More holding in arms was related to better reflex development on both the Dubowitz (p=0.04) and NNNS (p=0.02), but these were no longer significant after controlling for medical risk and social risk. More parent skin-to-skin care was related to better fine motor skills on the ASQ (p=0.02), but this was no longer significant after controlling for medical and social risk. More skin-to-skin care was related to better reflex development (p=.03) and less asymmetry (p=.04) at term as well as better gross motor development (p=.02) at age 4–5 years, after controlling for social and medical risk. There were no other significant relationships besides those reported in the table.

Discussion

The key findings of this study were that parents were present an average of 4 days per week and held their infants an average of 2–3 days per week during NICU hospitalization. More parent participation in the NICU was observed among mothers who were Caucasian, married, employed, or older, and those who had familial support, fewer children, or provided breast milk. More parent participation was observed in infants with fewer medical interventions. Infants whose parents held them more often in the NICU had better short-term outcomes, with those who were held skin-to-skin demonstrating better short and long-term developmental outcomes.

Rates of parent presence and holding varied across families, but were generally low. The median number of days parents were present in the NICU was 4 days (57% of days) per week; did any holding 2.8 days (40% of days); held their infants in arms 2 days (31% of days) per week; and held their infants skin-to-skin less than one day (3% of days) per week. This study identified less parent presence in the NICU compared to a previous cohort [5 days per week (74% of days)] at the same study site conducted on infants enrolled from 2007–2010, but comparable rates of holding were observed [22]. Parent presence was lower than other reports in Columbus Ohio (78%), but comparable to reports in urban Chicago (61–70%) [13, 39]. However, parent presence in NICUs in the United States is vastly different from other research conducted in several European countries, which describe parent presence in the NICU related to the number of hours per day (averaging 3.3 hours per day in Como, Italy and 22.3 hours per day in Huddinge, Sweden), rather than days per week [40]. Some European settings have been able to achieve full parent participation 24 hours per day [41]. However, European countries also have significant support for new mothers that may differ from that in the United States. Such differences can potentially aid our understanding of how culture, medical establishments, and social policies may impact parenting behaviors.

Although decreased parent participation has been documented in the NICU, this study has begun to identify some of the reasons why parents participate in a NICU based in the United States. Increased medical severity of the infant was related to less parent presence, holding, and skin-to-skin care in the NICU. When an infant is on a ventilator or is medically fragile, it can lead parents to have more challenges and feel less confident in their ability to parent in the tenuous NICU environment. Social factors also appear to drive parent participation in the NICU, with mothers having more participation in the NICU if they were older, did not have any other children, or were Caucasian, married. These are consistent with other reports of parents stating barriers to visitation to be lack of childcare for other children and employment [39]. Our findings are consistent with other reports of lower visitation among parents who are African-American, are younger, are unmarried, have public insurance, and have issues with childcare related to having other children in the home [39]. While previous research has identified employment as a barrier to NICU visitation [39], the current study identified more parent participation in the NICU among fathers who were employed. Additionally, having other family members involved in care in the NICU was related to more parent participation. While specific factors related to poor participation were identified, determining ways to optimize participation is critical.

Parent participation in the NICU is important, because being held is related to improved neurobehavioral outcomes at term equivalent age and being held skin-to-skin is related to improved neurobehavioral outcomes at term and developmental outcome at 4 to 5 years of age.

Our findings are consistent with other reports that parent involvement in the NICU is related to better long-term outcomes [32]. The period from birth to three years has been described as a critical period of development, during which early experiences are important for brain development [42]. Negative experiences and stressful exposures in the NICU have been shown to impact early brain structure and function through decreased brain size and altered

brain microstructure and functional connectivity [5]. However, parent participation in the NICU can mitigate stressful exposures. Facilitated tuck, breastfeeding, and skin-to-skin care have been shown to decrease stress and pain experiences in this population [23, 43, 44], and brain development can be optimized by having parents engage in the NICU. This study further contributes to the growing body of research, demonstrating that parent involvement, specifically being held and put skin-to-skin, can have a significant impact on long-term outcomes.

Although the potential impact of parenting in the NICU on the infant is plausible, frequent parent presence and holding could also lead to stronger parent-child attachment, laying the foundation for later interactions which may further enhance the child's development. An infant's attachment to the parent is critical for survival and development [45]. However, children born preterm have higher rates of attachment disorders [46]. Failing to visit and interact with their young preterm infant in the NICU can lead to altered behavioral and emotional problems [47]. Thus, there is a risk of long-term consequences with early suboptimal parenting in the NICU.

This study has limitations including a small sample size and a single study site. Despite the small sample size, multivariate analysis was employed which decreases power and may have limited the ability to identify relationships. This was an exploratory study that sets the stage for additional, appropriately powered investigation. The study site was a NICU in an urban area with a largely diverse sample of individuals with low socioeconomic status, and findings may not generalize to other settings that serve different populations. Collection methods of parent presence, holding, and skin-to-skin care relied upon accurate nursing documentation in the medical record, and documentation may have varied across different staff. In addition, data was collected on parent presence, holding, and skin-to-skin care, but the quality and specific quantity (related to amount of time per day) of these interactions was not captured. While parent participation for this study was defined as parent presence, holding and skin-to-skin care in the NICU, there are other ways for parents to participate in care in the NICU, and this was not captured in this study. This study also did not account for other developmental interventions including touch, containment, massage, auditory exposures, etc. Holding and skin-to-skin care could be confounded by the medical stability of the infant, which could have been influenced by the parents' confidence in interacting with the infant and potentially could have been influenced by the nurses' comfort with advocating for and supporting infant holding and skin-to-skin care. There was also a significant time lapse between the time in the NICU and assessing developmental outcome at 4 to 5 years of age. Subsequently, there can be confounding factors related to parenting, the home environment, and interventions received during the 4 to 5 years following NICU hospitalization that were not captured as part of this study. In addition, there was a large attrition rate, with only 43% of parents completing the ASQ-3 at age 4–5 years.

Future research on parent presence, holding, and skin-to-skin care can be improved by identifying not only frequency, but also the quality of interactions. Better methods of capturing parent participation in this population could strengthen future research, including prospective quantification of visiting and holding that does not rely on chart review. Expanding capture of parent participation to include other interventions such as auditory

interventions, touch and containment could also improve future research. Tracking parent interactions after NICU discharge would aid our understanding of how attachment and parent engagement evolves once an infant is discharged home. Further, investigating changes in parent-child interaction and the impact on development with mothers who receive targeted interventions to improve engagement in parenting would improve our understanding of this important relationship. Finally, in circumstances when parent training is ineffective in improving parent participation in the NICU, exploring the influences of others (volunteers, nurses, other family members) providing support and interventions in the NICU may help us develop a better understanding of how the type and quality of interactions determines the key behaviors that lead to developmental advances and whether this interaction can or cannot be mitigated by a surrogate.

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Highlights

- In the NICU, parents were present an average of 4 days/week and held their infants 2 days/week.
- More parent holding in the NICU was related to better neurobehavior prior to NICU discharge.
- More skin-to-skin care in the NICU was related to better gross and fine motor skills at 4–5 years.

Table 1

Medical and socio-demographic characteristics of the cohort.

N = 81	N (%), Mean (standard deviation), or Median (IQ range)
Medical factors	
Female sex	46 (57%)
Caesarean section delivery	60 (74%)
Multiple	20 (25%)
EGA, weeks	28.3 (2.7)
Apgar scores at 1 minute	4.3 (2.6)
Apgar score at 5 minutes	6.3 (2.1)
Number of days on oxygen	18.0 (6.0–80.5)
Ventilator, days	1.0 (1.0–7.5)
CPAP, days	1.0 (0.0–4.0)
NEC	7 (9%)
Sepsis	26 (32%)
Length of stay, weeks	9.0 (6.0–15.5)
PMA at discharge, weeks	39.6 (4.3)
Breast milk received at discharge	20 (25%)
Single patient room	49 (61%)
Socio-demographic factors	
Caucasian race	35 (43%)
Parents married	16 (20%)
Maternal age	25.9 (6.7)
Private insurance	48 (59%)
Mother employed (n=78)	36 (46%)
Father employed (n=56)	37 (66%)
Number of siblings	1.0 (0.0–2.0)
Distance traveled to hospital, miles	9.9 (5.3–23.2)
Familial support	32 (40%)

EGA, estimated gestational age; PMA, postmenstrual age; CPAP, continuous positive airway pressure; NEC, necrotizing enterocolitis

Table 2

Parent presence, holding, holding in arms and skin-to-skin care characteristics.

N=81

Type of Participation	N (%) that received any of the parent participating over the course of hospitalization	Median (IQ Range) days per week over length of stay received intervention	N(%) that received the parent participating 6–7 times per week
Parent presence	81 (100%)	4.0 (2.4–5.8)	18 (22%)
Maternal presence	81 (l00%)	3.8 (2.2–5.7)	15 (19%)
Paternal presence	79 (98%)	1.8 (0.7–2.9)	1 (1%)
Any parent holding (holding in arms plus skin-to-skin care)	81 (100%)	2.8 (1.4–4.3)	15 (18.5%)
Any maternal holding	81 (100%)	2.7 (1.2–3.9)	15 (18.5%)
Any paternal holding	74 (91.4%)	0.71 (0.2–1.5)	1 (1.2%)
Parent holding in arms	81 (100%)	2.2 (1.2–3.2)	15 (18.5%)
Maternal holding	81 (100%)	2.0 (1.1–2.8)	15 (18.5%)
Paternal holding	72 (89%)	0.7 (0.2–1.4)	1 (1.2%)
Parent skin-to-skin care	58 (72%)	0.2 (0.0–0.7)	0 (0%)
Maternal skin-to-skin care	58 (72%)	0.2 (0.0–0.7)	0 (0%)
Paternal skin-to-skin care	31 (38%)	0.0 (0.0–0.2)	0 (0%)

Table 3

Relationships between socio-demographic and medical factors and parent participation.

	Factors Related to Parent Presence		Factors Related to Any Parent Holding		Factors Related to Parent Holding in Arms		Factors Related to Parent Skin-to-Skin	
Medical Factors	**β value**	**p value**	**β value**	**p value**	**β value**	**p value**	**β value**	**p value**
Greater EGA			0.28	0.01	0.39	<0.001		
Greater Apgar score at 5 minutes					0.28	0.01		
Greater days on oxygen			−0.31	0.005	−0.33	0.002		
Greater days on CPAP			−0.23	0.04	−0.24	0.03		
Greater length of stay					−0.26	0.02		
Breastmilk at Discharge	0.40	<.001	0.47	<0.001	0.27	0.02	0.49	<0.001
Sociodemograohic Factors								
Caucasian race	0.30	0.006	0.33	0.003	0.29	0.01		
Parents married	0.24	0.03	0.38	<0.001			0.42	<0.001
Maternal age	0.22	0.049						
Father employed			0.37	0.005	0.41	0.002		
More siblings	−0.39	<0.001	−0.34	0.002	−0.39	<0.001		
Family support	0.47	<.001	0.38	<0.001	0.40	<0.001		

P values are from investigations into the relationships between medical, sociodemographic or environmental factors and parent presence, holding, holding in arms, and skin-to-skin care. EGA, estimated gestational age; CPAP, continuous positive airway pressure; NEC, necrotizing enterocolitis

Table 4

Relationships between any parent holding, holding in arms, and skin-to-skin care and neurobehavioral and developmental outcomes.

	Univariate		Multivariate	
	β value	p value	β value	p value
Any Parent Holding (Skin-to-Skin Care and Holding Combined)				
Term Equivalent Age- NNNS Sub-Optimal Reflexes	−0.35	0.02	−0.36	0.02
Term Equivalent Age- NNNS Asymmetry	−0.27	0.03	−0.20	0.09
4–5 Years- ASQ-3 Gross Motor	0.15	0.03	0.16	0.054
4–5 Year- ASQ-3 Fine Motor	0.15	0.048	0.15	0.10
Parent Holding in Arms				
Term Equivalent Age-Dubowitz Reflexes	0.27	0.04	0.26	0.06
Term Equivalent Age- NNNS Sub-Optimal Reflexes	−0.48	0.02	−0.41	0.06
Parent Skin-to-Skin Care				
Term Equivalent Age-Dubowitz Reflexes	0.31	0.04	0.36	0.03
Term Equivalent Age-NNNS Asymmetry	−0.47	0.03	−0.48	0.04
4–5 Years- ASQ-3 Gross Motor	0.25	0.02	0.28	0.02
4–5 Years- ASQ-3 Fine Motor	0.27	0.02	0.25	0.055

P value is from investigations exploring relationships between parent engagement in the NICU and outcome using linear regression models. Multivariate analysis controlled for social risk and medical risk (social risk=maternal age <21 or public insurance; medical risk= <28 weeks estimated gestational age or cerebral injury defined as Grade III or IV intraventricular hemorrhage or cystic periventricular leukomalacia on cranial ultrasound). Abbreviations: NNNS=NICU Network Neurobehavioral Scale; ASQ-3=Ages and Stages Questionnaire, third edition. Any parent holding is number of days per week either parent held infant in arms or provided skin-to-skin care. Skin-to-Skin care is number of days per week either parent held unclothed infant directly on bare chest.