

Early Sleep Regulation in High Risk Infants: Medical and Contextual Factors

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Infant sleep patterns are influenced by both medical/biological and contextual factors, although previous research has found that the influence of these factors differs across development and sleep parameters (Davis et al., 2004). For example, night waking in newborns is considered a biological function, whereas night waking after 4 months of age is often attributed to contextual factors. Infants experiencing medical or contextual risks, such as preterm or low birth weight infants, may be particularly sensitive to sleep pattern disruption. Following a transactional perspective, this short-term longitudinal study assessed the relative importance of medical/biological and contextual factors on early sleep development within a sample of high risk infants.

Transactional theory hypothesizes that regulatory processes are a central component of development. Rather than emphasizing child or contextual factors, development is seen as “a complex function of the interplay of child and environment over time” (Sameroff & Fiese, 2000, p. 141). Transactional theory also highlights the importance of cumulative contextual influences over time. Following these principles, contextual and medical factors were assessed via composite indices and interactions between medical and contextual factors were examined. The medical/biological factors assessed included infant birthweight and medical complications and treatments during the infant’s NICU stay. The contextual factors included sociodemographic stressors, ethnicity, and breast/bottle feeding.

Based on an extensive literature review and consideration of the child’s developmental age, high quality sleep within this study was conceptualized as more sleep per sleep/wake cycle, nighttime sleep, diurnal sleep consolidation and fewer night wakings that required parental assistance. Medical and contextual predictors of sleep quality were examined across two complementary models. The first model predicted that sociodemographic stressors would moderate the relationship between medical risks and sleep quality. The second model posited that these same factors would relate to a dyad’s ability/decision to breast or bottle feed, which in turn would relate to infant sleep quality at 4 months of age.

Hypotheses

- Family sociodemographic stressors will interact with infant medical risks to influence infant sleep quality (Figure 1). Infants who experience more medical risks and higher sociodemographic stressors are expected to show lower quality sleep.
- Infants who experience more neonatal medical risks and family sociodemographic stressors will be less likely to breastfeed at 4 months; and bottle feeding at 4 months will relate to higher sleep quality (Figure 2).

Figure 1. Conceptual model of the interaction between infant medical/biological risks and family sociodemographic stressors on sleep parameters.

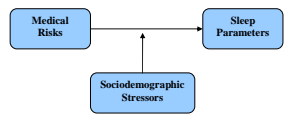
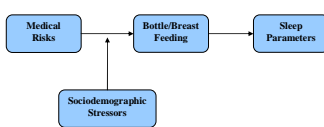


Figure 2. Conceptual model of the interaction between infant medical/biological risks and family sociodemographic stressors on breast/bottle feeding and sleep parameters.



Methods

Multiple methods were used to collect data at the baby’s hospital discharge and at 4 months (corrected for gestational age). At hospital discharge, collaborating nurses collected information from infant medical records. When infants were 4 months post-term, mothers completed demographic forms, an infant sleep log and a short in-home interview on their infants sleeping and eating habits.

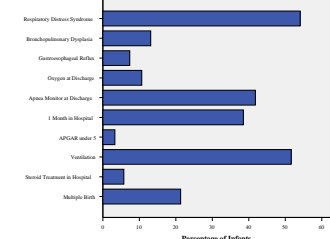
Sample

This sample was part of a larger longitudinal study of high risk infants. For this report, data were collected from 123 families recruited from 3 Wisconsin NICUs. Infant birth weights ranged from 564g to 3328g with an average weight of 1750g ($SD = 603g$). Infant gestational age ranged from 24 to 37 weeks with an average of 32 weeks ($SD = 3$ weeks). Ninety one (74%) of the infants were Caucasian, 7 (5.7%) were African American, 2 (1.6%) were Latino, 1 (.8%) was Asian, and 19 (18%) were more than one ethnicity.

Measures

Medical/Biological Risks. Infant medical records were reviewed to assess birth weight, medical complications, and treatments during the infant’s NICU stay. These items were used to generate a 10 item risk index with one point given for each factor listed in Figure 3. This index ranged from 0 to 9 with an average of 2.44 ($SD = 2.20$) and an internal consistency alpha of .77.

Figure 3. Percentage of infants experiencing medical/biological risks ($N = 121$).



Sociodemographic Stressors. Mothers completed a demographic questionnaire when their infants were 4 months post-term which included information on family income, education, family composition, employment, and smoking (Table 2). A 7 item sociodemographic stress index was created, with one point given for: family income below federal poverty guidelines, parent unemployed, single parent, more than 4 children in the home, adult in the home smokes, and mother or father had less than a high school education. This index ranged from 0 to 5 with an average of 0.85 ($SD = 1.16$).

Variable	N	Range	Mean	SD
Income	123	\$7,536 - \$200,000	\$60,648	\$38,061
Maternal Education	123	8 - 21	14.85	2.48
Maternal Employment	123	0 - 53	21.60	17.24
Paternal Education	121	6 - 21	14.28	2.93
Paternal Employment	121	0 - 80	38.43	17.18

Breast/Bottle Feeding. At 4 months post-term, mothers completed a short interview focusing on their infant’s sleeping and eating habits. Mothers were asked if their infant bottle or breast fed at night. Within this sample, 29 infants were breast fed and 94 infants were bottle fed at night.

Sleep Parameters. Infant sleep parameters were generated via maternal report sleep logs. Mothers were asked to indicate when their infant slept for at least three consecutive 24 hour periods. Based on these reports, sleep per sleep/wake cycle, nighttime sleep, diurnal sleep consolidation, and the number of night wakings that required parental assistance were estimated (Table 2).

Variable	Range	Mean	SD
Total Sleep per Sleep/Wake Cycle	525 - 1000	806.02	95.54
Nighttime Sleep	367.5 - 710	580.09	71.74
Diurnal Sleep Consolidation	48% - 100%	72%	.08
Night Waking	0 - 4.5	.87	.82

Note. Nighttime sleep and total sleep are reported as minutes and diurnal sleep consolidation is reported as the percentage of sleep consolidated during nighttime hours.

To assess the relations between infant sleep parameters, a series of bivariate correlations were calculated (Table 3). Consistent with expectations, infants who slept more at night slept more per sleep/wake cycle and had better diurnal sleep consolidation. Consistent with the developmental progression of diurnal sleep consolidation, infants who had more diurnal sleep consolidation slept less per sleep/wake cycle and had fewer night wakings. However, the number of night wakings did not relate to the amount infants slept at night or per sleep/wake cycle.

	1	2	3	4
1. Sleep per Sleep/Wake Cycle	1			
2. Nighttime Sleep	.47**	1		
3. Diurnal Sleep Consolidation	.42**	.54**	1	
4. Nightwakings	-.05	-.13	-.16*	1

Results

Considering the potential confound between sociodemographic stressors and ethnicity in the U.S. (e.g., Leyendecker et al., 2005), in all analyses containing the sociodemographic stress index, infant ethnicity was held constant. Ethnicity was coded in a binary fashion, with 0 for Caucasian and 1 for all other ethnicities.

Hypothesis 1

To assess how biological and contextual factors interacted on infant sleep, a series of hierarchical regression equations were computed (one for each sleep parameter). Within each equation the sleep parameter was regressed on: (step 1) the controls, (step 2) medical risks and sociodemographic stress, and (step 3) the interaction term between medical and sociodemographic risks.

Sleep Per Sleep/Wake Cycle. For total sleep per sleep/wake cycle, none of the overall regression models, controls or predictors were significant.

Nighttime Sleep. For nighttime sleep, none of the overall regression models were significant. The only predictor that appeared moderately influential was the interaction term, $B = .18, p < .06$. Post-hoc analyses revealed that infants who experienced more medical risks and sociodemographic stressors tended to sleep less at night.

Diurnal Sleep Consolidation. Diurnal sleep consolidation analyses followed a pattern similar to nighttime sleep. None of the overall models were significant, although the interaction term reached trend level significance, $B = .17, p < .08$. Infants who experienced more medical risks and sociodemographic stressors tended to have less diurnal sleep consolidation.

Night waking. For night waking, the overall model for step 2 reached trend level significance, $F(4, 113) = 2.09, p < .09$. Within this model, infants who experienced more sociodemographic stressors, $B = -.24, p < .05$, and Caucasian infants, $B = -.20, p < .05$, tended to wake less at night.

Hypothesis 2

To assess how biological and contextual factors related to infant bottle/breast feeding, a logistic regression equation was computed. Within this model, bottle/breast feeding was regressed on: (step 1) the controls, (step 2) medical risks and sociodemographic stressors and (step 3) the interaction term.

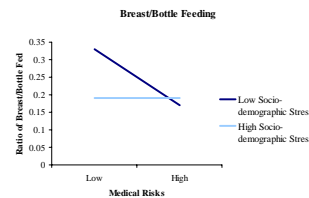
To assess how breast/bottle feeding related to infant sleep quality, 4 hierarchical regression equations were computed (one for each sleep parameter). For each equation, the sleep parameter was regressed on: (step 1) the controls of infant ethnicity, birth weight, medical risks, sociodemographic stressors, and the interaction term and (step 2) breast/bottle feeding.

Breast/Bottle Feeding. For the outcome of breast/bottle feeding, step 3 resulted in a significant model (Table 4). Within this model, infants who weighed more at birth were more likely to breast feed, and families who experienced more sociodemographic stressors were more likely to bottle feed. Post-hoc analyses revealed that the interaction was only significant at low levels of medical risk and sociodemographic stress, $X^2(3) = 9.57, p < .05$. Infants who experienced fewer medical risks and sociodemographic stressors were more likely to breastfeed than other infants, $B = .53, Wald = 4.35, Exp(B) = 1.69, p < .05$ (Figure 4).

Table 4. Logistic regression analysis with breast/bottle feeding.

Variables	Step 1 (Exp)			Step 2 (Exp)			Step 3 (Exp)		
	B	Wald	B	B	Wald	B	Wald	B	Wald
Ethnicity	.03	1.03	.01	.56	1.43	.37	.46	1.58	.58
Birth Weight	.01	1.00	4.71*	.01	1.00	5.14*	.01	1.00	5.82*
Sociodemographic				.95	6.4	2.74*	-.50	.61	2.94*
Medical				.10	1.11	.55	.18	1.19	1.41
Medical & SocioDemo								.26	1.29
$X^2(df)$				5.26*(2)		9.24*(4)		13.16*(5)	
Nagelkerke R ²				.07		.11		.16	
Cox & Snell R ²				.04		.08		.11	

Figure 4. Interaction between medical risks and sociodemographic stressors on feeding.



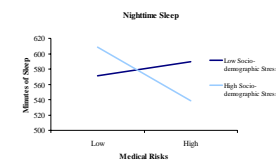
Sleep Per Sleep/Wake Cycle. For sleep per sleep/wake cycle, none of the overall regression models were significant. The only significant predictor was breast/bottle feeding ($B = -.27, p < .01$). Infants who bottle fed slept more per sleep/wake cycle.

Nighttime Sleep. For nighttime sleep, step 2 reached trend level significance, $F(6, 111) = 2.03, p < .08$. Infant breast/bottle feeding, $B = .21, p < .05$, and the interaction term, $B = -.21, p < .05$, related to nighttime sleep. Infants who bottle fed slept more at night. Post-hoc analyses revealed the interaction was only significant at high levels of medical risk and sociodemographic stress, $t(110) = 1.92, p < .05$. Infants who experienced more medical risks and sociodemographic stressors slept less at night than other infants (Figure 5).

Diurnal Sleep Consolidation. For diurnal sleep consolidation, none of the overall models reached significance. Breast/bottle feeding was not a significant predictor of diurnal sleep consolidation.

Night Waking. For night waking that required parental assistance, the overall model for step 2 was significant, $F(6, 111) = 4.32, p < .01$. Most of the variability in night waking was accounted for by infant breast/bottle feeding, $B = .37, p < .01$. Infants who bottle fed woke less at night.

Figure 5. Interaction between medical and sociodemographic stressors on nighttime sleep.



Summary

Results revealed complex interactions between infant medical/biological and contextual factors. Infants with higher birth weights were more likely to breast feed, which was associated with less nighttime sleep, sleep per sleep/wake cycle, and more night waking (Figure 6 & 7). In addition, infants who experienced a combination of fewer medical risks and sociodemographic stressors were more likely to breast feed (Figure 7). Finally, infants who experienced more medical risks and sociodemographic stressors slept less at night than other infants by 4 months of age.

Figure 6. Birth weight related to a dyad’s ability/decision to breast/bottle feed which in turn related to infant total sleep per sleep/wake cycle and night waking.

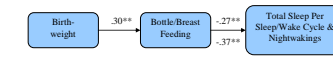
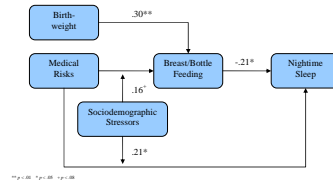


Figure 7. Sociodemographic stressors moderated the relation between medical risks and nighttime sleep and the relation between medical risks and breast/bottle feeding.



Conclusions

Consistent with transactional theory, infant medical/biological risks and family sociodemographic stressors interacted to predict total nighttime sleep at 4 months of age, although this relationship was not consistent across the four sleep parameters assessed in this study.

Based on the findings of this study, there appear to be two distinct paths through which infant and contextual factors may influence infant sleep parameters. The first path supports the tenet of transactional theory that the accumulation of medical and sociodemographic risks matter more than risk type. The second path relates to sleep via bottle or breast feeding. Infant birth weight related to a dyad’s decision/ability to breast feed at 4 months, which in turn related to less sleep per sleep/wake cycle and more night wakings that required parental assistance. These findings are intriguing because infant breast feeding has been linked with numerous positive developmental outcomes (e.g., Gómez-Sánchez et al., 2003). Yet, within this study and across the sleep literature, breast feeding in typically developing infants has been linked with indicators of lower quality sleep (e.g., less total sleep and more night waking at 4 months). To reconcile this paradox, we may need to reconsider what constitutes adaptive or high quality infant sleep, especially when infants are young (i.e., less than one year of age). Perhaps less sleep and more night waking is an evolutionarily developed regulation pattern which promotes optimal development, and breast feeding is associated with this pattern.

Alternatively, differences in infant night waking may simply reflect a difference in sleep architecture and not sleep quality. As indexed by the correlations between sleep parameters in this study, night waking may be a function of feeding route rather than sleep quality.

Both of the proposed paths of influence emphasize the roles of infant and contextual factors, including infant health risks, family contextual stressors, and their interactions.

References

Davis, K., Parker, K., & Montgomery, G. (2004). Sleep in infants and young children: From one Normal sleep. *Journal of Pediatric Health Care, 18*, 48-51.
Gómez-Sánchez, M., Calvo, R., & Botero, L. (2003). Influence of Breast-Feeding on Mental and Psychosocial Development. *Clinical Pediatrics, 42*(1), 62-65.
Leyendecker, B., Harwood, R., & Compton, L. (2005). Socioeconomic Status, Ethnicity, and Parenting by Low and High Income Mothers. *Parenting: An Interdisciplinary Journal of Research on Applied Family Psychology, 5*(1), 131-149. Mahan, N. L. (2002). *Parenting: An Interdisciplinary Journal of Research on Applied Family Psychology, 2*(1), 1-10.
Sameroff, A. J., & Fiese, W. H. (2000). *Transactional theory: The developmental ecology of early experience*. In J. P. Shaffer & S. J. Meeus (Eds.), *Handbook of Early Childhood Intervention* (2nd ed., pp. 135-166). New York, NY: Cambridge University Press.

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