18-Month Follow-Up of Infants Cared for in a Single-Family Room Neonatal Intensive Care Unit

Barry M. Lester, PhD[1,2,3,4], Amy L. Salisbury, PhD[1,2,4], Katheleen Hawes, PhD[1,2,4], Lynne M. Dansereau, MSPH[1,4], Rosemarie Bigsby, ScD[1,2,4], Abbot Laptook, MD[2,4], Marybeth Taub, RN[4], Linda L. Lagasse, PhD[1,2,4], Betty R. Vohr, MD[2,4], and James F. Padbury, MD[2,4]

Objectives To determine whether the single-family room (SFR)-neonatal intensive care unit (NICU) is associated with improved 18-month neurodevelopmental outcome, especially in infants of mothers with high maternal involvement.

Study Design An 18-month follow-up was undertaken that compared infants born <30 weeks gestational age; 123 from a SFR-NICU vs 93 from an open-bay NICU. Infants were divided into high vs low maternal involvement based on days/week of kangaroo care, breast/bottle feeding, and maternal care. Infants with high vs low maternal involvement in the SFR and open-bay NICUs were compared on the Bayley Cognitive, Language, and Motor scores and Pervasive Developmental Disorders autism screen.

Results There were more mothers in the high maternal involvement SFR than in the high maternal involvement open-bay group ($P = .002$). Infants with high maternal involvement in both NICUs had greater Cognitive ($P = .029$) and Language ($P < .000$) scores than infants with low maternal involvement. Effect sizes within NICU were moderate to large in the SFR-NICU for Language scores and moderate for the Language composite in the open-bay NICU. The number of days of maternal involvement was greater in the SFR than open-bay NICU ($P < .000$), and length of stay was shorter in the high maternal involvement SFR than high maternal involvement open-bay NICU ($P = .024$). Kangaroo and maternal care predicted Cognitive (kangaroo, $P = .003$) and Language scores ($P = .015$, $P = .032$, respectively). Infants with ≥1 symptom of autism were more likely to be in the open-bay low maternal involvement group vs the SFR high maternal involvement group (OR = 4.91, 95% CI = 2.2-11.1).

Conclusions High maternal involvement is associated with improved 18-month neurodevelopmental outcome, especially in infants cared for in a SFR-NICU. *(J Pediatr 2016;■■:■■-■■).*

The single-family room (SFR) neonatal intensive care unit (NICU) increasingly is being adopted. It is expected to improve the care of preterm infants and reduce the prevalence and severity of later neurodevelopmental impairment, especially in infants born <30 weeks' gestational age at birth. Although most studies have reported beneficial effects associated with the SFR-NICU,[1-9] negative effects also have been reported.[9-12] In previous work we compared medical and neurobehavioral outcomes at NICU discharge between infants cared for in an open-bay vs SFR-NICU. We found improved medical and neurobehavioral outcomes at discharge associated with the SFR model of care[1] and that the benefits of the SFR-NICU were mediated, in part, by increased maternal involvement with the infant. The SFR setting affords more opportunities for maternal involvement, which, in turn, is related to better medical and neurobehavioral outcomes at NICU discharge. These results provided the first evidenced-based data suggesting how and why the SFR model improves infant outcome at NICU discharge.

Of critical importance is to determine whether these findings are long lasting. To date, the only follow-up study reported lower Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) Language Composite scores at age 2 years and negative findings on magnetic resonance imaging related to the SFR-NICU.[12] These results were attributed to stimulus deprivation that could have been attributable to low levels of parental involvement. The latter study underscores the necessity for additional follow-up studies of infants cared for in SFR-NICUs, including studies that have varied demographic characteristics in their patient population and that vary in delivery of care. We conducted an 18-month follow-up of infants from our original study to determine whether the initial findings of positive neurodevelopmental outcomes related to the SFR-NICU were maintained beyond

ASD	Autism spectrum disorder
Bayley-III	Bayley Scales of Infant and Toddler Development, Third Edition
LOS	Length of stay
NICU	Neonatal intensive care unit
PDDST-II	Pervasive Developmental Disorders Screening Test, 2nd edition Stage 2
SFR	Single-family room

From the [1]Center for the Study of Children at Risk, Warren Alpert Medical School of Brown University, Providence, RI; [2]Departments of Pediatrics, Warren Alpert Medical School of Brown University, Providence, RI; [3]Departments of Psychiatry and Human Behavior, Warren Alpert Medical School of Brown University, Providence, RI; and [4]Department of Pediatrics, Women and Infants Hospital of Rhode Island, Providence, RI

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NICU discharge. The follow-up was limited to infants born <30 weeks' gestation because these infants are at greatest risk for later neurodevelopmental impairment.[13-16] Our hypothesis was that maternal involvement would be associated with improved neurodevelopmental outcome at 18 months, especially in infants cared for in a SFR-NICU.

Methods

In the original study, all infants born <1500 g were eligible for enrollment. Consecutive new admissions were recruited from the open-bay NICU over 18 months in 2008 through 2009 before the unit was moved to a SFR-NICU.[1] After a 3-month hiatus, consecutive new admissions were enrolled in the SFR-NICU over 31 months from 2010 through 2012. We enrolled 78% of eligible patients in the open-bay NICU and 76% of eligible patients in the SFR-NICU. This resulted in 2 distinct cohorts; 151 infants cared for in the open-bay NICU and 252 cared for in the SFR-NICU. Of the 403 infants in the original study, 293 (72.7%) were born <30 weeks' gestational age. Among these, follow-up data were available for 216 infants (73.7%), 93 (43.0%) from the open-bay NICU and 123 (57.0%) from the SFR-NICU. The study was approved by the hospital institutional review board, and written informed consent was obtained from all participants including nurse participants.

The infants were seen at 18 months' corrected age in our Neonatal Follow-up Clinic. Outcomes measures included the Bayley-III Cognitive, Language, and Motor Composite scores, Receptive and Expressive Communication scores, and Fine and Gross Motor subtest scores. We also administered the Pervasive Developmental Disorders Screening Test, 2nd edition, Stage 2 (PDDST-II),[17] a 14-item parent report questionnaire screen for autism spectrum disorders (ASDs). The cut-off for a positive screen is a score of ≥5 with a sensitivity of 0.73 and specificity of 0.49.[18]

Maternal, infant, and medical characteristics from the original study were abstracted from the electronic medical records. Maternal stress was measured with the Parental Stressor Scale: NICU[19] and depression with the Beck Depression Inventory.[20] Maternal involvement was a composite variable based on kangaroo care (skin to skin), breast-feeding, bottle feeding, and maternal care (eg, bathing/diapering/holding). Each interaction was counted and aggregated by day and then by week. The score is the number of days of involvement per week. Maternal involvement was divided into groups based on a median split into high maternal involvement (above the median) and low maternal involvement (at or below the median) only for those available for follow-up.

Categorical variables were described as percentages and continuous variables as means and SDs. ANOVA was used for continuous measures and χ^2 for categorical measures. ANCOVA was used to adjust for covariates. Bonferroni correction for multiple comparisons was used for post hoc tests. Effect sizes were calculated within NICU as the mean difference between maternal involvement groups divided by the SD of the Bayley scores (15 for the Cognitive and Language Composite scores and 3 for the Expressive and Communication subtest scores) and described as small (0.20-0.50), moderate (0.50-0.75), and large (>0.75).[21] Linear regression was used for the analysis of continuous maternal involvement variables and logistic regression for the categorical maternal involvement variable. Area under the curve was used to describe the distribution of the number of days per week of maternal involvement between the 2 NICUs over the first 12 weeks of life via use of the trapezoidal rule.[22]

Results

There were no differences in demographic characteristics by NICU between mothers of infants born <30 weeks' gestational age who were included and not included in the 18-month follow-up (**Table I**). Infants included in the 18-month follow-up had a lower birth weight, shorter gestational age, and smaller head circumference at birth in both NICUs. Infants included in the SFR-NICU had a longer length of stay (LOS) than infants not included. In the open-bay NICU, infants included had a lower gestational age at full enteral feeding than infants not included (**Table I**). Mothers in the open-bay NICU reported more stress than those in the SFR-NICU (**Table II**). Infants seen at 18 months from the SFR-NICU had a greater weight at discharge and faster rate of weight gain than those in the open-bay NICU (**Table II**). Accordingly, parental stress, weight at discharge, and rate of weight gain were used as covariates in the analysis of neurodevelopmental outcome measures.

There were more mothers in the high maternal involvement SFR group than in the high maternal involvement open-bay group (high maternal involvement SFR, n = 73, 59.3%; low maternal involvement SFR, n = 50, 40.7%; high maternal involvement open-bay, n = 35, 37.6%; low maternal involvement open-bay, n = 58, 62.4%; $P = .002$). Mothers were 1.5 times more likely to be in the high maternal involvement group in the SFR than open-bay NICU (risk ratio = 1.53, 95% CI = 1.18-2.0). There were no differences in the percent of infants in the high maternal involvement groups between the follow-up sample of 216 and the 293 infants born <30 weeks' gestational age in the original sample (high maternal involvement SFR, n = 103, 56.3%, $P = .594$; high maternal involvement open-bay, n = 42, 38.2%, $P = .936$).

There were no significant effects of NICU type on cognitive, language, or motor scores on the Bayley-III at 18 months of age; however, infants in both the open-bay and SFR-NICU high maternal involvement groups had greater Cognitive and Language Composite scores and greater Receptive and Expressive Communication scores on the Bayley-III than infants in the open-bay and SFR low maternal involvement groups (**Table III**). For every 1-day increase in the number of days per week of maternal involvement, the Cognitive Composite score increased by 1.6 points ($P = .002$), the Language Composite score increased by 2.9 points ($P < .000$), and both the Receptive and Expressive Communication scores increased by 0.5 points ($P < .000$). Examination of scores across the 3 composites revealed that 7 (7.87%) children scored <70 on 1 of 3

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