

*Reprinted from*

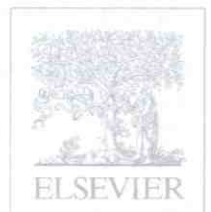
VOLUME 8 • NUMBER 2 • JUNE 2008

# NEWBORN & INFANT NURSING REVIEWS

## Quality Improvement Analysis of Developmental Care in Infants Less Than 1500 Grams at Birth

Susan Ludwig, OTR  
Jean Steichen, MD  
Jane Khoury, MS  
Pam Krieg, RN

[WWW.NAINR.COM](http://WWW.NAINR.COM)



# Quality Improvement Analysis of Developmental Care in Infants Less Than 1500 Grams at Birth

Susan Ludwig, OTR, Jean Steichen, MD, Jane Khoury, MS, and Pam Krieg, RN

The study evaluated the effect of developmental care (DC) on short-term outcome, weight gain, and length of stay in very low-birth-weight infants (1000–1499 grams) and extremely low-birth-weight infants (<1000 grams at birth). The infants were cared for in the neonatal intensive care unit (NICU) at the University Hospital in Cincinnati. It was hypothesized that providing consistent DC to all babies in the NICU weighing 1500 grams or less at birth would increase weight gain and decrease length of stay. Data for both cohorts, predevelopmental care (preDC) and postdevelopmental care (postDC) were collected prospectively as part of the National Institutes of Health Neonatal NICU Research Network generic database on babies less than 1500 grams. This database included all variables studied and used in both cohorts. The study consisted of a pre-DC historic control and post-DC treatment group. The postDC period started 3 months after the entire staff had undergone a 4-day focused educational program on DC. This was done so that the data collected for the postDC group would occur after the initial learning curve for DC in the NICU. This study was carried out in a 50-bed level III NICU in a university teaching hospital setting. Infants weighing 1500 grams or less at birth between July of 1998 and July of 2002 were included. This population was divided into two groups: the preDC group (July 1998–July 2000) and the postDC group (2000–2002). Subgroups were then established by birth weight, less than 1000 and 1000 to 1499 grams, and the second subgroup used to separate groups less than 28 weeks gestational age and greater than 28 weeks gestational age. The total study population consisted of 292 infants. There was a statistically significant increase in weight at 36 weeks of age in the postDC period as compared to the preDC group for both the extremely low-birth-weight and very low-birth-weight groups ( $P < .05$ ). The postDC group had a significant increase in the percentage of infants discharged by 40 weeks postconceptional age ( $P < .01$ ). In conclusion, the successful introduction of a broad practice-based DC program in a university hospital NICU setting is described. This program coincided with significant improvement in weight gain and early discharge in preterm infants less than 1500 grams at birth. This is the first study to incorporate bubble continuous positive airway pressure into a DC regimen and the first National Institutes of Health Neonatal Network site to document positive benefits from the widespread implementation of DC practice across a single NICU.

© 2008 Elsevier Inc. All rights reserved.

**Keywords:** Premature infant; Developmental care; Weight gain; Length of stay; Neonatal intensive care unit

From the The University Hospital, Rehab Services Department, ML#0741, Cincinnati, OH; Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, OH; Division of Epidemiology and Biostatistics, Department of Environmental Health, University of Cincinnati Medical Center, Cincinnati, OH; and Neonatal Intensive Care Unit, The University Hospital, Cincinnati, OH. The study took place at the NICU at University Hospital, Cincinnati, OH. This was supported by a cooperative agreement with the National Institute of Child Health and Human Development (U10 HD27853).

Address correspondence to Susan Ludwig, OTR, 5324 Race Rd., Cincinnati, OH 45247. E-mail: sludwig1@cinci.rr.com.

© 2008 Elsevier Inc. All rights reserved.

1527-3369/08/0802-0253\$34.00/0

doi:10.1053/j.nainr.2008.03.011

Developmental care (DC) has been described as "a pervasive orientation of all care procedures toward maintaining the infant in as organized or stable a condition as possible and managing the physical care and social environment to minimize stressors."<sup>1</sup> This practice is a paradigm shift in neonatal intensive care unit (NICU) care, bringing the infants' individual developmental needs and caretaking practices in alignment with physiologic needs, to support the infants' growth and development. Developmental care is a comprehensive transformation of the NICU environment promoting the infants' comfort, growth, and development. As such, it requires total commitment of the entire staff. Developmental care encompasses clinical care and procedures as well as social and physical aspects in the NICU.<sup>2</sup> It is a philosophy of care in which the individual needs of the infant are recognized, prioritized, and supported, so their

development may continue as normally as possible in the extrauterine environment. Developmental care creates a supportive microenvironment for the infant within the supportive macroenvironment of the NICU. In an effort to improve the quality of care in the NICU, the task of introducing and educating an entire staff in the research and implementation of DC was undertaken.

## Review of Literature

Although DC has become an integral part of patient care in numerous NICUs, the potential benefits have not been extensively evaluated. Studies have variously shown DC to decrease the duration of mechanical ventilation, improve weight gain, shorten hospital stays, decrease incidence of neonatal intraventricular hemorrhage, and decrease hospital costs.<sup>3-5</sup> However, as noted in a systematic review by Symington and Pinelli,<sup>6</sup> many studies were of small sample size and included multiple interventions.

Developmental care involves a combination of multiple philosophies and numerous intervention techniques all focused on the infant as the central figure in the NICU. These strategies are aimed at increasing the infants' comfort and reducing stress in an individualized manner from admission through discharge. These include, but are not limited to, developmentally supportive positioning and handling, recognizing and responding to infant cues, clustering of care and procedures to promote rest, and offering nonnutritive sucking for self-regulation and pain management.<sup>7,8</sup> Light and sound are adjusted according to the needs of the infant in addition to the needs of the staff.<sup>7</sup>

In a position statement by the American Academy of Pediatrics (AAP) in 1997, it was stated that monitoring and reducing noise level in the NICU should be encouraged.<sup>9</sup> Noise levels of more than 55 decibels are of concern and should be avoided.<sup>9</sup> In addition, this AAP statement reported that exposure to noise may disrupt normal growth and the development of normal auditory processing in premature infant. Graven stated, "For the preterm infant it is essential that background neurosensory stimulation (sensory noise) be kept at a level such that sensory systems can discriminate and accommodate meaningful signals or stimulation."<sup>10</sup> Hospitals, therefore, need to provide a means of addressing excessive sound levels.<sup>11</sup>

Many premature infants are exposed to either continuous bright direct light or continuous dim light in the NICU. Current literature supports the use of low-intensity cycled lighting, which reflects the individual infants' developmental needs.<sup>7</sup> This practice has shown that distinct patterns of organized rest-activity are apparent within 1 week after discharge in infants so exposed as compared to those exposed to continuous dim light.<sup>12</sup> Cycled lighting more closely mimics the intrauterine environment where the infant is exposed to maternal circadian rhythm time-of-day cues and hormonal changes that synchronize the fetal clock with the external light-dark cycle.<sup>13</sup> Preterm infants need exposure to light only to facilitate biologic rhythms.<sup>14</sup> Direct bright light should be avoided except during

care procedures.<sup>15</sup> The infant's eyes should be covered any time direct light is necessary for care.

Premature infants are at risk for positional deformities acquired in the NICU.<sup>16</sup> The premature infant is often virtually "pinned" to the bed by gravity, exaggerating his already extensor-dominant tone. If the infant is not supported in this intrauterine flexed position, his extensor tone remains dominant and unbalanced. This extended posture is contrary to the intrauterine environment where the infant experiences a predominantly flexed position and is floating in a fluid environment. These acquired positional deformities may lead to developmental motor delays manifesting in the older infant or child.<sup>17</sup> The most common of these deformities include shoulder/scapular retraction with elbow flexion leading to delays in bringing hands to midline and reaching, and hip abduction and external rotation with ankle eversion leading to delays in sitting, crawling, and weight bearing.<sup>17</sup> The very low-birth-weight (VLBW) infant is at risk for postural and tonal abnormalities known to affect developmental motor milestones up to 6 years of age.<sup>18</sup> These positional abnormalities were described as related to immaturity, physiologic hypotonia, and the effects of gravity.<sup>18</sup> Positioning the infant in a contained, more flexed position, mimicking the intrauterine position, while continuing to allow movement against some resistance is optimal to promote a more normal base of support from which all other movement may develop. This type of postural support has both and immediate and lasting impact on the infant's development.<sup>19</sup>

The use of nonnutritive sucking in combination with sucrose for painful procedures has been shown to reduce pain scores during procedures.<sup>20</sup> Although studies have shown that using nonnutritive sucking and sucrose separately can affect behavioral and physiologic responses, it was also demonstrated that they had their greatest effect when used in conjunction.<sup>21</sup>

## Methods

### Staff Training and Maintenance of Staff Competence

The Children's Medical Ventures' Wee Care Program was introduced as the method of choice for teaching staff not only the research and theory of DC but to assist in practical implementation of this type of care. This education included all NICU staff to facilitate a global change in care delivery, occurring over a brief time frame.

Education was presented in both didactic and hands-on format. It included on-site bedside consultation by the educators for patient-specific questions on all shifts. Implementation of the DC program into the existing structure of this unit was addressed. The program took place over a 4-day period and was designed to promote rapid and uniform exchange of care practice, *making DC a 24-hour 7-day a week practice.*

In this 4-day training period (number of days was based on number of staff), nurses, respiratory therapists, occupational and physical therapists, and physicians attended an 8-hour mandatory program. Many other disciplines were educated in

one of several 1-hour sessions. All services were included to ensure that every staff person entering the NICU was aware of how their interactions within that environment can effect the development of the infants. In addition to this initial program, the unit was provided with five 1-day follow-up sessions with a consultant from the educational training team. The topics for these 1-day sessions were chosen based on needs identified as a priority for this individual unit. Topics that were chosen included developmentally supportive feeding, kangaroo care, pain management, and a review of the 8-hour program for new staff. These follow-up visits secured the ongoing efforts of the unit to provide individualized DC.

Any new staff hired since the initial program were required to attend a 4-hour in-service on DC provided by the unit's occupational therapist. Developmental care policies were also written and implemented within 1 year of the Wee Care Program.

The unit's occupational therapist and DC committee continuously monitor the implementation of DC. There is a concerted ongoing effort by the unit to make DC an integral part of the all care received by the infant. Parents are invited and encouraged to actively participate in the infant's care within a framework that supports positive interaction. This allows parents to build confidence in their ability to care for their infants, read their infant's cues, and respond supportively.

### Procedure and Study Design

In the predevelopmental care (preDC) group, infants were cared for as per existing standards of care. The policies at that time did not include DC, noise, and light reduction levels or positioning. The postdevelopmental care (postDC) group infants were cared for using the principles of DC taught in the educational program. Comparisons of the preDC and postDC principles are shown in Table 1. All infants in the postDC group were cared for using DC practice from admission through discharge in an individualized manner.

### Positioning

Positioning was addressed using the underlying principles of developmentally supportive positioning and using commercial positioning aids as indicated to provide the best support possible and establish consistency among caregivers. The goals of positioning were to provide flexion, containment/boundaries, alignment, and comfort in an individualized manner.

### Nonnutritive Sucking

An appropriate-sized pacifier was also used for infants of any age to allow for self-calming through nonnutritive sucking (NNS) and to promote positive sensorimotor input in the presence of necessary but noxious procedures. The practice of providing nonnutritive sucking opportunities during gavage feedings was also implemented. Policies for use of sucrose and nonnutritive sucking were created and implemented.

### Lighting

Incubators were covered with quilts made by volunteers to protect the smallest infants from direct light. Lighting was dim and less than 60 foot candles. The lighting was changed to using only "up lighting," with no continuous direct light over the infant's bed space. The infants' eyes were covered for any procedure in which bright light was needed at the bedside.

### Clustering Care/Promotion of Sleep

Care provided to the infant by each discipline was clustered in all non-emergent situations to promote sleep and decrease stress on the infant. Because all staff had been educated, each bedside nurse and caregiver was able to respond to the infants' cues regarding stress and self-calming as these cues occurred.

**Table 1. Description of Care in the First Study Period (pre-DC) vs the Second Study Period (post-DC)**

No monitoring of sound; all doors to pods open	Baseline sound levels established and sound monitored regularly; doors to pods closed; door buzzer changed; alarm sound levels lowered; intercom system eliminated
Lighting included fluorescent bedside lighting, which was used frequently in addition to indirect lighting, no cycled lighting; incubators covered inconsistently	Use of direct light at bedside eliminated except when necessary for care, then infants' eyes covered; primarily only up lit lighting used, dim during the day, dark at night; all incubators covered
Infants were inconsistently positioned in developmentally supportive manner with inconsistent supply, use of, and understanding of positioning aids	Consistent positioning and handling in developmentally supportive manner with all bedside staff educated in rationale for positioning and use of positioning aids
Inconsistent use of nonpharmacologic pain assessment and intervention	Pain assessed with pain scale and was treated both pharmacologically as previous, as well as nonpharmacologically
Consistent use of NNS for self-calming/regulation; inconsistent staff education regarding signs of stress and self-regulation in premature infants	Continued use of NNS for self-calming/regulation and when indicated, in conjunction with sucrose for painful procedures; all bedside staff educated regarding signs of stress and supporting self-regulatory behavior in premature infants
No formal education of new staff regarding principles, research, and implementation of DC	DC education (both didactic and hands on) became a mandatory class for nursing orientation

**Table 2. Maternal and Neonatal Characteristics**

	Delivery Weight <1000 grams (ELBW)			Delivery Weight 1000–1500 grams (VLBW)		
	Pre-DC (n = 68)	Post-DC (n = 80)	P	Pre-DC (n = 71)	Post-DC (n = 73)	P
Maternal race (black)	44%	39%	.51	45%	33%	.13
Antibiotic use	53%	64%	.06	58%	60%	.76
Steroid use	81%	81%	.95	89%	85%	.50
Labor	60%	68%	.36	72%	63%	.26
Cesarean delivery	56%	50%	.48	59%	60%	.89
Delivery gestation (weeks)	26.3 ± 2.2	25.8 ± 1.9	.15	30.5 ± 2.8	29.7 ± 1.9	.02
Outborn	3%	5%	.69	3%	7%	.44
Multiple delivery	22%	18%	.49	22%	18%	.77
Sex (female)	46%	54%	.37	56%	58%	.99
APGAR 1 minute <7	75%	84%	.19	65%	46%	.03
APGAR 5 minutes <7	53%	56%	.69	30%	12%	.01
PDA	44%	52%	.25	18%	14%	.38
NEC	15%	15%	.96	14%	5%	.36
Death	26%	24%	.70	1%	1%	1.00

Data are presented as percentage or mean ± SE. PDA = patent ductus arteriosus, NEC = necrotizing enterocolitis.

## Noise Control

Conversation among staff was moved away from the infant's bedside to decrease noise, and alarms were attended to as quickly as possible. Doors that separated the patient care areas from the entryway and documentation area were closed after every pass-through, whereas before DC education they were routinely left open for staff convenience. Staff radios were removed to decrease the overall sound level. Sound was measured routinely with a decibel reader to ensure compliance to AAP recommendations of less than 55 decibels.

## Study Design

Institutional review board approval was obtained for this study. Anonymized data for both cohorts were collected prospectively as part of the National Institutes of Health (NIH) Neonatal NICU Research Network generic database on babies less than 1500 grams at birth. This database includes all variables studied in both groups. Respiratory outcomes were not reported as outcomes of the study because of introduction of bubble continuous positive airway pressure (CPAP) during the study period.

The period of the study was from July of 1998 through July of 2002. The study period was divided into two analysis periods: pre-DC and post-DC, 2 years after the introduction of DC. The 3 months just after training and implementation of DC were not used in the study as they were considered a learning period for DC in the unit.

## Study Population

This study was carried out in a 50-bed, level III NICU that is part of a 650-bed tertiary care center and teaching hospital.

Infants weighing less than 1500 grams at birth between July of 1998 and July of 2002 were included. Each group was

then subdivided by birth weight (BW): less than 1000 grams BW and 1000 to 1499 grams BW. The total study population consisted of 292 infants. Exclusion criteria included death within first week of life, major syndromes or congenital malformations, and those transferred to another facility before discharge home. Those transferred to another facility were excluded because of the lack of data at time of discharge, that is, weight and inability to ensure consistency of DC practice in another facility.

## Data Collection Analysis

### Data Collection

All infants, preDC and postDC, were part of the generic database collection of infants less than 1500 grams enrolled in the NIH Neonatal Research Network. Thus, the same group of NICU Research Network-trained research nurses collected all data for the preDC and postDC prospectively. There were no changes in the Manual of Operations for data collected during this period. Weight gain and hospital stay were the primary outcomes chosen to act as global measures of improved short-term outcome.

### Data Analysis

Data were managed and analyzed using SAS version 8.2 (SAS Institute Inc, Cary, NC) with further analysis done using SUDAAN to allow for the clustering due to multiple gestations included in the analysis and to allow for the estimation of the correct variance.  $\chi^2$  and *t* tests were used as appropriate for bivariate analysis of categorical and interval variables. Analysis of covariance was used to adjust birth weight and birth length for gestation, and to adjust weight and length at the equivalent

**Table 3. Neonatal Weight and Length**

	Delivery Weight <1000 grams (ELBW)			Delivery Weight 1000–1500 grams (VLBW)		
	Pre-DC (n = 68)	Post-DC (n = 80)	P	Pre-DC (n = 71)	Post-DC (n = 73)	P
Unadjusted birth weight (grams)	751.3 ± 17.0	743.9 ± 17.9	.77	1255 ± 17.6	1263 ± 16.5	.74
Adjusted birth weight (grams)*	739.5 ± 14.8	754.0 ± 13.6	.47	1240 ± 15	1278 ± 14.7	.07
Weight at “36 weeks gestation” (grams)	2079 ± 111	2397 ± 125	.03	2177 ± 69	2390 ± 70	.02
Adjusted weight at “36 weeks gestation” (grams) †	2090 ± 115	2388 ± 107	.03	2174 ± 69	2393 ± 66	.01
Weight gain/week—birth to 36 weeks (grams)	146.5 ± 11.2	174.0 ± 13.2	.06	180.5 ± 13.0	180.3 ± 9.2	.45
Unadjusted birth length (centimeters)	32.7 ± 0.36	32.5 ± 0.34	.71	38.5 ± 0.24	38.2 ± 0.31	.45
Adjusted birth length (centimeters)*	32.6 ± 0.30	32.7 ± 0.30	.72	36.4 ± 0.26	38.4 ± 0.28	.85
Length at “36 weeks gestation” (centimeters)	43.1 ± 0.70	44.3 ± 0.73	.12	43.7 ± 0.44	44.6 ± 0.38	.06
Adjusted length at “36 weeks gestation” (centimeters) †	43.0 ± 0.76	44.3 ± 0.75	.12	43.6 ± 0.41	44.6 ± 0.45	.06
Length gain/week—birth to 36 weeks (centimeters)	1.12 ± 0.08	1.20 ± 0.08	.24	1.04 ± 0.12	1.05 ± 0.06	.46

Data presented as mean ± SE.

\*Adjusted for gestation at delivery.

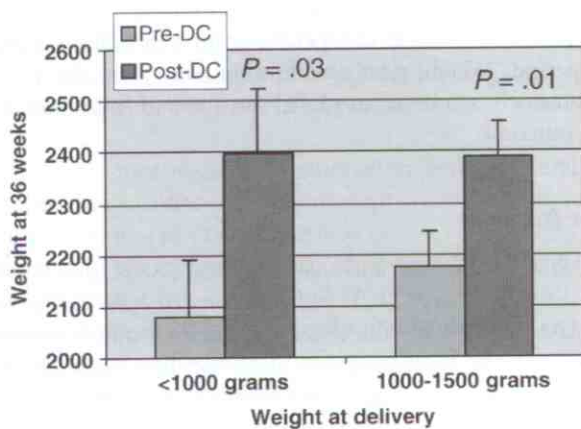
†Adjusted for delivery weight or length as appropriate.

of 36 weeks of gestation for birth weight and birth length, respectively, the a priori time of reporting.

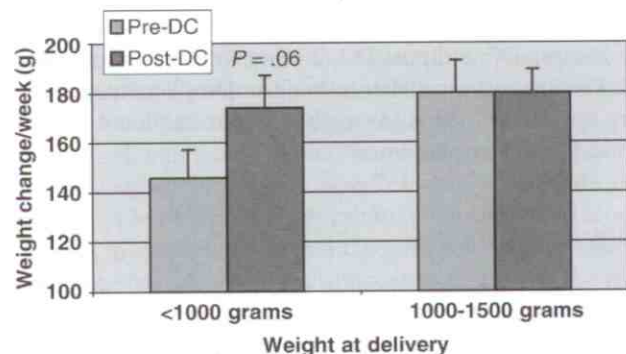
## Results

There were 139 infants in the preDC group and 153 infants in the postDC group. As shown in Table 2, the infants in the preDC and postDC groups were comparable with respect to maternal race, antenatal steroid use, labor, and birth by cesarean delivery. Gestation at delivery was lower for the postDC group for VLBW ( $P = .02$ ), but APGAR scores were higher at 1 and 5 minutes ( $P = .03$  and  $.01$ , respectively). There were no other statistically

significant differences in neonatal characteristics for the preDC infants vs the postDC infants in either the extremely low-birth-weight (ELBW) or VLBW infants. Comparison of weight and length variables may be seen in Table 3. At birth, weight and length were comparable between the groups for both ELBW and VLBW groups. Weight at 36 weeks corrected age both unadjusted and adjusted for birth weight was statistically significantly higher in the postDC group compared to the preDC group for both the ELBW and VLBW groups ( $P = .03$  and  $.01$ ), and may be seen in Fig 1. There were no significant changes in nutritional practices during this time frame. Increases were also seen for length; however, the differences were not statistically significant. There was an improvement in weight gain per week by 36 weeks gestation in the ELBW postDC group infants ( $P = .06$ ) compared to the ELBW preDC infants (Fig 2). In addition, postDC group infants in the ELBW group regained



**Fig 1.** Weight at 36 weeks adjusted for weight at delivery.



**Fig 2.** Weight gain per week from birth to 36 weeks.

their birth weight an average of 2 days earlier than preDC ELBW infants, by 8 days of life and 10 days, respectively.

For purposes of analysis, infants were divided into those delivered at less than 28 weeks gestation and those delivered at 28 weeks or more of gestation to evaluate the infants who were discharged to home by 40 weeks postconceptional age. The average gestational age of the less than 28-week group was 25 weeks gestational age, whereas the average gestational age for the 28 weeks and greater group was 30 weeks gestational age. Thus, the former group was compared for discharge at 105 days, that is, 40 weeks postconceptional age, and the latter group at 70 days postdelivery, that is, 40 weeks postconceptional age. There was a statistically significant increase in the percentage of infants discharged home by 105 days (35/78, 45%) in the postDC group infants born at less than 28 weeks of gestation compared to (14/58, 24%) the preDC infants born at less than 28 weeks of gestation ( $P = .01$ , Fig 3). There was no difference between periods for discharge home by 70 days for infants born at 28 or greater weeks of gestation: 72/81 (89%) in the preDC group and 61/75 (81%) of the postDC period were discharged home by 70 days ( $P = .18$ ).

## Discussion

Achieving an earlier time to discharge while providing quality care is essential in low-birth-weight infants who can easily spend 2 to 3 months in the NICU before discharge. In this study, nearly twice the number of <28-week infants in the postDC group were discharged home by 40 weeks vs the preDC infants. A Cochrane Review of DC indicated decreased length of stay after DC intervention.<sup>22</sup> Westrup et al,<sup>23</sup> however, did not report findings of earlier discharge in 2000.

Analysis supports the suggestion that improvements in weight gain can be attributed to specific changes in care practice. It is believed that by handling in a supportive manner, responding to individual cues, positioning in flexion with boundaries, and clustering care, sleep was protected and energy conserved thereby improving weight gain.

To integrate DC principles into bedside practice, staff education is paramount. By engaging all staff in the program within a brief period, knowledge was not limited to only a few specialists in the area of DC or staff with a particular interest in

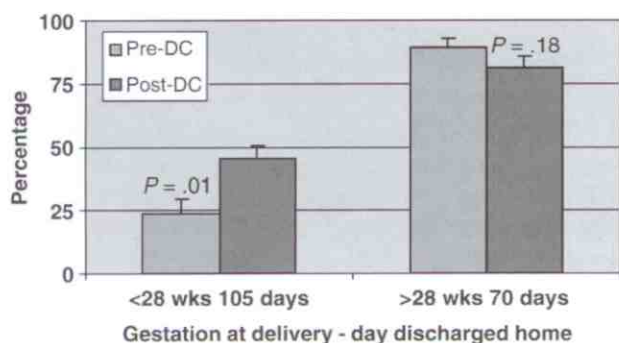


Fig 3. Percentage of those discharged home by 40 weeks of gestation.

DC. This proved to be a key component of successful implementation of DC. This type of education was noted to be "effective in initiating immediate and global change in a NICU."<sup>5</sup> However, such a dramatic change in practice requires ongoing education, reinforcement, and support to maintain continued success. All NICU staff continues to receive education regarding DC. This initial and ongoing training has made DC part of the culture of this unit, as it is done seamlessly with all care vs as a separate activity focusing on development. This study illustrates how focused bedside patient care can improve quality and positively affect patient outcomes.

## Limitations

It cannot be determined that the results regarding weight gain and LOS are exclusively the result of DC intervention. However, there were no changes in nutritional practices during the period of evaluation.

A 4-year time frame does allow for other changes in care practice. The only significant care change identified between the two periods in our NICU was the introduction of bubble CPAP. Although not specifically identified as a DC practice, we introduced this minimally invasive respiratory support technique in the context of DC.

Finally, another limitation is the inherent variability in delivery of care when more than 100 staff members provide the care. Therefore, staff complete competencies in DC practice to establish continued proficiency in all aspects.

## Implications for Future Research

Research on DC has shown benefits for short-term outcomes such as improved growth, decrease in ventilator days, decrease in length of stay, and lower hospital costs. However, randomized controlled studies are limited and difficult to conduct on DC as a whole vs breaking it down into individual components. Type I evidence will be difficult to obtain given the nature of this intervention. Caregivers cannot be blinded to this type of care, and segregation of care providers in the same unit would be challenging. Comparing different NICUs would infuse the data with too many variables in care.

Comparing a NICU before and after DC, collecting the data prospectively and carefully controlling for any changes in the unit may provide our best evidence. Ultimately assessing the effect of this intervention on longer-term cognitive and motor development is necessary. Evaluating neuromotor and cognitive outcomes at 1–3 years of age is feasible.

## Acknowledgments

The authors would like to thank the NICU staff at the University Hospital in Cincinnati for their initial and continued support of DC practice. We would also like to thank Linda Reasoner, RN, and Mary Lou Torres, RN, for their dedication to this project, Kyra Witmer PhD for her assistance in manuscript preparation, and Ed Donovan, MD, the Principle Investigator of

the NIH NICU Research Network for facilitating access to the NICU Research Network database.

## References

1. Becker PT, Grunwald PC, Moorman J, Stuhr S. Effects of developmental care on Behavioral organization in very-low-birth-weight infants. *Nursing Research*. 1993;42:214-220.
2. Als H. Developmental care in the newborn intensive care unit. *Curr Opin Pediatr*. 1998;10:138-142.
3. Als H, Duffy FH, McAnulty GB, Gibes-Gross R, Blickman JG. Individualized developmental care for the very low-birth-weight preterm infant. Medical and neurofunctional effects. *JAMA*. 1994;272:853-858.
4. Fleisher BE, VandenBerg K, Constantinou J, Heller C, Benitz WE, et al. Individualized developmental care for very-low-birth-weight premature infants. *Clin Pediatr*. 1995;10:523-529.
5. Hendricks-Munoz KD, Prendergast CC, Caprio MC, Wasserman RS. Developmental care: The impact of Wee Care developmental care training on short-term outcome and hospital costs. *Newborn Infant Nurs Rev*. 2002;2:39-45.
6. Symington A, Pinelli JM. Distilling the evidence on developmental care: a systematic review. *Adv Neonat Care*. 2002;2:198-221.
7. VandenBerg KA. Individualized developmental care for high risk newborns in the NICU: A practice guideline. *J Early Hum Dev*. 2007;83:433-442.
8. Stevens B, et al. Consistent management of repeated procedural pain with sucrose in preterm neonates: is it effective and safe for repeated use over time? *Clin J Pain*. 2005;21:543-548.
9. American Academy of Pediatrics. Noise: a hazard for the fetus and newborn. *Pediatrics*. 1997;100:724-727.
10. Graven SN. Sleep and brain development. *Clin Perinatol*. 2006;33:693-706.
11. Graven SN. Sound and developing infant in the NICU: Conclusions and recommendations for care. *J Perinatol*. 2000;20:588-593.
12. Rivkees SA, Mayes L, Jacobs H, Gross I. Rest-activity patterns of premature infants are regulated by cycled lighting. *Pediatrics*. 2004;113:833-839.
13. Rivkees SA. Developing circadian rhythmicity in infants. *Pediatrics*. 2003;112:373-381.
14. Graven SN. Early neurosensory visual development of the fetus and newborn. *Clin Perinatol*. 2004;31:199-216.
15. Recommended standards for newborn ICU design. *J Perinatol*. 2003;23(4 Suppl).
16. Fay MJ. The positive effects of positioning. *Neonatal Network*. 1988;6:23-28.
17. Wilhelm IJ. Positioning the high-risk neonate in the special care nursery. *Topics in Pediatrics*. 1990:1-8.
18. Monterosso L, Kristjanson L, Cole J. Neuromotor development and the physiologic effects of positioning in very low birth weight infants. *JOGGN*. 2002;31:138-146.
19. Waitzman KA. The importance of positioning the near-term infant for sleep, play, and development. *Newborn Infant Nurs Rev*. 2007;7:76-81.
20. Leslie A, Marlow N. Non-pharmacologic pain relief. *Sem Fetal Neo Med*. 2006;11:246-250.
21. Blass EM, Hoffmeyer LB. Sucrose as an analgesic for newborn infants. *Pediatrics*. 1991;87:215-218.
22. Symington A, Pinelli J. Developmental care for promoting development and preventing morbidity in preterm infants. *The Cochrane Library*. 2004;4.
23. Westrup B, Kleberg A, von Eichwald K, Stjernqvist K, Lagercrantz H. A randomized, controlled trial to evaluate the effects of the newborn individualized developmental care and assessment program in a Swedish setting. *Pediatrics*. 2000;105:66-72.

TSP 58437



ELSEVIER

email: [reprints@elsevier.com](mailto:reprints@elsevier.com)

Please visit [www.elsevierreprints.com](http://www.elsevierreprints.com)