

Small Baby Unit Improves Quality and Outcomes in Extremely Low Birth Weight Infants

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abstract

OBJECTIVE: The survival rates for extremely low birth weight (ELBW) infants have improved, but many are discharged from the hospital with significant challenges. Our goal was to improve outcomes for this population by using a multidisciplinary team-based quality improvement approach.

METHODS: A unique program called the Small Baby Unit (SBU) was established in a children's hospital to care for the ELBW infant born at 28 weeks or less and weighing less than 1000 g at birth. These patients were cared for in a separate location from the main neonatal unit. A core multidisciplinary team that participates in ongoing educational and process-improvement collaboration provides care. Evidence-based guidelines and checklists standardized the approach.

RESULTS: Data from the 2 years before and 4 years after opening the SBU are included. There was a reduction in chronic lung disease from 47.5% to 35.4% ($P = .097$). The rate of hospital-acquired infection decreased from 39.3% to 19.4% ($P < .001$). Infants being discharged with growth restriction (combined weight and head circumference <10th percentile) decreased from 62.3% to 37.3% ($P = .001$). Reduced resource utilization was demonstrated as the mean number per patient of laboratory tests decreased from 224 to 82 ($P < .001$) and radiographs decreased from 45 to 22 ($P < .001$).

CONCLUSIONS: Care in a distinct unit by a consistent multidisciplinary SBU team using quality improvement methods improved outcomes in ELBW infants. Ongoing team engagement and development are required to sustain improved outcomes.

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Dr Morris partnered with Dr Soliman in the conceptualization, implementation, and leadership of the extremely low birth weight (ELBW) program, guided data collection and statistical analysis, drafted the initial and revised manuscript, and approved and submitted the final manuscript; Dr Cleary participated in the conceptualization of the ELBW program, participated in the analysis of results, review and revision of the initial manuscript, and approved the manuscript as submitted; and Dr Soliman partnered with Dr Morris in the conceptualization, implementation, and leadership of the ELBW program, participated in analysis of results, review and revision of initial manuscript, and approved the manuscript as submitted.

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Progress in the care of preterm newborns has gradually moved from what we do (new medications and devices) to how we do it. Although the survival rate of extremely low birth weight (ELBW) infants has improved with advances in neonatal intensive care, many survivors are discharged from the hospital with neurodevelopmental delays and/or chronic medical problems.¹

Significant variation in outcomes among NICUs has been documented.²⁻⁴ Practice variation among providers at the same institution also complicates

care.^{5,6} Collaborative quality improvement (QI) and team-based care has been shown to significantly improve outcomes.⁷⁻¹⁰

Outcomes for the ELBW population in the study NICU demonstrated average performance compared with national benchmarks. We hypothesized that we could improve outcomes including a reduction in chronic lung disease (CLD), a major ELBW morbidity, with a QI initiative that changed our practice model by establishing a separate unit and specialized team to care for these infants. We further hypothesized that

this unique program, called the Small Baby Unit (SBU), would affect rates of nosocomial infection and postnatal growth failure, standardize clinical practice for this vulnerable population, and improve staff satisfaction.

METHODS

Setting, Study Design, and Patient Sample

This was a single-center QI initiative to evaluate the impact of a change in the model of delivering care on outcomes of ELBW patients. CHOC Children's Hospital is an academic center with a 67-bed Level IV NICU averaging a daily census of 40. During the study period, there were approximately 700 annual admissions with 55 to 60 ELBW infants per year. The CHOC Children's Office of Research Compliance reviewed the QI process and determined that official institutional review board approval was not required, as the project did not meet the definition of human subject research.

Data on all patients admitted to the SBU were collected retrospectively and compared with a historical cohort of patients from the 2 immediate preceding years before opening the SBU. The preintervention period included 117 infants from 2008 to 2009. The postintervention period included 232 infants from 2010 to 2013. All study infants were born with a gestational age ≤ 28 6/7 weeks, delivered at referring hospitals, and transferred to the SBU before 1 month of life.

Intervention

Planning the implementation phase of the program began in January 2008 with an analysis of outcome data. Interventions included the creation of a unique ELBW program called the SBU that opened in March of 2010 and established a physically separate location from the main NICU. Care was provided by a core

multidisciplinary team by using evidence-based guidelines, protocols, and checklists. Designation of a lead physician and neonatal nurse practitioner (NNP) acting as both program coordinators and clinicians, and were physically present in the unit improved continuity of care and provided greater program oversight. Multidisciplinary project champions in key areas were engaged and an essential program component.

Dedicated Core Team

Core team members were selected from experienced NICU staff based on interest and expertise in caring for ELBW patients. Interdisciplinary team members completed independent study before attending an 8-hour class (Appendix 1). Staff obtained continuing education credit for completion of the prework and were compensated for attending class. Classes included didactic as well as hands-on workshops, which provided an opportunity to begin the process of team development. In addition to nursing staff, key disciplines identified as integral members of the SBU core team included NNPs, respiratory therapists, developmental specialists, dietitians, lactation support, pharmacists, social services, transport services, and high-risk infant follow-up clinic staff. Direct care was NNP led. Neonatal fellows and pediatric residents were included in the care model with a reduced footprint and oversight by SBU NNPs and physicians.

Continued education and team communication were key components of program development. Opportunities were provided as quarterly 3-hour meetings in which relevant topics and outcome data were presented and process improvement discussed. Twice per week there were informal talks in the SBU to discuss care practices, research, and/or staff concerns. Weekly pharmacy/

nutrition rounds with the neonatologist, NNP, dietician, pharmacist, and lactation consultant provided review and refinement of nutritional processes and medication stewardship.

Evidence-Based Guidelines

One goal of the ELBW program was to provide consistent and uniform practice informed by best evidence. Guidelines were structured as 3 phases of care: Guideline 1, birth through 10 days of life; Guideline 2, days of life 11 to 30; and Guideline 3, 1 month to discharge.

Use of guidelines improved standardization of key practice changes essential for this population. One example was a significant increased use of continuous positive airway pressure (CPAP) and earlier extubation. As the program evolved and evidence supported, this transitioned to increased avoidance of intubation.

Guideline development integrated best evidence with current unit culture, included input from the multidisciplinary team, and was approved by the medical team. The guidelines contained tools with which the team was already familiar and had become standard practice in our unit. These guidelines and checklists were available in hard copy form and accessible via the SBU Department Page on the hospital intranet site.

Skilled and trained professionals work in medicine, yet, avoidable mistakes are made.¹¹ A primary tool used in the SBU to standardize practice, reduce variation, and improve safety was development of checklists. Most were process or procedural in scope and include 3 phases: preprocedure, procedural, and postprocedure. Previous use of checklists in our NICU was limited, but despite initial skepticism, the SBU team embraced change and were quick to identify new processes in need of a checklist.

Distinct Developmentally Appropriate Location

One objective of the program was to cohort this population in a location physically separated from the main NICU, recognizing that progressive changes in culture were essential for successfully shifting our practice model. The main NICU had predominantly a pod room structure. We selected a location down the hall from the NICU that was previously a PICU. This space became the 12-bed SBU, consisted of 4 individual patient rooms, 2 of which were surgical suites, and three 4-bed pods. This smaller unit allowed a darker, quieter environment encouraging developmentally supportive care. On entry, the SBU “feels” different than the main NICU. Grouping this population also provided parents an opportunity to form strong bonds with other families sharing similar experiences.

Outcome Measures

Achieving a reduction in CLD was a primary clinical outcome motivating the creation of the SBU. The incidence of CLD, an oxygen requirement at 36 weeks postmenstrual age as defined by Vermont Oxford Network (VON), and the percentage of infants discharged from the hospital on oxygen were analyzed. Nosocomial infection and postnatal growth failure, defined as discharge weight and head circumference <10th percentile, were also targeted for improvement after opening the SBU. Nosocomial infection rates were collected for all infants admitted to the SBU. CLD and growth failure were collected for all infants discharged from the hospital from the SBU.

A focused program to care for ELBW infants potentially affects a number of outcomes. As an overall assessment, we evaluated the VON composite measure of survival without specified morbidities (Appendix 2).¹² In addition to CLD and infection, which are reported separately, this measure

also includes other morbidities, such as severe intraventricular hemorrhage, periventricular leukomalacia, necrotizing enterocolitis, and pneumothorax.

As a QI project, analysis of several process measures enabled us to assess practice influence on outcomes. Many of the process measures were both clinical and value measures. Evaluation of resource utilization, including the average number of laboratory tests and radiographs per patient, were reviewed as a potential benefit of a consistent team.

An additional goal of the SBU was to improve family satisfaction by improving the consistency of care and providing a unique environment for families who experience similar lengths of hospitalization, complications, and outcomes. Another aim was to increase staff satisfaction, as consistent care was delivered by a dedicated team. Staff perception of the quality of care delivered to this fragile population and team collaboration was assessed via periodic surveys.

Statistical Analysis

Many data points for the SBU Database were collected as a participant in California Perinatal Quality Care Collaborative and VON. Other variables were chosen specifically related to the development of the ELBW program and all data were collected retrospectively from the electronic health record. Infants who were transferred to the SBU for a specific purpose, such as a patent ductus arteriosus ligation, and transferred back to their referring facility, were included in some of the analysis, such as infection rates. Data presented as discharge outcomes include only those discharged from the hospital from the SBU. Data were analyzed by using SPSS version 18.0 (IBM SPSS Statistics, IBM Corporation, Chicago, IL). Intervention group differences

were assessed for significance by using the χ^2 test statistic for categorical variables and independent *t* test for continuous variables. When unanticipated demographic differences were found between groups, logistic regression analysis was performed. Additional data were collected on several other clinical, nonclinical, and process measure outcomes, but are not included in this article.

RESULTS

General Characteristics

There were 117 ELBW patients in the 2 preintervention years and 232 patients in the 4-year postintervention period (Table 1). There were no statistically significant differences between groups in gestational age, mean birth weight, race, or method of delivery (Table 1). Unexpectedly, there were differences in gender distribution ($P = .005$), inborn ($P = .004$), and antenatal steroid administration ($P = .008$) between groups (Table 1).

Logistic regression analysis, including the effects of gender, inborn status, and antenatal steroids, did not alter the statistical significance described as follows.

As much of the data analyzed related to outcome measures, results from 222 patients discharged from the hospital from the SBU of 349 admitted are presented unless otherwise noted. Data for patients who expired or those transferred back to referring centers are included only in nosocomial infection rates. As a children’s hospital, all patients were technically outborn, but infants delivered in an adjacent, physically joined delivering center were cared for immediately after birth and are referred to as “inborn” for some data points.

Respiratory Outcomes

There was a reduced incidence of CLD after implementing the SBU program.

TABLE 1 Demographic and Clinical Characteristics

Characteristic	Preintervention <i>n</i> = 117	Postintervention <i>n</i> = 232	<i>P</i> ^a
Mean birth gestational age, wk	25.6	25.7	.704
Mean birth weight, g	772	839	.477
Girls, <i>n</i> (%)	37 (31.6)	110 (47.4)	.005
Inborn, <i>n</i> (%)	34 (29.1)	104 (44.8)	.004
Maternal race, <i>n</i> (%)			.394
Hispanic	58 (49.6)	126 (54.3)	
White	40 (34.2)	63 (27.2)	
Other	19 (16.2)	43 (18.5)	
Antenatal steroids, <i>n</i> (%)	80 (68.4)	188 (81.0)	.008
Vaginal delivery, <i>n</i> (%)	25 (21.4)	61 (26.3)	.313
Multiple births, <i>n</i> (%)	23 (19.7)	50 (21.6)	.681
Mortality, ^b <i>n</i> (%)	19/80 (23.8)	33/194 (17.0)	.196
Growth restriction, at birth, ^c <i>n</i> (%)	8/28 (28.6)	18/111 (16.2)	.134
Mean Apgar score, all patients			
1-min	4.7	5.3	.235
5-min	6.8	7.5	.127
Mean Apgar score, inborn patients			
1-min	4.9	5.1	.291
5-min	7.0	7.3	.766

^a *P* value based on χ^2 test statistic for categorical variables and independent *t* test for continuous variables.

^b Mortality rates were known in 274/439 infants, 75 infants were transferred out of the unit and the rates were unknown.

^c Growth restriction is defined as both weight and head circumference <10th percentile, data were unknown for 83 patients.

In the preintervention period, 47.5% of patients had CLD compared with 35.4% postintervention (*P* = .097, Table 2). Improvement over time can be noted as seen in Fig 1.

The percentage of patients discharged from the hospital from the SBU on oxygen decreased from 23% to 18% (*P* = .41, Table 2). Continued improvement over time was noted (Fig 1), with the last 2 postintervention years reduced to 12.8%.

Process measures were assessed to determine if SBU management strategies aimed at increasing noninvasive ventilation improved respiratory outcomes. Successful extubation (defined as remaining extubated >72 hours) in the first week of life or admission to the SBU improved from 47.5% to 65.2% (*P* = .016, Table 2). For inborn infants, those patients managed with CPAP alone increased from 3.8% to 30.1% (*P* = .006, Table 2).

Infection Prevention

There was a reduction in hospital-acquired infection from 39.3% to

19.4% (*P* < .001, Table 2). Again a downward trend over time was observed (Fig 1). The average number of central line days was not significantly different between groups. As expected with a reduction in sepsis, there were fewer days of antibiotic administration in the postintervention group.

Growth

Growth restriction decreased significantly after implementing the ELBW program from 62.3% vs 37.3% (*P* = .001, Table 2). Continue improvement over time was again demonstrated (Fig 1).

Composite Morbidities

By using the VON outcome measure of survival without specified morbidities (Appendix 2), there was a significant improvement in the number of infants post-SBU who survived and were discharged from the hospital without 1 of the identified morbidities: 24.6% vs 47.8% (*P* = .002). As with much of the analysis, the second 2-year postintervention period (55%) compared with the first 2-year

postintervention period (41%) demonstrated a continued improvement trend (*P* = .07).

Resource Utilization

Delivering care via a consistent dedicated team reduced unnecessary ordering of routine diagnostics (Table 3). For patients discharged from the hospital, the mean number of laboratory tests per patient, including blood gas analysis, electrolyte panels, and complete blood counts, decreased from 224 to 82 (*P* < .001). The mean number of radiographs per patient, including both abdominal and chest radiographs, decreased from 45 to 22 (*P* < .001).

Staff Satisfaction

The original core SBU team completed a 10-question Likert Scale survey at initial training classes. This survey was repeated at years 1 and 4 of the program. By combining the scores for agree and strongly agree, there was sustained improvement in perception of team support and quality of care. Before the SBU, 67% of our team felt they had the skills and equipment to care for the ELBW population, which increased to 90% at 1 year, and 93% at 4 years. Opinion of being part of the team and actively contributing professional input regarding plan of care was 69% before SBU, 90% at 1 year, and 86% at 4 years. Team members were asked to evaluate the quality of care provided to the ELBW infants, and the percentage who believed high-quality care was delivered increased from 60% to 96% at 1 year, and 98% at 4 years.

DISCUSSION

We report a QI initiative that established a physically separate unit with differentiated staffing and practice models to care for ELBW infants. This intervention overcame barriers to process change and improved outcomes and resource

TABLE 2 Outcome Measures

	Preintervention, % <i>n</i> = 61	Postintervention, % <i>n</i> = 161	<i>P</i> ^a
CLD	47.5	35.4	.097
Home on oxygen	23.0	18.0	.41
Successful extubation first wk	47.5	65.2	.016
CPAP alone ^b	3.8	30.1	.006
Nosocomial infection ^c	39.3	19.4	<.001
Growth restriction	62.3	37.3	.001

^a *P* value based on χ^2 test statistic.

^b CPAP alone results are for inborn patients, preintervention *n* = 26, postintervention *n* = 93.

^c Late-onset sepsis results include all SBU admissions.

utilization at our institution. There was a reduction in infants with CLD and discharged from the hospital on oxygen. Significant reductions were seen in nosocomial infections and postnatal growth restriction. Development of program ownership

by providing continuity of care via a core interdisciplinary team was a program strength.

Differentiated units for specialized care of certain populations, such as intensive care (adult, pediatric, and neonatal), cardiac, and oncology,

have become common practice. Reduced mortality and improved outcomes for preterm infants at institutions with higher patient volumes and levels of care has been shown.^{13,14} The concept that a consistent team caring for the ELBW population would improve care was supported by reports of improved safety, process, and outcomes with team-based training, and provided the foundation of our care-delivery model.^{10,15} The improved outcomes in the SBU likely reflect the benefits of consistency in practice by a dedicated team that gained expertise in the care of this population. One NICU demonstrated that care in the first 7 days of life for

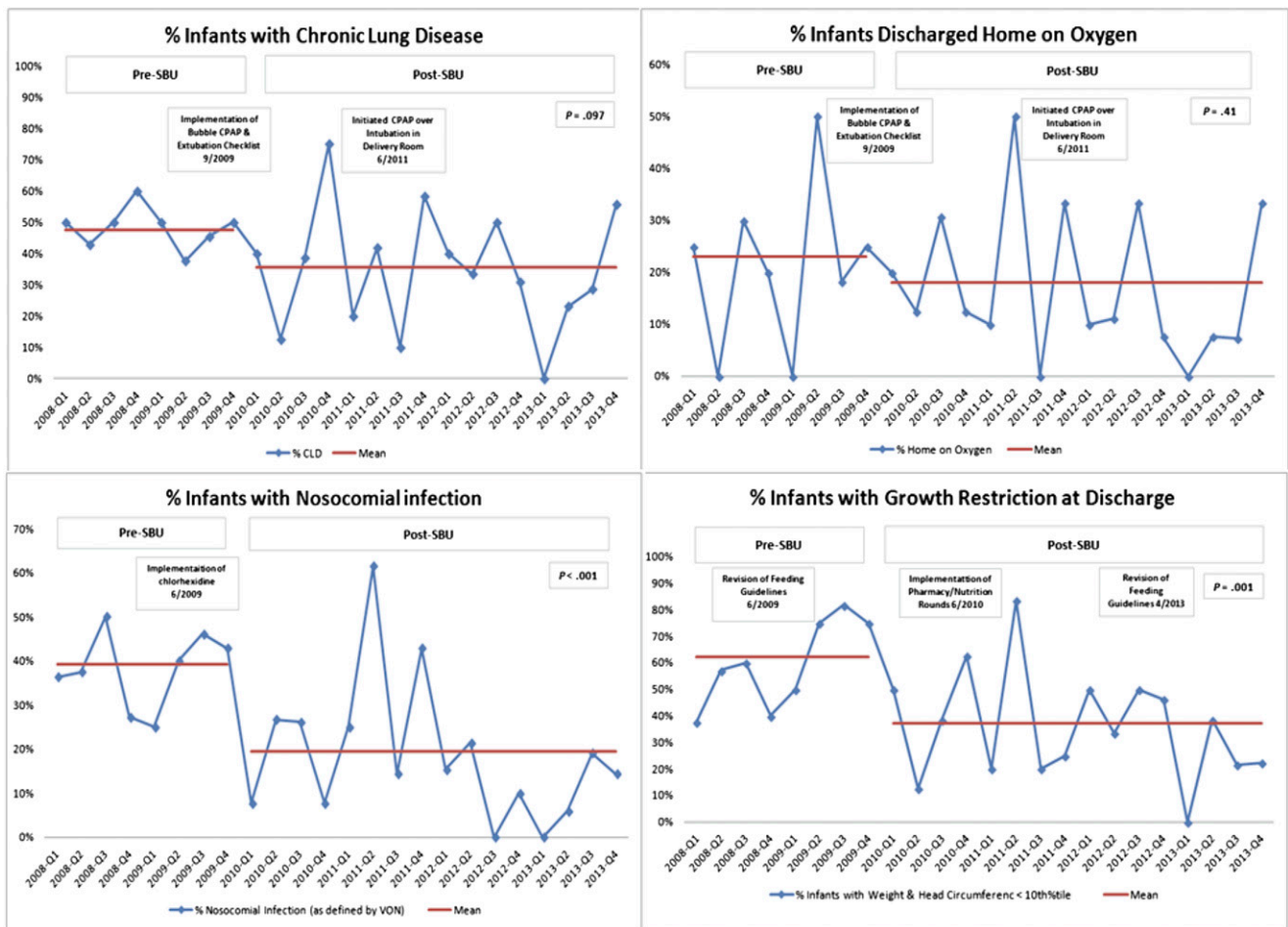


FIGURE 1

Outcomes presented by quarters are the percentage of SBU infants discharged home who were diagnosed with CLD, discharged from the hospital on oxygen therapy, and who had growth restriction, and for all infants admitted to the SBU, the percentage who had nosocomial infection. *P* value indicates significance by χ^2 test statistic.

TABLE 3 Resource Utilization Per Patient

	Preintervention <i>n</i> = 61	Postintervention <i>n</i> = 161	<i>P</i> ^a
Total no. laboratories, mean	224	82	<.001
Total no. radiographs, mean	45	22	<.001

^a *P* value based on independent *t* test for continuous variables.

the ELBW infant by using guidelines improved outcomes and decreased length of hospitalization.¹⁶ The SBU program extended this concept through the entire hospitalization and showed improved clinical outcomes with reduced resource utilization.

Another essential component in the SBU care model was applying best evidence in developing tools, such as guidelines and checklists, to standardize care and improve outcomes and safety as shown in multiple studies.^{17–19} All checklists and guidelines were developed based on evidence and with the NICU's current culture and practice in mind. Simply developing a tool without an effort to pair the tool with a change in approach, training, and removal of barriers is less likely to change practice.²⁰ Although many tools, such as feeding guidelines were already used with a modicum of success, increased adherence became a part of the transition in culture achieved in the SBU.

A reduction in CLD can be attributed to a team commitment to using less invasive respiratory support. Initially this involved early extubation to CPAP, and later, included nonintubation in the delivery room and consistent use of CPAP. Many of these interventions were in line with current evidence-based practice recommendations and achieved by other QI efforts to reduce morbidities.^{8,9,21–23}

Significant reductions in nosocomial infections and growth restriction were credited to consistent team application of practice. Although there were no specific process changes targeting

a reduction in infection, usual processes, such as strict adherence to central line care and antibiotic stewardship, were further standardized by the team. Consistent providers was recognized as the most influential factor reducing growth failure, as there was better adherence to tools previously implemented before the SBU, such as the feeding guidelines, which demonstrated a more positive change in outcomes after the SBU.

Nonclinical outcomes noted in the SBU were improved staff and parental satisfaction. Staff felt a sense of accomplishment, pride, and engagement as they actively participated in process improvement and witnessed superior outcomes. Specific parent satisfaction data were not captured, but overwhelming positive feedback described relationship-building with other families facing similar challenges during the prolonged hospital experience.

One limitation of this report was an unanticipated demographic difference, with a higher proportion of female patients, more antenatal steroid exposure, and an increased percentage of inborn patients after initiation of the program, although logistic regression for these factors did not alter the significance of the results. We cannot account for any particular factors that led to the discrepancy in gender. Increased antenatal steroid administration was likely due to an updated obstetrical practice to administer prenatal steroids to women in preterm labor. Although there were no interventions implemented, we speculate the increased inborn

population was due to increased knowledge of the SBU program. Results reflect outcomes of patients treated in a single NICU at a children's hospital with high patient volume and severity of illness, which may render the interventions less generalizable to settings with lower volumes and acuity.

Barriers to change, such as the financial and social cost of differentiating care, education of team members, staffing challenges, and team member fatigue must be overcome to successfully demonstrate and sustain outcomes. This population of patients presents unique challenges because of high acuity and prolonged hospitalization. Continued team engagement was a crucial element for sustained culture change and sense of program ownership. It was important to evaluate process measure toward overall outcomes, as long-term improvement takes time to reveal.

We demonstrated significant improvement with a dedicated team by using best-practice strategies to care for ELBW infants in a developmentally appropriate environment. Understanding that gains observed during QI processes may decline over time, we implemented a strategy to maintain the gains achieved.²⁴ Implementation of a robust educational and team-building plan to recruit and retain staff resulted in sustained improvement trends and low attrition. Existing guidelines and order sets are continually refined in light of emerging evidence. Sharing our experience with others through participation in QI collaboratives further builds our program. We are optimistic that the improved outcomes over time demonstrated by the SBU are encouraging for standardization and refinement of enduring process improvement.

CONCLUSIONS

We have shown that significantly improved outcomes in ELBW infants can be achieved with reduced resource utilization at a quaternary NICU by changing the culture of practice. The essential elements of success for this QI initiative were a differentiated team using standardized practice based on evidence, in a separate developmentally appropriate location. Ongoing team engagement can sustain improved outcomes. Despite the complexity of illness in

extremely preterm infants, our experience reinforces “how we do it” matters, and a gentle approach of “less is more” is often best.

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ABBREVIATIONS

CLD: chronic lung disease
CPAP: continuous positive airway pressure
ELBW: extremely low birth weight
NNP: neonatal nurse practitioner
QI: quality improvement
SBU: Small Baby Unit
VON: Vermont Oxford Network

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APPENDIX 1 CORE TEAM TRAINING AND EDUCATION

Initial SBU core team training included ~8 hours of independent study and attendance at an 8-hour didactic and hands-on skills workshop. Team members self-identified themselves as being interested and those who were in good standing were selected by the NICU leadership team to join the SBU core team. Nursing staff committed to an uninterrupted 6-month assignment in the SBU to assist in development of the unit. Content, taught by local topic/systems experts included the following:

1. Introduction, including ELBW outcome data, institutional data, and plans for the program.
2. Delivery room care and management practices.
3. Families as partners in care.
4. Admission and daily care practices.
5. Fluids/Electrolytes/Nutrition.
6. Respiratory care practices.
7. Cardiovascular care practices.
8. Neurologic care practices.
9. Brain and sensory development with developmental care practices.
10. Infection control practices.
11. Retinopathy of prematurity.

Skills workshops included bubble CPAP, the admission process, and developmental positioning.

APPENDIX 2 DEFINITION FROM VERMONT OXFORD NETWORK, NIGHTINGALE DATA DEFINITIONS

Indicates whether the infant survived with none of the following key morbidities: Severe intraventricular hemorrhage, CLD, necrotizing enterocolitis, pneumothorax, any late infection, or periventricular leukomalacia. Survival without specified morbidities is coded as follows:

1. If the infant survived and had none the morbidities listed, survival without specified morbidities is coded "yes."
2. If the infant died or had any of the morbidities listed, survival without specified morbidities is coded "no."
3. If the infant's final disposition status is unknown, death or morbidity is coded "unknown."

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Small Baby Unit Improves Quality and Outcomes in Extremely Low Birth Weight Infants

Mindy Morris, John Patrick Cleary and Antoine Soliman

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