

Evaluation, Development, and Implementation of Potentially Better Practices in Neonatal Intensive Care Nutrition

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ABSTRACT. *Objective.* The desire for evidence-based clinical guidelines for nutritional support of the preterm infant has been identified. Published evidence has not yielded clear guidelines about the best method of delivery, substrate use, or appropriate outcome measure to evaluate nutrition support. In addition, reports on research of nutrition support often fail to give the most rudimentary process necessary to improve quality in various unit settings.

Methods. The Vermont Oxford Network "Got Milk" focus group developed eight potentially better practices for nutrition support, implementation strategies for these practices, and a comprehensive appraisal process to measure nutrition outcome in preterm infants.

Results. After implementation of the potentially better practices, all participating institutions showed earlier initiation of nutrition support, earlier attainment of adequate energy intakes, reduced delay in reaching full enteral feeds, more consistent nutrition support practice, decreased length of stay, cost savings, and improved growth at time of discharge.

Conclusions. Development and implementation of evidence-based better nutrition support practices in neonates led to improved nutrient intake and growth with reduced length of stay and related costs. Consistent, comprehensive, multidisciplinary appraisal of practice is an integral component of improving nutrition outcomes in the neonatal population. *Pediatrics* 2003;111:e461-e470. URL: <http://www.pediatrics.org/cgi/content/full/111/4/e461>; collaborative quality improvement, NIC/Q 2000.

ABBREVIATIONS. VLBW, very low birth weight; NICU, neonatal intensive care unit; PBPs, potentially better practices; PDSA, plan-do-study-act; NIC/Q 2000, Neonatal Intensive Care Quality Improvement Collaborative Year 2000; NEC, necrotizing enterocolitis; VON, Vermont Oxford Network; CAT, critically appraised topic; TPN, total parenteral nutrition.

KEY POINTS OF ARTICLE

- Self-appraisal of practice is a key first step in any quality improvement effort.
- Consistent, comprehensive systematic appraisal of growth and nutrition intake leads to improved

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and more cost-effective nutrition outcome for very low birth weight (VLBW) infants.

- Nutrition quality improvement efforts benefit from a multidisciplinary approach with involvement of an experienced neonatal nutritionist.
- Comprehensive, consistent protocols for delivery of nutrition support can improve nutrition outcome and reduce length of stay.

LESSONS LEARNED TO APPLY TO PRACTICE

- Develop a core multidisciplinary team including a neonatal nutritionist to focus on nutrition practices in the neonatal intensive care unit (NICU).
- Identify a nutrition practice appraisal plan with key data to be collected on current practice and reviewed systematically as practice changes evolve.
- Benchmark current nutrition practices and balancing measures with the literature, available network data, and centers of excellence as part of the development of potentially better practices (PBPs).
- Use many plan-do-study-act (PDSA) cycles to address larger practice issues spreading involvement in practice development to as many NICU staff as possible.

Although it is universally accepted that infants who are delivered prematurely require nutritional support to survive, the published evidence does not provide clear indications of the best method of delivery, substrate use, timing, or appropriate outcome measures to evaluate nutrition support. Furthermore, reports of research on nutrition support often fail to give even the most rudimentary information about the process necessary to improve actual practice.¹ Clinicians are being held accountable for the quality of care that they deliver to an unprecedented degree,² and they are being asked to meet the overwhelming needs of the population of premature infants with fewer resources, although lower health care spending has been shown to be significantly associated with lower life expectancy and higher infant mortality rates.³ One explanation for the lack of evidence on best practices to help clinicians may be that the formal clinical trials lag behind the improving neonatal survival rate. The Neonatal Intensive Care Quality Improvement Collaborative Year 2000 (NIC/Q 2000) was established to use the resources of multidisciplinary collaborative learning, develop consensus on evidence-based

PBPs, and establish durable habits for improvement.¹ This article describes the experiences of the Nutrition-NEC Focus Group (“Got Milk”) as part of the collaborative quality improvement project. This article outlines the team’s effort to develop a measurable aim, identify PBPs, implement strategies and tools, and establish ongoing assessment of nutrition practices to bridge the gap between evidence and practice.

METHODS

The reasons for focusing on nutrition practices were numerous. They include group interest in changing existing rate of necrotizing enterocolitis (NEC), the implications of nutrition practice on NEC, the inability of the existing Vermont Oxford Network (VON) database to provide information on possible relationships between nutrition practices and NEC or between nutrition practices and growth, and the limitations of available evidence on the best way to feed VLBW infants. The establishment of evidence-based practice guidelines in conjunction with consistent comprehensive appraisal should improve growth, decrease length of stay, and thereby decrease costs. Furthermore, interdisciplinary involvement, data collection, and review of data and current literature is vital to maintaining state-of-the-art guidelines.

As part of the collaborative learning process outlined by Horbar and Plsek,¹ the group identified the following improvement aims: draft and implement written nutrition practice guidelines, provide adequate nutrient intake at 34 weeks’ postconceptional age, promote optimal growth and development at 34 weeks’ postconceptional age, and decrease or maintain the incidence of NEC at or below the 50th percentile of the VON database. Because of the magnitude of the topic of nutrition practices and the controversy over the pathogenesis of NEC, the group decided to focus on enteral nutrition, appraisal of nutrition practices, and outcome measurement using the rate of NEC as a balancing measure. In addition, it was believed that nutrition support should approximate the in utero growth of a normal fetus.⁴ The group adopted the goal that 90% of the time infants born ≤ 1500 g would receive optimal nutrition support as assessed by consistent use of effective feeding protocols and standard anthropometric measures. One strength of this group was a commitment to improve neonatal nutrition for the entire group, which required some modification of the goals of particular institutions. Areas of emphasis and delineation of tasks then emerged based on institutions’ objectives and the availability of resources. The group members thus maintained a sense of independence while participating in a collaborative effort, as evidenced by the development of 3 distinct nutrition protocols with all institutions adopting all PBPs.

A member of the NIC/Q 2000 collaborative and a group facilitator led the group through the model for learning the habits for change improvement. Two consultants, a neonatal nutritionist and a neonatologist with expertise in quality improvement applications, supported the group’s critical thinking processes. It quickly became apparent that self-appraisal of current practices and ongoing appraisal as interventions were implemented were integral parts of developing the PBPs. The first step was the development and implementation of the Enteral Feeding Practice Survey tool for self-assessment in all 3 participating facilities. The areas addressed by the tool are listed in Table 1. The survey was distributed to the 3 participating institutions and 49 responses from physicians (11), neonatal nurse practitioners (10), staff nurses (26), and neonatal nutritionists (1) were received. The surveys showed significant practice variability among institutions and within

institutions when various disciplines were directly involved in feeding decision making. The survey identified a general lack of consistency in feeding practices, poor coordination of interdisciplinary efforts, and a need for ongoing systematic appraisal. The second step in self-appraisal was to review retrospectively the charts of infants ≤ 1500 g birth weight to discover actual feeding practices in the participating institutions. Comparison of perceived practices and actual practices showed sizable variations (see Table 2).

The willingness to share data on current feeding practices and outcomes increased group cohesiveness and provided momentum for beginning to gather evidence to support PBPs. The Cochrane Database Systematic Reviews, Medline Search, and a reference bibliography developed by the Ohio Neonatal Nutritionists to develop critically appraised topics (CATs) were used for each area of focus. Although the process was tedious at times, multidisciplinary review and critical evaluation of the evidence and CAT creation reinforced the habit for systems thinking.

After current practices were identified and available evidence was gathered, benchmarking was started. Centers of excellence, defined as institutions with a rate of NEC less than the mean for the VON, were identified. A query was developed and posted to PEDI RD, a professional listserv for pediatric nutrition. Centers of excellence were asked to identify themselves and give reasons for self-identification. In addition to the criterion of a “low” rate of NEC, we sought institutions that were doing ongoing appraisal of nutrition practices and outcomes. Children’s Hospital of Iowa; Forsyth Medical Center, Winston-Salem, NC; North Carolina Baptist Hospital Brenner Children’s Hospital, Winston-Salem, NC; and the Children’s Hospital of Bronson Medical Center at Kalamazoo, MI, self-selected as benchmark sites.

A well-planned benchmark visit plan was developed to maximize collaborative learning while minimizing disruption to the unit and staff schedules of the host site. A set of benchmark questions was sent to all of the centers, and a structured multidisciplinary site visit was planned. At each visit, all disciplines represented in the group participated. A cross-discipline interview time was built in to all site visits. A debriefing was done with the entire group via conference call after each visit, and a written summary was prepared. At each center visited, nutrition excellence was a high priority. Interdisciplinary efforts to maintain excellence were evident in consistent feeding practices, systematic appraisal of practice, and regular evidence review. All centers had neonatal nutritionists to provide direction and continuity of care. Several authors have reported positive nutrition outcomes when a neonatal nutritionist is involved on the care team.^{5–8} A key benchmarking practice was the use of human milk as the first enteral feeding substrate. The benchmarking experience was an excellent opportunity for collaborative learning. The centers of excellence provided additional evidence for the PBPs that were emerging.

RESULTS

The 8 PBPs and the supportive evidence developed by the “Got Milk” group are listed in Table 3. By September 2000, all PBPs were implemented in all participating institutions.

Consistent and Comprehensive Monitoring of Growth and Nutrition Intake Leads to Improved and More Cost-Effective Nutrition Outcomes for VLBW Infants

It is difficult to invite change if current practice is unknown. Systematic appraisal of nutrition practices includes formation of a multidisciplinary core interest group, current evaluation of practice, needs assessment, a philosophy of nutrition care for the preterm infant, and implementation and evaluation of measurable goals promoting potentially better nutrition support. Sufficient evidence supported the idea that ongoing appraisal not only improves nutrition outcomes of preterm infants but also decreases the cost of care.^{9–12} The presence of an active, experienced neonatal nutritionist is vital to maintaining a

TABLE 1. Enteral Nutrition Self-Assessment Tool

Initiation of feedings first week of life
Progression of feeds
Methods of feeding type and route
Substrate use, supplement use
Indications for discontinuations of feedings
Role delineation in feeding decisions
Health care provider variation
Use of established feeding protocols

TABLE 2. Variations in Perceived Feeding Practices and Actual Feeding Practice

Feeding Practice	Perceived	Actual
Use of breast milk as first feed	50–100%	47%
Day first enteral feedings started	74% by d 4	Average day 10.23
Expected time to reach full feedings (infants 500–750 g)	54% d 14	Average day 39.89
Expected time to reach full feedings (infants 750–1000 g)	89% by d 16	
	100% by d 14	Average day 25.82

TABLE 3. PBP in Nutrition

PBP	Level of Evidence*	Reference†
Consistent and comprehensive monitoring of growth and nutritional intake leads to improved and more cost-effective nutrition outcomes for VLBW infants.	Levels 2–5 Benchmark visits	9–12
The early initiation of enteral nutrition enhances gastrointestinal development, reduces the days required to reach full feeds, and reduces the days needed for parenteral nutrition.	Levels 2–5 Benchmark visit	13–16, 23, 37
Consistent systematic advancement of enteral feedings by 10–20 mL/kg/d once trophic feedings have been established enhances the growth and outcomes of premature infants.	Levels 2–5 Benchmark visit	Cochrane Database of Systematic Reviews 15, 17, 18
Uniform consensus and written definitions and guidelines for withholding feedings should be adopted.	Levels 2, 3, and 5 Benchmark visit	13–22
Breast milk is the preferred nutritional substrate for premature infants.	Levels 1–4	23–26
Initiation of TPN should be done as soon as the infant is medically stabilized, preferably within the first 24 h of life.	Levels 2, 3, and 5	15, 27, 28
Nutrition outcome measures should be an integral aspect of the medical management of the premature infant.	Levels 3–5	29–32
Use appropriate enteral products to maintain growth and meet nutrient needs of the premature infant.	Levels 2–5	10, 33, 34

* Muir Gray Classification System (1997): Level 1—Strong evidence from at least 1 systematically reviewed well-designed randomized control trial; Level 2—Strong evidence from at least 1 properly randomized controlled trial of appropriate size; Level 3—Evidence from well-designed trials without randomization including single group, pre-post, cohort, time series or matched case controls; Level 4—Evidence from well-designed nonexperimental studies, preferably from >1 center or research group; Level 5—Opinion of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees.

† Partial list of references used.

comprehensive, consistent approach to optimizing nutrition practice in the NICU.

Early Initiation of Enteral Nutrition Enhances Gastrointestinal Development, Reduces Days Required to Reach Full Feeds, and Reduces Days Needed for Parenteral Nutrition

Early initiation of enteral feeding has been shown to promote gastrointestinal development; reduce the total days of total parenteral nutrition (TPN) needed; improve overall tolerance and potential for advancement of feeds; and potentially reduce cost, length of stay, and side effects of prolonged TPN use.^{16,20,25,37,38} Several CATs on minimal enteral feeding and its impact on growth, feeding tolerance, and the incidence of NEC were developed in support of this approach.^{39,40} Assessment of physiologic stability and readiness for feeding should be undertaken before enteral nutrition is begun. Once this is determined, enteral feeding should begin between 1 and 8 days of life. Trophic feedings (<10–20 mL/kg/d) of breast milk or premature formula should be given to stimulate and prepare the gut for later advancement of enteral feedings. Trophic feedings should continue for 3 to 4 days before feedings are advanced. Each participating institution developed unit-specific feeding protocols for initiation and advancement of enteral nutrition.

Consistent Systematic Advancement of Enteral Feedings by 10–20 mL/kg/d Once Trophic Feedings Have Been Established Enhances the Growth and Outcomes of Premature Infants

Once feedings have been initiated, a consistent plan for advancement is important to achieve the full benefits of early feeding. Early attainment of full enteral nutrition can reduce the potential for infection and complications of prolonged TPN use.⁴⁰ Early establishment of enteral feedings has been shown to promote earlier achievement of full enteral feedings and shorter time to reach full oral feedings.¹⁴ Length of time on TPN and overall costs can be reduced with a consistent systematic approach to feeding. Ability to meet micronutrient needs is enhanced compared with the solution limitations of TPN. Because of delayed gastric emptying times and limited gastric capacity, small bolus feedings at intervals of every 3 to 8 hours are suggested. In the event that bolus feedings cannot be established, continuous enteral feedings can be attempted.²⁰ Feedings should be advanced daily at rates of 10 to 20 mL/kg/d until full feedings are achieved. Full feedings refer to the delivery of enteral nutrition at either 80% of expected nutrient needs or 150 mL/kg/d and 120 kcal/kg/d.⁴⁴ Nursing staff can advance volume rates daily in stable, growing infants based on feeding protocols. In most cases, full feedings can be reached in approximately 14 days. Adjustment of

feeding volume should be done taking into account weight gain and energy and micronutrient needs that may be affected by the medical course.

Uniform Consensus and Written Definitions and Guidelines for Withholding Feedings Should Be Adopted

Proposed guidelines for the definition of feeding intolerance include the presence of any of the following:

- Significant abdominal distension or discoloration
- Signs of perforation
- Obvious blood in stool
- Gastric residuals $\geq 25\%$ to 50% of interval volume for 2 to 3 feedings
- Bilious gastric residual or emesis
- Significant apnea/bradycardia
- Significant cardiopulmonary instability

Uniform guidelines for feeding intolerance will enhance the consistency of feeding practices.^{14,17,18,20,21,25}

The definition of feeding intolerance remains largely subjective rather than evidence based. Consistent unit-based and uniform guidelines based on the available research will lead to less variability in practice and overall achievement of full feedings with safety. Evidence in this area is minimal, and it has been reported primarily in studies of initiation of enteral feeds, with unit-based criteria in each study. Whatever the unit defines as feeding intolerance, the following algorithm should be pursued. Once a feeding has been held for intolerance, each subsequent feeding should be seen as a potential new feeding start and as such the following questions asked:

Can minimal enteral feeds be started at this time (10–20 mL/kg/d) with an interval change?

Can feedings be restarted at the previous rate again?

Does the infant's medical condition warrant the holding of feeds for another scheduled feed?

Breast Milk Is the Preferred Nutrition Substrate for Premature Infants

Breast milk is the best-tolerated substrate for enteral feedings in the premature infant.²⁴ Full enteral feedings are reached sooner when breast milk is used, thereby decreasing the total days of TPN needed and the potential for TPN-induced side effects.⁴¹ The protective properties of breast milk cannot be duplicated. A decreased risk of NEC and infection has been demonstrated when breast milk is used for enteral feedings.^{23,26} The provision of breast milk also promotes active participation by parents in the care of the infant. However, breast milk cannot supply all of the nutrients needed, because of volume limitations developmentally or medically induced. The addition of breast milk fortifiers augments the nutrients in breast milk but may not promote a growth rate like that seen in infants who are predominantly formula fed.⁴¹ When breast milk is used, the potential exists for cytomegalovirus and other harmful microbes to be transmitted to the in-

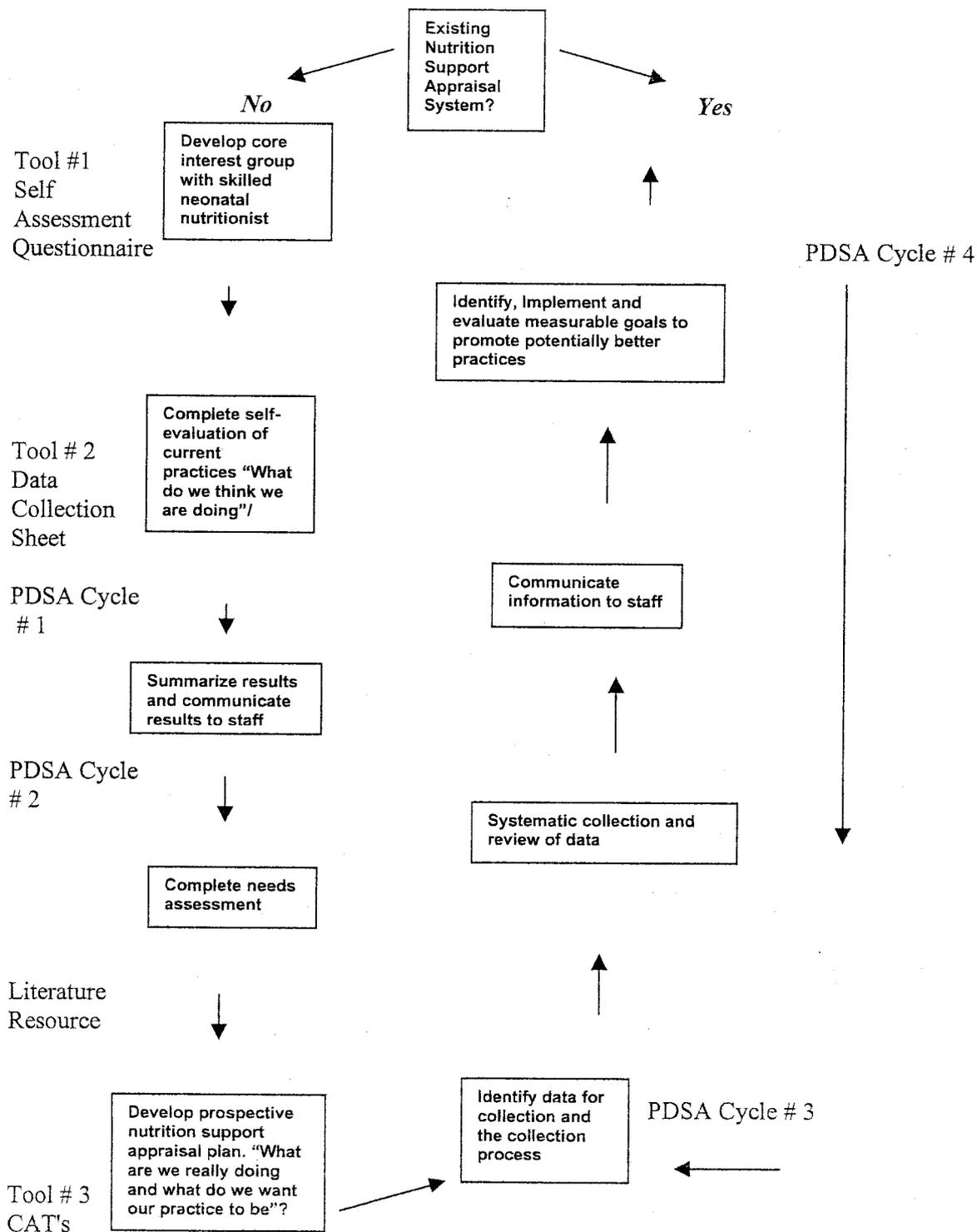
fant, resulting in possibly devastating sequelae.^{42,43} The use of breast milk as the preferred substrate is supported until cytomegalovirus-related concerns could be investigated further. The goal is for at least 75% of premature infants to receive breast milk for at least the first 2 weeks of enteral nutrition and for as long as the mother wishes to provide it. Educational programs for parents and staff stressing the benefits of breast milk should be implemented throughout the partum period. The resources of an experienced lactation consultant in the NICU setting are important in meeting this goal. The fortification of breast milk is done to meet the needs of the premature infant beyond 2 weeks of age. At discharge, vitamin and mineral supplementation should be provided to premature infants whose needs may not be met by breast milk alone. The desire of the mother to breast-feed her infant can be supported by promoting breastfeeding as soon as the premature infant is medically stable and developmentally ready. Establishing breastfeeding before the introduction of bottle feeding may facilitate the transition to all breastfeeding.

Initiation of TPN Should Be Done as Soon as the Infant Is Medically Stabilized, Preferably Within the First 24 Hours of Life or the First Days of Life

Intolerance of energy intake is a significant issue for an extremely low birth weight infant. The minimum energy requirement to metabolize protein is not known. Intakes of 1.0 to 1.5 g/kg of amino acids accompanied by energy intakes of at least 30 to 35 kcal/kg/d can prevent catabolism in parenterally fed extremely low birth weight infants, with protein deposition occurring at intakes greater than this.²⁷ Early initiation of TPN once an infant is stabilized reduces the net nutrient loss and catabolism that occur when an infant is born prematurely.²⁷ Provision of TPN helps promote anabolism and can decrease the severity of neonatal hyperglycemias.²⁸ The potential dangers to brain growth and tolerance of the rigors of medical treatment without a consistent nutrient source outweigh the risks when TPN is prescribed judiciously.¹⁵ Medical complications from TPN can be devastating. The cost of TPN necessitates prudent monitoring, with the goal of safe delivery of parenteral nutrition support for the shortest duration necessary.

Nutrition Outcome Measures Should Be an Integral Aspect of the Medical Management of the Premature Infant

Not only should nutrition outcome measures be an integral aspect of the medical management of premature infants, but also outcomes should be measured at several points during the medical course, after discharge, and at follow-up. Recommend data collection for monitoring growth and nutrient adequacy should be done at the following time points: birth, day of life 28, discharge, or 34 weeks of age.⁴ Weight gain needs to be monitored daily and then every other day once the infant is stable and growing. Head circumference and length should be monitored weekly to gain a more complete view of



- Tools**
- # 1 Self-Assessment Questionnaire
 - # 2 Data Collection sheet
 - # 3 CAT's

- PDSA Cycles**
- # 1 Self-Assessment Cycle
 - # 2 Communication of information to staff
 - # 3 Data Collection cycle
 - # 4 Education to staff regarding proposed practice guidelines

Resources
 Benchmark Visits
 CAT's

Vermont Oxford Network Database
 Potentially Better Practices

Fig 1. A systematic method of appraising nutrition support and measuring outcomes.

<i>Overall Measurable Aim</i>	
Improve the quality and consistency of nutritional support of high-risk infants as measured by:	
Time to regain birth weight.	Target: day 10-15
Time to attain 80 cal / kg /day	Target day 5
Time to attain 120 cal/kg/day	
Number of days on TPN	
DOL enteral feeds started	Target day 3
DOL full enteral feeds achieved	
Episodes of feeding intolerance	
Incidence of NEC	
<i>Cycle 1 January 99 - July 99</i>	
<i>Aim</i>	Improve documentation of nutritional assessment on the 24 hour summary
<i>Measurement</i>	24-hour fluid volume and calorie count completed
<i>Plan</i>	Identify problem in chart review, educate staff, monitor compliance.
<i>Do</i>	Utilize a portion of the staff meetings in both January and February to discuss the nursing role in infant nutrition and establish expectations that accurate fluid and calorie counts are a nursing responsibility. Provide calorie charts for convenient bedside use.
<i>Study</i>	Monitor compliance through the nursing QI process and report results to staff.
<i>Act</i>	Provide a tool and solicit staff involvement in monitoring nutrition practices.

Fig 2. Sample PDSA cycle.

growth and development. Although it may be difficult, achieving expected intrauterine growth rates is the optimal outcome. The appropriate growth charts should be used to plot premature infants at their corrected age for up to 2 years or until they have reached acceptable percentiles of their term peers.^{11,29} Several extrauterine growth charts are available. All have merits and limitations.³⁶ For weekly assessment of head circumference, weight, and length, the Babson or National Institute of Child Health and Human Development charts are suggested.³² Unit-defined growth curves provide adjunct information for intra-unit and regional comparisons. Potential methods for evaluating growth change might include use of change in z score or a target goal of >75% of the population reaching a specified percentile ranking at discharge. Programs with follow-up clinics should collect similar data at 6-month intervals for the first year and then yearly to at least 3 years of age.

Use Appropriate Enteral Products to Maintain Growth and Meet Nutrient Needs of the Premature Infant

When breast milk is not available, premature infants should be fed appropriate formulas to meet their total nutrient needs.^{10,33,34} Premature infants <1500 g at birth should be fed breast milk with fortifier or 24-cal/oz iron-fortified premature formula at a minimum rate of 150 mL/kg/d. However, if infants are fluid restricted and receiving <120 mL/kg/d, it is impossible to meet high nutrient demands. The use of high caloric density formulas that are carefully prepared to maintain the original balance of macronutrients may be beneficial when fluid restriction is imposed. Care should be taken not to exceed 450 mOsm/L, as suggested by the American Academy of Pediatrics.⁴⁵ Recommendations for iron supplementation are to give 2 to 4 mg/kg/d in the interval between 2 weeks and 2 months of life or when birth weight has doubled.⁴⁶ After discharge,

premature infants should be fed an enriched formula until they are at least 9 months' corrected age.^{34,47,48}

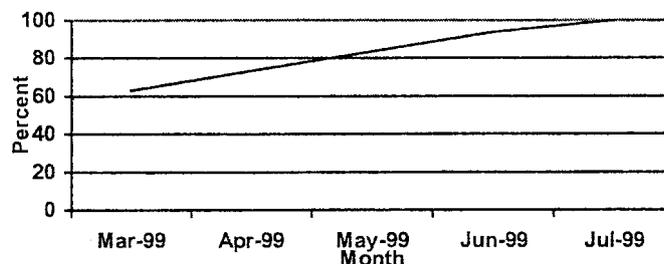
To evaluate change, the group needed a method that was concise, comprehensive, efficient, and consistent across all unit cultures. The consultant neonatal nutritionist developed a computerized nutrition database for easy implementation in each institution. The database allowed for queries that were institution specific and captured group change as well. The database was implemented at the beginning of the project to capture baseline data. Additional data points were collected at the development and implementation stages of the PDPs. Serial measurements increased the opportunities for improvement. Uniform definitions of terms were established, and data collation was done by the consultant nutritionist. Data comparing each institution and the whole group were communicated 3 times a year. During the last year of the collaborative, institutions maintained their own databases and submitted them for collation to the group.

The team's approach to systematic appraisal of nutrition support and outcome measurement is shown in Fig 1. This schematic model shows the integration of the key habits for change, PDSA cycles, CATs, and other resources in the implementation of PDPs.

Implementation of the PDPs

PDPs are not protocols; they are evidence-based guidelines that support decisions in regard to nutrition practices. They are flexible to accommodate different unit cultures. As Fig 1 shows, self-assessment of current practice yields information about whether ongoing systematic appraisal of nutrition practices exists. A core interest group including physicians, nurses, nurse practitioners, and a skilled neonatal nutritionist may be formed to address the issue. If no such appraisal exists, then a self-assessment questionnaire can be given to all staff members about

Fig 3. Results of sample PDSA cycle.



their beliefs about current practice. It is important not only to summarize this information but also to disseminate it to staff. Once needs are identified, a prospective nutrition support appraisal plan can be implemented to determine what is being done and what is the ideal practice. "What we are really doing?" "What do we want our practice to be?"

This plan should include both short- and long-term goals, be developed as a multidisciplinary effort, reflect the unit culture, and identify a systematic approach to evaluation of change. In short, it is the template for how nutrition practices are integrated in the medical plan. This plan might address the following areas of nutrition practice: enteral/parenteral feeding practices, growth measurement, formula use, iron supplementation, discharge planning, staff education, parent education, and follow-up care. The next steps may occur simultaneously. A critical appraisal of nutrition practices by group members provides the foundation for developing evidence-based practices and enhances the habit for collaborative learning across disciplines. Current practice is appraised while PBP guidelines are being developed. Ongoing communication with staff comparing current practices with perceived practices is crucial for change to be seen as a priority. Evidence-based PBPs should then be implemented with ongoing appraisal.

The rapid-cycle improvement model uses the PDSA cycle to test change. At all 3 participating institutions, local collaborative teams were set up to include members from available disciplines. Two institutions did not have a neonatal nutritionist available to them at the beginning of the group work. These institutions used the experiences of the collaborative to substantiate the need for and to train and incorporate a nutritionist into the medical team. After the self-appraisal process was completed, energies were poured into conceptualizing a nutrition program and creating an appraisal data collection tool. The primary goal was to make nutrition practices a more integral part of medical care. Therefore, data were collected more frequently than the group needed. Weekly nutrition appraisal became the

norm. At 1 institution, a bright yellow data collection tool became a prominent part of the bedside chart. Soon data collection moved from the core group to several other NICU staff members. This highly visible tool increased attention to nutrition. The systematic approach served as the foundation for providing better nutrition support. Parallel processes occurred in the other 2 units in the group. Figure 2 gives an example of a PDSA cycle used to implement the PBP on consistent and comprehensive monitoring of growth and nutrition intake. Multiple PDSA cycles building on each other are often necessary to reach desirable aims as seen in Fig 3.

Each participating institution has been able to evaluate local change and compare data with others in the group. Practices that were introduced early in training or had become comfortable remained in use despite inability to recall the thought processes supporting them.³⁵ The shift to a feed-by-feed decision-making paradigm to maximize enteral nutrition required education, training, and a modification of staff coverage in some cases. Holding the feeding until the morning shift was no longer an option if each feed was to be treated as a potential new feeding start. It was found that nutrition practice guidelines needed to balance structure with flexible accommodation to the individual unit culture. The methods of achieving the overall aims of improved nutrient delivery, improved growth outcome, and acceptable balancing measures may look very different from one unit to the next.

Ongoing appraisals continued to spread collaborative learning. The results of individual team and institution learning were shared within the group and encouragement for continued improvement spread. This helped to support the demanding pace of change expected by the project. Despite the demands, the group remained committed to moving forward within their own institutions. Data presented in Tables 4 to 6 provide an example of the support for continuing the goal-oriented evidence-based plan.

After implementation of the PBPs, all participating

TABLE 4. Demographics of Neonatal Nutrition Focus Group (N = 421)

Baseline Phase January 1, 1998–August 30, 1999 (N=83)		Implementation Phase April 1, 2000–April 1, 2001 (N=246)	
Gestational Age	Birth Weight*	Gestational Age	Birth Weight*
26.42 wk ± 2.23	836.46 g ± 211.64	28.27 wk ± 2.76	1032 g ± 287.85

* Includes appropriate for gestational age and small for gestational age infants.

TABLE 5. Selected Nutrition Outcomes of the Neonatal Nutrition Focus Group (All Participating Institutions)

Nutrition Outcome Infants <1500 Grams	Baseline	Implementation	Focus Group Goals
Days to start enteral feeds	8.96 ± 10.14	4.7 ± 5.01	Between d 1–8
Days to reach full feeds	34 ± 77	23.7 ± 14.6	By d 14 of enteral feeding
Days to reach 80 kcal/kg	19 ± 7.83	6.5 ± 2.86	
Days to reach 120 kcal/kg from enteral	38.7 ± 25.7	27.69 ± 15.42	By d 14 of enteral feeding
Days to start TPN	3.24 ± 125	1.81 ± 0.88	Within 24 h
Use of breast milk as first feed	47%	62%	75% of all infants
Rate of NEC			
Institution 1	16%	6%	≤VON mean (6%)
Institution 2	6%	4%	
Institution 3	5%	5%	

Sample sizes available at baseline $n = 61$ to 71 ; sample size available at implementation $n = 146$ to 246 .

TABLE 6. Changes in Average LOS by Gestational Age Baseline and Implementation Groups

Birth Weight	Baseline N	LOS Days	Implementation N	LOS Days
501–750 g	24	83	35	84
751–1001 g	41	78.23	72	61.4
1001–1250 g	4	51.75	54	42.3

LOS indicates length of stay.

institutions and the group as a whole showed improved consistency of practice, as evidenced by less variability on all variables measured. Growth data are summarized in the following tables. The aim was to maintain expected intrauterine growth patterns using the data provided by Alexander et al.¹⁹ Fig 4 describes the growth patterns of the baseline and implementation groups as compared with the percentiles of expected intrauterine growth. An improvement in the percentage of infants from 98% ($n = 61$) to 83% ($n = 189$) who were discharged at <10th percentile was seen after implementation of the PBPs. Another approach could be to compare the discharge weight of infants at their discharge gestational age to determine whether efforts to improve nutrition support and decrease length of stay result in infants' being discharged heavier than previously. Although the expected rate of intrauterine growth may be the current standard, it may not be realistically attainable with current technology. An improvement gain with respect to greater achievement

of weight and linear growth at discharge may be more reasonable.

Implicit in quality improvement must also be some measure of the cost of that improvement. For this group, decreasing the incidence of NEC itself would result in cost savings per infant alone. As a result of more formalized nutrition support protocols, a slight reduction in length of stay for all 3 centers was noted.

DISCUSSION

Three NICUs with different levels of care, different sizes, and different unit cultures formed the "Got Milk" focus group of the NIC/Q 2000 collaborative. These units shared a common goal: to improve nutrition practices and outcomes without doing harm. For many months, the group lacked focus. Despite the occasional blurred focus, however, the collaborative learning process supported a movement away from what had become comfortable, down the path toward best practices.¹ A process of appraising nutrition practices was developed and is broad-based enough to meet the needs of a variety of units and specific enough to help put evidence into practice.

The process of self-assessment was crucial in enabling 3 very different institutions to create a common measurable aim. Best practices must have some evidence base. However, the limitations imposed by the slow pace of publication of formal clinical trials are an issue. The process requires consistent, systematic appraisal of practice for continued improvement.

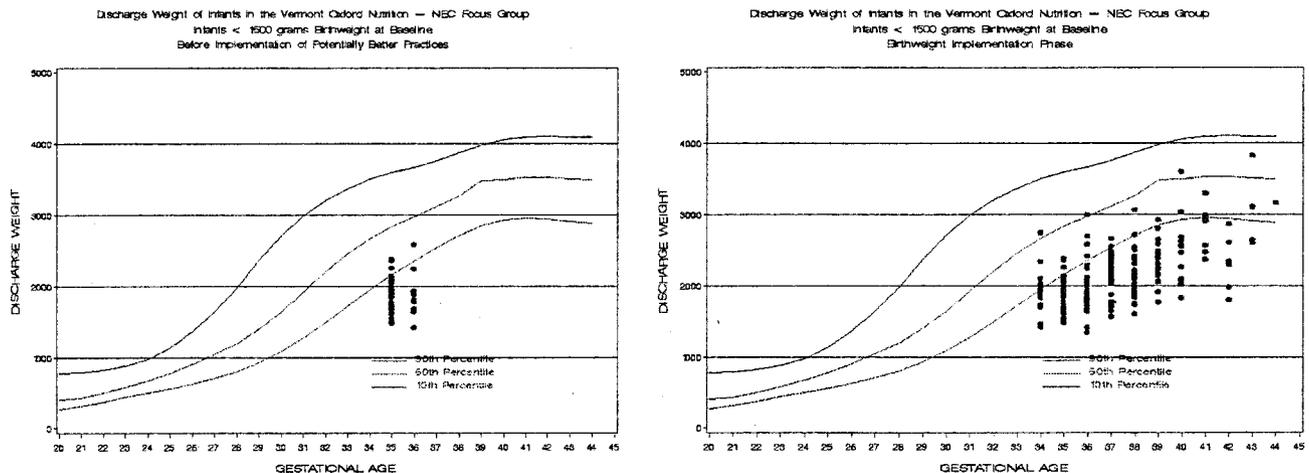


Fig 4. Growth outcome baseline and intervention period compared with expected intrauterine.

This process is very effective when a multidisciplinary approach is taken and the expertise of a neonatal nutritionist is used to promote continuity of care. The PBP's developed here are evidence-based guidelines that support decisions about nutrition practices and are flexible enough to accommodate different unit cultures. PBP's implies the need for continued review and refinement, which should include balancing measures to assess undesirable outcomes. Although the pathogenesis of NEC may be unclear, feeding practices cannot be ignored while NEC rates climb. Approximating in utero growth rates of normal fetuses may be difficult to achieve, but this is the current standard for growth outcome.

All of the PBP's developed have been in practice in this group for >1.5 years and have spread across the collaborative. Some areas of nutrition practice still need review; for example, a comprehensive PBP on TPN has not been developed. A discussion on adding growth/nutrition practice outcomes to the main VON database is needed. Collaboration between groups has been a natural extension of the project. The focus of the NIC/Q 2000+ collaborative on medical errors, patient safety, and systems thinking will extend the work of this group further. The consensus of the group is that although the work has been demanding, the rewards in the knowledge gained, the momentum of the rapid-cycle model, and successful implementation of PBP's in the home units have created a system of change needed to move beyond previous barriers and improve nutrition practice.

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