

Evaluation and Development of Potentially Better Practices to Prevent Chronic Lung Disease and Reduce Lung Injury in Neonates

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ABSTRACT. *Objective.* Despite increased knowledge and improving technology, chronic lung disease (CLD) rates in extremely low birth weight infants have remained constant for 20 years. One reason for this is an ineffective translation of research-proven improvements into practice. The Neonatal Intensive Care Quality Improvement Collaborative Year 2000 (NIC/Q 2000) was created to provide participating nurseries the tools necessary to effect change. The objective of this study was to develop and implement a process that uses quality improvement techniques to collaboratively improve CLD rates.

Methods. Nine member hospitals of the NIC/Q 2000 collaborative formed a focus group aiming to decrease CLD rates. The focus group established goals and outcome measures, created a list of potentially better practices (PBPs) based on available literature, benchmarked and performed site visits, encouraged individual site implementation of PBPs, developed a database, and measured outcomes.

Results. The goal "decrease CLD rates in extremely low birth weight infants" was established. Nine PBPs were identified, and 57 PBPs were implemented by the 9 participating sites. Twelve site visits were conducted, and a 435-patient database of infants with a mean birth weight of 789 g was established.

Conclusions. Collaborative use of quality improvement techniques resulted in creation of a logical, efficient, and effective process to improve CLD rates. Group creation of PBPs, based on literature review and reinforced with site visits, internal data analysis, and improved individual site outcomes, resulted in accelerated and effective change, unlikely to occur if attempted outside of the collaborative. *Pediatrics* 2003;111:e426–e431. URL: <http://www.pediatrics.org/cgi/content/full/111/4/e426>; collaborative quality improvement, chronic lung disease, extremely low birth weight infants, best practice, NIC/Q 2000.

ABBREVIATIONS. PBPs, potentially better practices; CLD, chronic lung disease; VON, Vermont Oxford Network; NIC/Q 2000, Neonatal Intensive Care Quality Improvement Collaborative Year 2000; CAT, critically appraised topic.

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KEY POINTS OF THE ARTICLE

- A process to facilitate collaborative quality improvement is described.
- Translation of research into practice can be accelerated by collaborative quality improvement.
- Collaborative quality improvement can result in decreased duplication of effort, shared successes and failures, and healthy intersite competition, all of which facilitate improvement.
- Collaborative quality improvement can improve outcomes more efficiently and effectively than individual site quality improvement efforts.

APPLYING LESSONS LEARNED TO PRACTICE

- Evaluation and integration of the medical literature are critical to successful implementation of Potentially Better Practices
- Outcomes measurement is critical to implementation and permanent integration of identified potentially better practices (PBPs).
- Small, rapid cycles of change establish momentum and facilitate implementation of evidence-based interventions.
- Benchmarking and site visits are invaluable in effecting change as they identify and define in detail alternative cultures of care that can affect outcomes substantially.

With the advent of surfactant, prenatal steroids, and intensive care techniques, the survival rate of extremely low birth weight infants has improved dramatically.^{1–3} Despite these improvements, however, the incidence of chronic lung disease (CLD) has remained stable over the past 2 decades.^{3,4} Countless studies using multiple interventions have shown improvements in CLD rates.^{4–66} However, experience suggests that many of these interventions have not been effectively translated into practice in neonatal intensive care units. A recent report from the Institute of Medicine⁶⁷ noted that in many areas of medicine, a large chasm has developed between what we know and what we do. This seems to be true of efforts to prevent CLD as well.

In 1998, a group of 34 Vermont Oxford Network (VON) sites began a structured program called the Neonatal Intensive Care Quality Improvement Collaborative Year 2000 (NIC/Q 2000) project. The goal was to improve collaboratively the quality of care in their intensive care nurseries⁶⁸ by implementing established rapid-cycle improvement methods. It was

TABLE 1. Members of the CLD Focus Group

Hospital	Location
Children's Hospitals and Clinics	Minneapolis, MN
Inova Fairfax Hospital for Children	Falls Church, VA
Lehigh Valley Hospital	Allentown, PA
Lucile Packard Children's Hospital at Stanford	Palo Alto, CA
Miami Valley Hospital	Dayton, OH
Providence St Vincent Medical Center	Portland, OR
St Barnabas Medical Center	Livingston, NJ
St John's Mercy Medical Center	St Louis, MO
DeVos Children's Hospital*	Grand Rapids, MI

* Hospital joined the focus group 6 months after formation.

clear that there were significant variations in outcomes between participating neonatal intensive care units, including the rate of CLD. Representatives from 9 institutions with varying rates of CLD chose to focus their collaborative efforts on reducing CLD. This article describes the process that these institutions used to effect quality improvement changes to reduce CLD rates. The participating institutions are listed in Table 1.

METHODS

Structure of the CLD Group

At the first meeting of the CLD group, an experienced facilitator was assigned and a group leader was chosen. The facilitator advised the group on data collection tools, measurement strategies, data analysis, and group processes. The group leader facilitated discussions on the goals and measures to be used, delegated responsibilities to member sites, established accountability for assigned tasks, corresponded with the leaders of the NIC/Q 2000 project, led conference call discussions, presented ideas and data at collaborative meetings, and established time lines. Each site in the group selected a representative to coordinate site efforts, communicate between site members and the CLD group members, and ensure completion of assigned tasks.

Establishment of Goals and Outcome Measures

The initial discussions of the CLD group focused on the most appropriate definition of CLD. The group agreed on a definition identical to that used in the VON database: an infant with CLD is "an infant who remains in hospital and is on supplemental oxygen at 36 weeks' adjusted age." After agreement was reached, primary and secondary goals for the group were established. Outcome measures were selected to assess the effectiveness of future interventions. The primary goal was to reduce the need for supplemental oxygen at 36 corrected weeks' gestation. The primary outcome measure was the percent of infants requiring supplemental oxygen at 36 weeks. Seven secondary goals were established, with 6 outcome measures and 11 process measures selected. Goals are listed in Table 2, and measures are listed in Table 3.

TABLE 2. Goals of the CLD Focus Group

Primary goal
Reduce the need for supplemental oxygen at 36 corrected weeks gestation
Secondary goals
1. Reduce ventilator days
2. Reduce supplemental oxygen days
3. Reduce pneumothorax rate
4. Reduce dexamethasone use
5. Reduce or maintain length of stay
6. Reduce or maintain ROP rates
7. Reduce, or at least monitor, if "home on oxygen," CPAP days, and cost

ROP indicates retinopathy of prematurity; CPAP, continuous positive airway pressure.

TABLE 3. Outcome and Process Measures for CLD Focus Group

Outcome measures
1. CLD, rate
2. Percentage of infants sent home on oxygen
3. Pneumothorax rate
4. Length of stay
5. ROP rates
6. Cost
Process measures
1. Ventilator days
2. Supplemental oxygen days
3. Number of infants treated with dexamethasone, dose, and duration of treatment
4. CPAP days
5. Completion of vitamin A protocol
6. Mean fluid volume (mL/kg/d) over the first 7 d of life
7. Mean maximum daily serum sodium values over the first 7 d of life
8. Percentage of infants treated with postextubation CPAP
9. Mean minimum and maximum Paco ₂ levels for the first 7 d of life
10. Percentage infants using high-frequency ventilation, and percentage of total ventilator days using high-frequency ventilation
11. Use and type of prophylactic surfactant (within 30 min of birth)

Creation of PBPs List

A brainstorming session resulted in an initial list of practices thought to reduce the incidence and severity of CLD (PBPs). This list was compared with lists from other groups in the NIC/Q 2000 project. Two practices, improving nutrition and decreasing nosocomial infection rates, were deleted from the CLD list because other groups in the collaborative were addressing them. An important aim was to minimize duplication of efforts and unnecessary use of resources. Each site in the group was then assigned 1 to 2 PBPs to study in detail and assemble the evidence supporting the practice.

Literature searches using Medline and the Cochrane Database of Clinical Trials and Systematic Reviews were conducted for each of the PBPs. After these reviews, the most representative article for assessing the effectiveness of the PBP was identified. A 1- to 2-page summary of this publication, called a critically appraised topic (CAT), was prepared. CATs have been described in detail elsewhere.⁶⁹ A sample CAT is shown in Appendix 1. Each CAT was reviewed by the group, which discussed the quality of the data. On the basis of these CATs, other literature sources, clinical experience, and physiologic arguments, the group either rejected the proposed PBP or included it in a final list of PBPs for implementation. One PBP, encouraging the use of inhaled steroids, was removed from the list at this point because the literature review indicated that the evidence of its effectiveness was inconclusive. The 9 PBPs on the final list are shown in Table 4.

Once the final list was created, each PBP was assigned to a site for extensive description using a collaborative-established worksheet called the "PBP worksheet." On completion of the worksheet, a PBP packet (including the CAT, the PBP worksheet, and suggested implementation strategies) was created to facilitate implementation. Each participating site was then asked to implement as many of the PBPs as possible.

Benchmarking and Site Visits

In preparation for benchmarking and site visits, a detailed survey tool to identify processes and outcomes and explore practice variations was developed by the CLD group. First, the group brainstormed to establish a draft list of questions. Next, these questions were categorized into 4 temporal domains related to the development of CLD (resuscitation, stabilization, weaning, and convalescence). Duplicate or confusing questions were removed. The draft survey was then piloted at each site in the group. This internal pilot revealed substantial practice variability within each site as well as substantial variability between sites. Furthermore, practices and outcomes at the sites often differed from the perceptions of practices and outcomes that each group had expressed

TABLE 4. PBPs: Reducing CLD Focus Group

PBP	Level of Evidence*	Reference
Vitamin A supplementation	Level 1	5,6
Decrease fluid administration	Level 3	7–13
Postextubation CPAP	Level 1	14–21
Permissive hypercarbia	Level 2	22–28
Decrease supraphysiologic corticosteroid exposure in premature infants	Level 1	29–34
Prophylactic surfactant for birth weight <1000 g or delivery room CPAP in birth weight >1000 g	Level 1	35–36
Reduce ventilator days	Level 1–5	28, 32, 35, 37–54
High-frequency ventilation or low tidal volume ventilation	Level 1–2	55–63
Gentle ventilation in the delivery room	Level 2–3	26, 37–41, 47, 64–66

* Muir Gray Classification System 70:

Level 1—Strong evidence from at least 1 systematic review of multiple well-designed randomized controlled trials.

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.

before the survey. Practices seemed to be influenced as much by culture as by policy.

Five sites were identified by VON as benchmark sites that were willing to host site visits for the CLD group. Benchmark sites had CLD rates ranging from 0% to 7%. They cared for a range of 42 to 136 infants per year between 500 and 1500 g birth weight, and between 90% and 100% of their very low birth weight infants were inborn. Nearly all mothers (between 81% and 96%) had had at least some prenatal care. Group participants were also encouraged to visit 1 or more of the other sites in the group and other sites in the NIC/Q 2000 collaborative. Once a site visit was scheduled, the 41-item survey tool was mailed in advance for completion and returned to the visiting site for review before the 1-day site visit.

After each site visit, a summary of site visit findings was sent back to the host site for edits and final comments. The visits supplemented literature searches and internal analyses by revealing the practices, processes, and culture of care at data-identified best practice sites. After the benchmark visits, a database containing all responses to the survey tool was developed to allow qualitative and quantitative analysis of responses from CLD focus group sites and benchmark sites.

RESULTS

PBPs

Nine PBPs to reduce CLD in low birth weight infants were identified. These were called “potentially” better practices because for many, the data do not show definitively that they reduce CLD. All 9 PBPs (Table 4) are based on the literature, internal data analysis, and benchmarking visits. Nevertheless, not all of the participating institutions considered the evidence compelling for all PBPs. Therefore, not all institutions implemented all of them. A total of 57 PBPs were implemented by 9 sites. An additional 13 PBPs were listed as already being done by the 9 sites. Thus, 70 of a possible 81 PBPs among the 9 sites were implemented before or during the establishment of the CLD focus group. Three of the focus group sites implemented all 9 recommended PBPs, whereas 3 other sites implemented 8 of the 9. Each of the 9 sites implemented at least 5 of the 9 PBPs from the CLD list (Table 5).

TABLE 5. PBPs Implemented at Each Site

PBP	A	B	C	D	E	F	G	H	I
Vitamin A supplementation		X	X	X				X	
Decrease fluid administration		X	X	X	X	O	O		X
Postextubation CPAP	O	X	X	X	X	O	X	X	X
Permissive hypercarbia	X	X	X	X	X	O	X	X	O
Decrease supraphysiologic corticosteroid exposure in premature infants	X	X	X	X	X	O	X	X	X
Prophylactic surfactant for birth weight <1000 g or delivery room CPAP in birth weight >1000 g	X	X	X	X	X		X	X	O
Reduce ventilator days	O	X	X	X	X	O		X	X
High-frequency ventilation or low tidal volume ventilation	O	X	X	X	X	X		X	O
Gentle ventilation in the delivery room	X	X	X	X	X	O		X	X

A–I indicates individual sites (blinded); X, implemented during inclusion in the CLD focus group; O, implemented before CLD focus group.

Benchmarking and Site Visits

Twelve site visits were made by 8 sites in the CLD focus group, including 7 visits to identified benchmark sites. Three site visits were made to geographically close NIC/Q 2000 project sites. Two site visits were made to member sites of the CLD focus group. Survey responses and site visits revealed that benchmark sites could often articulate the practices that they believed led to superior outcomes, but evidence-based practices were not always used. Outcome data analysis was critical. For example, it forced the focus group to accept that these better performing sites cared for infants in similar ways, that the low rates of CLD were not aberrations, and that specific practices seemed less important in improving outcomes than the consistency of practice.

Information obtained from the survey questions, when administered internally to the CLD focus group sites, revealed 1) substantial intrapractice vari-

ability within each site, 2) site-specific practices and outcomes were different from presurvey perceptions, 3) site-specific culture influenced care as much as policy, 4) substantial interpractice variability, and 5) site-specific process analysis proved more useful than comparison of processes between sites. Additional results obtained from the survey questions, when administered to benchmark sites, included that 1) benchmark sites can frequently articulate the practices that they believe lead to superior outcomes, 2) specific practices are less important than consistency of a given practice, and 3) outcomes data analysis is critical.

In summary, results from the benchmarking and site visits included that 1) many practices at focus group sites were not evidence-based, 2) evidence-based practices were not always seen at the benchmark sites, 3) best practices for 1 outcome may adversely affect other outcomes, 4) intuitive practice strategies were not always substantiated by evidence, and 5) consistent practices result in improved outcomes.

Resource Kit

A resource kit that included 11 CATs, 9 PBP, 10 PBP worksheets, 11 descriptions of implementation efforts (including site-specific barriers to implementation and strategies to remove these barriers), and 2 site-specific practice guidelines used to facilitate implementation of a particular PBP was developed. This resource kit also included the survey used for internal process analysis and benchmark site visits. The PBP resource kit was distributed to NIC/Q 2000 sites not involved in the CLD group for implementation of PBPs at their discretion.

Database Creation

As of April 1, 2001, a total of 435 patients with a mean gestational age of 26 weeks (standard deviation: 2; range: 23–33 weeks) and a mean birth weight of 789 g (standard deviation: 133; range: 505–1000 g) from the 9 CLD group members had been entered into the database.

DISCUSSION

The CLD group moved from the creation of a group structure, through establishment of goals and measures, development of a survey tool for internal and benchmark site process analysis, identification of benchmark sites and completion of benchmark site visits, to creation and implementation of a list of PBPs. In addition, the CLD group created a database to evaluate the process and clinical outcomes resulting from implementation of the PBPs. These accomplishments could not have occurred at any individual site; rather, they occurred as a direct result of collaboration.

There are several advantages to participating in a group when attempting to improve care quality. First, the work can be divided among the group members, minimizing duplication of efforts and maximizing the use of available resources. Second, an enthusiasm exists for collaborative work that is difficult to generate and maintain when working at

only 1 site. Third, a healthy competition naturally ensues, resulting in the acceleration of time lines and attention to practice detail. Fourth, a culture of accountability that accelerates the completion of assigned tasks is instilled. Fifth, the group provides a rich environment for learning. Site-specific strengths are inevitably discovered and discussed. Topics of mutual interest promote discussion during conference calls and meetings. Finally, data can be shared, creating larger databases for comparisons and combined analyses with larger numbers of patients and the ability to stratify to identify significant trends.

Our experience revealed several qualities necessary to create an effective focus group. First, clear evidence-based and measurable goals are critical to establishing and maintaining an effective focus group. Second, an experienced and dedicated leader is critical, acting as a catalyst to move the process forward quickly and maintain orientation to the assigned tasks. Third, each participant site must be willing to dedicate time and resources to the project. Fourth, each site must be willing to forego concerns of confidentiality to provide data and discuss care practices candidly. Fifth, frequent contact using strategies such as conference calls, listservs, and face-to-face meetings is crucial for moving the project forward. Sixth, a logical and aggressive timeline must be established with deadlines for each component of the process. Finally, a sense of accountability must be instilled into each site to maintain equal distribution of work and to ensure forward progress. This accountability stems from an effective leader, a need for return on investment, the peer pressure instilled from frequent contact between members, and an established time line.

Changing practice in large institutions requires energy, flexibility, and risk and rarely occurs without credible support from the literature. Thus, the literature review process for creation of the PBPs was a critical component of our efforts. First, it allowed a comprehensive review of data published related to CLD. An advantage of the focus group format was that each site could choose 1 or 2 areas of expertise, thus increasing the group knowledge base while minimizing duplication of effort. It also added to the efficiency of the process because clinical practices that lacked supportive data would not be pursued by the centers. Second, once the most relevant articles were obtained, they could be evaluated and classified by the strength and quality of the evidence. The confidence of a recommended PBP was then discussed relative to the strength of the study design and validity of the data. Third, extensive literature searches showed that many current practices had evolved without high-quality randomized trials to support these practices. Finally, creation of evidence-based PBPs provided the necessary background to recommend implementation of these PBPs at their own sites.

Development of the benchmarking survey tool was also critical to the improvement effort. Listing relevant questions forced us to consider the potential risk factors for CLD and then remove all questions not supported by evidence and not directly related to

CLD. In an effort to be parsimonious, questions were crafted to extract the most information with the least amount of effort. This process led to a debate about the significance of each question and the information sought in the answers. The survey answers provided information on actual rather than perceived processes of care. In many cases, actual processes differed considerably from perceived processes. Furthermore, when our survey responses were combined into a group database, analysis of the data revealed remarkable variation in practice between the 9 group members, despite evidence in the literature for specific practices. This discovery fueled discussions on the practical value of some literature-based recommendations and stressed that site-specific cultures heavily influence practice strategies.

The benchmarking visits were invaluable in demonstrating not only what practices were done but also how they were done and who did them at data-identified best practice sites. This type of information is crucial yet difficult to obtain using other formats.

As noted earlier, each of the PBPs identified was based on the literature, internal data analysis, and benchmarking visits. However, frequent reassessment of the literature must occur to validate the PBP creation process. For example, during the early CLD group meetings, dexamethasone use was identified as a potentially effective means of reducing lung inflammation and subsequent injury. However, during the ensuing 2 years, several studies that revealed significant long-term morbidity associated with early prophylactic use and later use of this drug were reported or published. This prompted a change in focus to reducing the use of dexamethasone and if used to a very low dose for a brief period of time. Finally, it is important to remember that implementation of any PBP may have an effect on other outcomes. For example, use of vitamin A to minimize CLD was identified as a PBP. However, the recommended protocol based on a published randomized controlled trial involves 14 intramuscular injections over 28 days.⁶ In competition with improved CLD rates from the vitamin A PBP is the increased risk of nosocomial infection in infants who have a high number of needle sticks. Thus, methods of ongoing measuring and monitoring are essential whenever any of the PBPs are implemented.

The final component of the CLD focus group's project was the patient database. Although difficult to create, this database will probably prove to be the most compelling argument for aggressive implementation of PBPs. Change concepts can be suggested based on the literature, benchmarking visits, and internal analysis of practice process. However, positive results must be achieved, maintained, and demonstrated for changes to become ingrained in the culture. Without the ability to demonstrate improvement, the ongoing process of rapid-cycle improvement efforts may eventually be abandoned. Other advantages of the database include an ability to monitor balancing measures and an ability to stratify outcomes based on known risk factors such as birth weight, gender, ethnicity, or site of care.

In summary, the process of establishing the CLD group as a component of a larger collaborative has allowed each participating site to establish and implement efficiently several evidence-based PBPs. Future efforts of the group will include completing collection of postintervention outcome data to determine whether efforts had an effect on CLD rates and on secondary outcomes. Efforts to risk-adjust CLD rates and to examine the effects of PBPs on other outcomes such as growth and central nervous system development will be the next phase in the evolution of this collaborative quality improvement process.

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