

# Implementing Potentially Better Practices to Reduce Lung Injury in Neonates

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**ABSTRACT.** *Objective.* Adherence to basic quality improvement principles enhances the implementation of potentially better practices (PBPs) and requires extensive planning and education. Even after PBPs have been identified and acknowledged as desirable, effective implementation of these practices does not occur easily. The objective of this study was to identify and assess implementation strategies that facilitate quality improvements in the respiratory care of extremely low birth weight infants.

*Methods.* The 9 members of the Neonatal Intensive Care Quality Improvement Collaborative Year 2000 Reducing Lung Injury focus group identified 9 PBPs in an evidence-based manner to decrease chronic lung disease in extremely low birth weight newborns. Each site implemented several or all PBPs based on a site-specific selection process. Each site was asked to submit 1 or more examples of experiences that highlighted effective implementation strategies. This article reports these examples and emphasizes the principles on which they are based.

*Results.* The 9 participating institutions implemented a total of 57 PBPs (range: 1–9; median: 5). Including previous implementation, the 9 participating institutions implemented a total of 70 of a possible 81 PBPs before or during the study period (range: 5–9; median: 8). We report 7 approaches that facilitated PBP implementation: information availability, feedback, perseverance, collaboration, imitation, recognition of implementation complexity, and tracking of process indicators.

*Conclusions.* Quality improvement efforts are enhanced by identifying and then implementing PBPs. In our experience, implementation of these PBPs can be difficult. Implementation strategies, such as those identified in this article, can improve the chances that quality improvement efforts will be effective. *Pediatrics* 2003;111:e432–e436. URL: <http://www.pediatrics.org/cgi/content/full/111/4/e432>; collaborative quality improvement, chronic lung disease, extremely low birth weight infants, best practice, NIC/Q 2000.

Neonatal Intensive Care Quality Improvement Collaborative Year 2000; VON, Vermont Oxford Network; CLD, chronic lung disease; NICU, neonatal intensive care unit; NCPAP, nasal continuous positive airway pressure; RCP, respiratory care practitioner.

## KEY POINTS OF THE ARTICLE

- Effective implementation strategies that facilitate improvements in the quality of respiratory care of extremely low birth weight (ELBW) infants are described.
- Ineffective implementation strategies, in an effort to identify common causes of failed implementation, are discussed.
- Collaborative quality improvement can result in identification of implementation strategies that are more likely to succeed at an individual site.

## APPLYING LESSONS LEARNED TO PRACTICE

- Identification of potentially better practices (PBPs) is only 1 component in the process of improving the quality of care for ELBW infants.
- Multiple implementation strategies that facilitate practice improvement are available.
- Implementation of literature-based PBPs is often a difficult and lengthy process.

The Reduce Lung Injury (ReLI) group was formed in 1999 as a subset of the Neonatal Intensive Care Quality Improvement Collaborative (NIC/Q 2000), which was sponsored and organized by the Vermont Oxford Network (VON).<sup>1,2</sup> The ReLI group of 9 hospitals chose as its goal reducing lung injury in ELBW infants (birth weight <1250 g) and identified 9 PBPs to accomplish this goal. This report describes the approaches that the ReLI group took to implement these PBPs and highlights the principles that ReLI participants found most effective.

## METHODS

Table 1 lists the members of the ReLI group. The ReLI group established a goal of decreasing chronic lung disease (CLD), defined by the requirement for supplemental oxygen at 36 weeks' corrected gestational age. ReLI participants worked to decrease both the incidence and severity of CLD in ELBW infants. Sharek et al<sup>1</sup> previously described construction of the PBP. Table 2 lists the PBPs as the ReLI group developed them in 1999, and Table 3 shows the PBP implemented by site. Participants at each site determined which PBPs to implement and how they would be implemented. Participants were permitted to apply PBPs according to the idiosyncrasies of their individual institutions. ReLI members instituted rapid-cycle improvements and participated in the NIC/Q 2000 semiannual symposia on quality improvements

ABBREVIATIONS. ELBW, extremely low birth weight; PBPs, potentially better practices; ReLI, Reduce Lung Injury; NIC/Q 2000,

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**TABLE 1.** Members of the CLD Focus Group

Hospital	Location
Children's Health Care	Minneapolis, MN
DeVos Children's Hospital*	Grand Rapids, MI
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

\* Hospital joined the focus group 6 months after formation.

in neonatal intensive care unit (NICU) care to develop effective methods to implement changes. Other tools included conference calls, site visits, and e-mail.<sup>2</sup> Finally, data were collected between April 1, 2000, and December 31, 2000, and again between April 1, 2001, and June 30, 2001, for inter- and intrasite postintervention data analysis. The ReLI group reviewed the implementation experiences of participating hospitals and categorized the implementation strategies as follows: information, feedback and behavior change, perseverance, collaboration and communication, imitation, compromise, and measurement. A previous article, detailing the methods of the ReLI focus group project, is described within this journal.<sup>1</sup>

## RESULTS

The ReLI group identified 9 PBP's to reduce CLD in low birth weight infants. These are called "potentially" better practices because for many, the data do not

**TABLE 2.** PBP's: Reducing CLD Focus Group

PBP	Implementation Goal
Vitamin A supplementation	Provide vitamin A 5000 IU (0.1 ml) intramuscularly 3 times each week for 4 wk to all infants with birth weight <1000 g who are on a ventilator or require supplemental O <sub>2</sub> at 24 h of age, starting at >24 h
Decrease fluid administration	Minimize fluid intake while maintaining 1) weight loss at 3%–5% daily or approximately 15% cumulative within 5 d, 2) serum Na 137–150 (osmolality = 285–310), 3) BUN <60, 4) UOP 1–3 cc/kg/h, 5) HCO <sub>3</sub> >18
Postextubation CPAP	Use NCPAP to reduce ventilator days and reintubations
Permissive hypercarbia	Keep Paco <sub>2</sub> of ventilated infants between 50 and 65 mmHg and the arterial pH >7.25. Do not intubate for a pH >7.25 or Pco <sub>2</sub> <60 unless the clinical situation of the infant mandates intubation, such as in severe, clinical respiratory distress, cardiovascular deterioration, apnea, etc.
Decrease supraphysiologic corticosteroid exposure	Avoid dexamethasone in the first 10–14 d after birth. At 10–14 d of age, consider using dexamethasone only if the following criteria are met: a) infant remains on mechanical ventilation and is not weaning. b) Fio <sub>2</sub> >0.40–0.50, MAP >8–9. c) chest x-ray shows PIE and/or early cystic changes. d) PDA and pneumonia have been ruled out. If dexamethasone is used, start at 0.20–0.30 mg/kg/d divided every 12 h for 48 h. If the course continues beyond 48 h, then halve the dose every 48 h and try to limit the entire course to <7–10 d.
Give either prophylactic surfactant for birth weight <1000 g or delivery room NCPAP to maintain functional residual volume	Give prophylactic surfactant (within 30 min of birth) to infants with birth weight <1000 g, gestational age <27 weeks, and/or respiratory distress. Alternatively, start NCPAP in the delivery room.
Reduce ventilator days	Gentle ventilation at birth with prophylactic surfactant, implementation of strict weaning and extubation criteria, and increased use of NCPAP to prevent or reduce the need for mechanical ventilation.
High-frequency ventilation or low tidal volume ventilation	Choose a high-frequency ventilator with which there is wide-spread, published experience, such as Sensor Medics 3100 A. Begin HFOV early, using a high volume (optimal volume) strategy. Alternatively, use a conventional ventilator using a low tidal volume. Tidal volume must be measured and higher Paco <sub>2</sub> values accepted (permissive hypercarbia).
Gentle ventilation in the delivery room	Measure tidal volume and peak inspiratory pressure in the delivery room. Minimize chest wall expansion and lung distention by using no more than 6 mL/kg tidal volume. Use a ventilator rather than hand bagging as soon as possible.

BUN indicates blood urea nitrogen; Fio<sub>2</sub>, fraction of inspired oxygen; MAP, mean arterial pressure; UOP, urine output; PIE, pulmonary interstitial emphysema; PDA, patent ductus arteriosus; HFOV, high-frequency oscillatory ventilation.

**TABLE 3.** Grid of PBP's Implemented at Each Site

PBP	Center									
	A	B	C	D	E	F	G	H	I	
Vitamin A supplementation		X	X	X					X	
Decrease fluid administration	O	X	X	X	X	O	O			X
Post-extubation CPAP	O	X	X	X	X	O	X	X	X	
Permissive hypercarbia	X	X	X	X	X	O	X	X	O	
Decrease dexamethasone	X	X	X	X	X	O	X	X	X	
Prophylactic surfactant delivery room NCPAP	X	X	X	X	X		X	X	O	
Reduce ventilator days	O	X	X	X	X	O			X	X
High frequency ventilation or Low V <sub>T</sub> Ventilation	O	X	X	X	X	X			X	O
Gentle ventilation in the delivery room	X	X	X	X	X	O			X	X

O, indicates implemented before ReLI; X, indicates implemented during ReLI; blank, no implementation; V<sub>T</sub>, tidal volume.

show definitively that they reduce CLD. All 9 PBP's (Tables 2 and 3) are based on published studies, internal data analysis, and benchmarking visits. Not all of the participating institutions considered the evidence compelling for all PBP's, and therefore not all institutions implemented every PBP. Each center selected between 1 and 9 new PBP's to implement (median: 5), with a total of 57 PBP's being newly implemented by the 9 sites. An additional 13 PBP's were listed as having already been implemented by the 9 sites. Thus, 70 of a possible 81 PBP's (range: 5–9;

median: 8) among the 9 sites were implemented before or during the establishment of the ReLI focus group. Three of the focus group sites implemented all 9 recommended PBPs, whereas 3 other sites implemented 8 of the 9 PBP. ReLI group members from each of the 9 sites implemented at least 5 of the 9 PBPs (Table 3).

## DISCUSSION

The ReLI focus group members of the NIC/Q 2000 collaborative collated their experiences into the following 7 successful strategies.

### Information

All meaningful efforts to improve quality required information on current clinical practice and the experience at other neonatal centers. Existing outcomes and practice patterns determined the ReLI group's site-specific quality improvement efforts. For example, prophylactic surfactant administration improves outcomes compared with later treatment surfactant in infants with gestational age <30 weeks.<sup>3</sup> However, prophylactic surfactant probably conveys an advantage on only the most immature infants: those with a gestational age of 26 weeks or less.<sup>4</sup> Participants at 1 site attempted to implement the prophylactic surfactant PBP by restricting prophylactic surfactant to infants <27 weeks' gestation. Despite the team's best efforts, data review indicated that delivery room teams continued to treat 80% of infants with gestational ages of 27 to 29 weeks with prophylactic surfactant. In response to these data, this site's quality improvement team developed a step-by-step respiratory support algorithm to guide surfactant administration, nasal continuous positive airway pressure use, and mechanical ventilation for infants based on gestational age (<27 weeks and >27 weeks). Providing clear information about present and desired (algorithm) processes markedly improved compliance.

### Feedback and Behavior Change

Feedback (both positive and negative) effectively improves clinical outcomes and influences behavior.<sup>5,6</sup> One ReLI team used positive feedback as an implementation strategy by offering a small gift to the resuscitation team when they followed the protocol for prophylactic surfactant use in infants with gestational ages  $\leq 27$  weeks or birth weight <1000 g. This immediate, positive feedback increased compliance with the prophylactic surfactant guideline and reduced the mean time of surfactant administration in ELBW newborns to  $6 \pm 5$  minutes.

### Perseverance

Perseverance proved an invaluable principle for quality improvement teams.<sup>7</sup> Perseverance is often required to overcome tradition and the resistance to change that often arises during quality improvement interventions. For example, 1 ReLI site team focused on implementing the PBP related to use of nasal continuous positive airway pressure (NCPAP) in the delivery room as the initial mode of ventilatory support. Their multidisciplinary team modified and

tested the new NCPAP equipment. They developed an extensive educational program and widely publicized their initiative. The team made a poster for the staff lounge, developed a packet of written instructions to leave at the bedside of any treated infant, and used other means to communicate their efforts. The team thought that these communication methods would quickly reach clinical personnel who worked with infants who were being treated with the new NCPAP delivery system. However, NICU personnel rejected the new technique, in part because of their previous, negative experiences with NCPAP.

This site's ReLI team decided that the next phase of implementation would include meetings with individual nurses to explain the value of NCPAP and the advantages of the new equipment and techniques for its administration. For months, the team continued with these educational efforts and displayed initial, favorable outcomes from the new NCPAP techniques. NICU personnel gradually accepted NCPAP as a reasonable alternative to mechanical ventilation in the delivery room and first few days of life after delivery in ELBW infants. Displaying similar perseverance, 3 ReLI centers treated at least 25% of infants with birth weight <1001 g with NCPAP in the delivery room. Perseverance was a common characteristic of sites that were successful with changing the attitudes and practices of the clinical personnel.

### Collaboration and Communication

Multidisciplinary teamwork accelerates the implementation of quality improvement.<sup>8</sup> The inclusion of nonclinical disciplines, such as administration, can increase the likelihood of successful implementation.<sup>9</sup> Several ReLI participants emphasized the importance of incorporating managers and administrators into their quality improvement efforts. One site team, for example, identified additional labor costs as necessary to implement greater use of NCPAP. They also recognized that they needed new capital equipment purchases, which would require deviations from the budgeted expenditures in the middle of a budget cycle. Because administrators were members of the quality improvement team, they understood the importance of these unplanned expenses and approved the purchases. Clinical and nonclinical personnel have been shown to be more supportive of quality improvement work when they have been directly involved in the process.<sup>10</sup>

### Imitation

Imitation is a staple of organizational improvement.<sup>11</sup> As a result, several ReLI participants visited other sites that had previously implemented a particular PBP in an effort to imitate their implementation. For example, 1 site visited a center that emphasized the use of NCPAP over mechanical ventilation. The visiting site team predicted that 1 obstacle to implementing greater NCPAP use would be nasal septal damage. Nurses from their team worried that, when applied for a long period of time, NCPAP would injure the infants' fragile nasal septum.

To improve their chances of success, the ReLI team

sought to copy exactly the techniques they had observed. They purchased the same equipment, proposed using the same techniques, and prepared educational materials and training to explain how NCPAP was used at the site they had visited. However, a few weeks into implementation, a case of nasal septum injury occurred. This sentinel case alerted NICU personnel to the possible problems with NCPAP and threatened to end implementation as other caregivers began noticing septal injuries. Although this ReLI team thought that they had effectively imitated the site that they had visited, subtle differences in technique resulted in nasal septum injury. Some caregivers at this ReLI site used more rigid tubing than what had been recommended during the site visit. In addition, some thought that the Velcro and nasal shields were not needed to secure the NCPAP prongs. This center learned that when imitating potentially best performers, even subtle differences in process could result in significant differences in outcomes. This site's experience demonstrates that for imitation to be an effective implementation strategy, careful attention to detail is frequently critical to success.

### Compromise

Seemingly simple changes in the process of care often become complex undertakings. For example, 1 ReLI team sought to reduce CLD by minimizing fluid administration.<sup>12</sup> A small group of physicians reviewed the relevant literature and developed an initial fluid administration protocol. The PBP "decrease fluid administration" (Table 2) seemed relatively simple to implement because it only required that appropriate admission orders be written. However, 16 neonatologists were practicing at this NICU and reaching consensus among the entire group proved challenging. They disagreed on appropriate fluid volumes, glucose needs, sodium needs, the role of insensible fluid losses, and the adjustments needed for different birth weights. This site's quality improvement team was reminded that fluid administration was only a part of overall fluid management, which affected many treatment decisions. As a result of this feedback, the site quality improvement team developed protocols to reduce fluid losses through the skin (by applying skin emollients) and monitor electrolytes and weight. In addition, the team had to construct adjustments for patients with hypotension or renal impairment. What seemed to be a simple protocol quickly evolved into a complex one.

### Measurement of Processes as Well as Outcomes

Process measures, as well as primary outcome measures, were identified by the ReLI focus group for monitoring. Process measures have substantial value in quality improvement projects, especially when there is suspicion that change may not ensure immediate improvement in the chosen primary outcome measures. Because the key drivers of CLD remain poorly understood, ReLI participants suspected that implementing the ReLI PBPs might not guarantee improvements in CLD rates or severity.

Preliminary analysis of implementation and outcomes confirmed this (complete analysis is ongoing). For example, 1 ReLI center achieved 69% compliance with completing the prescribed course of vitamin A in all infants <1000 g birth weight. In addition, this center reduced dexamethasone use to 20% in 2000 and 5% in 2001 and provided delivery room NCPAP to 24% of infants with birth weight  $\leq$ 1000 g. Despite these interventions, the mortality and CLD rates at this site remained unchanged. The lack of improvement in mortality or CLD rates disappointed the team, but team members derived satisfaction from reducing steroid use, which is anticipated to minimize poor long-term neurodevelopmental outcomes.<sup>13,14</sup> This site's experience illustrates the benefits of setting both outcome- and process-related goals.

### CONCLUSIONS

The ReLI group experience stressed the importance of 7 implementation strategies:

- Information and data are vital to effective quality improvement efforts. Without good data, little progress is possible.
- Feedback is a very useful technique for modifying behavior. Real-time feedback is particularly effective.
- Perseverance is often required to effect change because most change requires substantial time to become embedded into the NICU culture.
- Collaboration and communication are critical in effecting meaningful change. Many quality improvement efforts have unintended, downstream effects that require frequent and effective communication to mitigate.
- Imitation is a valuable technique to implement PBPs rapidly. However, when imitation is used as a method of change, great attention to detail is required.
- Compromise is frequently necessary when complex systems are being altered. The complexity of even apparently straightforward PBPs is almost always greater than expected. There are very few simple changes that produce worthwhile results.
- Measurement of processes as well as outcomes should accompany any quality improvement venture to help monitor progress. Frequently, improvements in the primary outcome are delayed, which can hinder quality improvement efforts unless intermediate indicators are tracked.

Identification of PBPs is only the first step in improving the quality of respiratory care for infants in NICUs. Implementation of these PBPs can be difficult. Implementation strategies, such as those identified in this article, can improve the chances that quality improvement efforts will be effective.

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