MEASURES OF PEDIATRIC HEALTH CARE QUALITY BASED ON HOSPITAL ADMINISTRATIVE DATA

THE PEDIATRIC QUALITY INDICATORS

NEONATAL INDICATOR APPENDIX

April 17, 2008

Introduction

For Phase II of the Pediatric Quality Indicator Project we sought to develop a group of novel, pediatric specific, indicators. After research on existing measures used by other groups & organizations the neonatal measures found were felt, as a group, to have the best potential for quality measurement work & research.

A separate set of quality measures for neonates was felt to be important for several reasons. Neonates, especially those that are critically ill, are a unique patient population, even within pediatrics. The medical concerns and risks they face are unique to this group (such as intraventricular hemorrhage, retinopathy of prematurity, necrotizing enterocolitis, etc.), and thus the quality issues involved in their care are also very different.

Almost two-thirds of all childhood hospital stays are for newborns & neonates (though the vast majority of admissions are for uncomplicated births). Even though neonatal intensive care unit (NICU) stays make up only a small part of the total number of neonatal hospitalizations, the costs they incur involve a much greater percentage of the total costs. In 2000 in California, for example, there were 437,500 hospital births which, in total, cost over 1.5 billion dollars. Of these newborns, less than 2.5% weighed less than 2000g (a group for which a NICU admission is highly probable). However, over 730 million dollars were spent on these less than 2000g infants (more than 40% of the total cost).[1]

Additionally, many of the complications and outcomes that are of concern in neonates can be prevented, or lessened with institutional protocols (e.g. routine hand-washing to prevent nosocomial infections), or with medical interventions (e.g. antenatal steroids to help prevent or reduce the severity of intraventricular hemorrhage). As mentioned above, various groups have developed neonatal quality measures, but many of these are either not for use with standard administrative data, or are available only to member institutions. Thus, a group of publicly available neonatal measures that used readily accessible administrative data were felt to have to potential to positively impact the quality of neonatal care.

Methods

Indicator selection

The selection of Phase II candidate indicators is outlined in the document "Measures of Pediatric Health Care Quality Based on Hospital Administrative Data: The Pediatric Quality Indicators" available at www.qualityindicators.ahrq.gov. From this initial list of candidate indicators, hospital level indicators focusing on the neonatal population were selected for further development during 2006-2007. Candidate indicators were:

Interventricular Hemorrhage, Meconium Aspiration, Necrotizing Enterocolitis, Retinopathy of Prematurity, Nosocomial Infection in Neonates, and Neonatal Mortality. As outlined in the above referenced report these candidate indicators included established indicators used by national organizations. Table 1 lists all indicators identified during our search for candidate indicators, and reasons for inclusion or exclusion.

Perinatal care	**Developer[1]**	**Evaluated / Reason for Exclusion**
Intraventricular hemorrhage in premature neonates	CHCA NPIC	Evaluated
Jaundice admission rate (Area level)	CDC	Area level indicators not considered
Meconium aspiration syndrome rate, all inborns (new)	NPIC	Evaluated
Nectrotizing enterocolitis in premature neonates	CHCA NPIC	Evaluated
Neonatal birthweight distribution and average length of stay	NPIC	Utilization based indicator, beyond scope
Neonatal mortality	JCAHO	Evaluated
Neonate immunization administration		Not feasible with administrative data available in restricted data set
Neonatal utilization and charge analysis by birthweight, DRG, payer, or risk category - unadjusted and APR Case Mix adjusted	NPIC	Utilization based indicator, beyond scope
Nosocomial bacteremia in premature neontates	NPIC	Evaluated
Perinatal mortality		Eliminated due to data concerns
Retinopathy of prematurity	CHCA	Evaluated

[1]Child Health Corporation of America (CHCA), National Perinatal Information Center (NPIC), Joint Comission for the Accreditation of Healthcare Organizations (JCAHO)

Initial Phase II candidate indicator definitions were developed by the QI Development team. Where possible, the original definition from the primary developer was used as a starting point. If this original definition utilized data elements other than those available in a limited-use dataset such as HCUP, we translated that definition into ICD-9-CM codes. In the case of neonatal mortality we developed an alternative definition based on preliminary literature and clinical experience.

During the development of the initial candidate definitions we conducted empirical analyses as needed to inform the indicator construction. For instance, for some indicators we examined the rates in certain high risk population when considering exclusion criteria. Analyses were conducted using the 2004 HCUP Kids' Inpatient Database.

Panel review

We reconvened our neonatal panel from the Phase I evaluation. Details on the selection of this panel and the panel review methods can be found in "Measures of Pediatric Health Care Quality Based on Hospital Administrative Data: The Pediatric Quality Indicators" available at www.qualityindicators.ahrq.gov. Seven panelists participated in the Phase II evaluation. One nurse practitioner declined to participate in the follow-up panel, and one neonatologist who was unavailable for Phase I joined the panel for Phase II. In addition, one pediatric infectious disease specialist (not a Phase I panelist) also reviewed the indicators and provided comments, but did not participate in the panel review.

Panelists conducted the review in the same manner as the Phase I evaluations. Details on the panel review methods can be found in "Measures of Pediatric Health Care Quality Based on Hospital Administrative Data: The Pediatric Quality Indicators" available at www.qualityindicators.ahrq.gov. The panel reviewed six new indicators: Intraventricular hemorrhage in premature neonates, Meconium aspiration syndrome rate, Necrotizing enterocolitis in premature neonates, Neonatal mortality, Nosocomial bacteremia in premature neonates (renamed Nosocomial blood stream infections in premature neonates), and Retinopathy of prematurity.

Risk Adjustment

As no risk adjustment tool exists for neonatal measures using large-scale administrative data, we undertook the development of our own method.

Using congenital anomaly diagnostic risk groupings derived by Phibbs, et al.[2] five (for intraventricular hemorrhage), or six (for the others) mortality risk groups were designed for each measure. These groupings were based on mortality rates for the anomalies given the complication identified by the QI.

A regression model including these risk groupings was then developed. Selection of other variables was based on clinical knowledge, those used in previous studies or research protocols,[2-5] and the data that would be consistently available in administrative databases. These included: birthweight (in 250 gram intervals), gender, multiple gestation, and gender and birthweight interacted.

This resulted in each measure having a "customized" risk adjustment model applied to its data.

Results

Summary of Results

Panelists reviewed six indicators. During the course of review the panelists suggested modifications to the indicator definitions and commented on the usefulness of the indicator. Each indicator was given a numeric rating on five aspects: Importance, preventability, likelihood of medical error, frequency of charting, and potential bias. In addition, each indicator received final ratings for overall usefulness for quality improvement and overall usefulness of comparative reporting. Details of these ratings for each of the indicators are contained below in the section, "Detailed Results."

For each indicator, we assessed the recommendation of the panel, based on previously reporting criterion. One indicator, "Nosocomial blood stream infection in premature neonates" was recommended for use for both quality improvement and comparative reporting. A second indicator, "Neonatal mortality" was recommended for use for

comparative reporting, but not viewed as useful for quality improvement. Panelists generally felt that tracking one's own mortality rate offers little guidance to improve quality of care. Although it may be useful, panelists noted that deaths are currently examined, and this indicator added little additional value for internal QI. However, they did feel that it would be particularly useful for comparative reporting.

The remaining four indicators, Meconium aspiration syndrome rate, Retinopathy of prematurity, Intraventricular hemorrhage rate, and Necrotizing enterocolitis were not recommended for either quality improvement or comparative reporting purposes, with Meconium aspiration receiving the lowest ratings. One overarching theme for these indicators was the lack of association between processes of care and these complications. Although many theories exist of how to prevent these complications, and systematic variation in rates suggest that these complications might be better prevented by some hospitals, few studies have been undertaken to identify such processes of care. The panelists noted that these indicators may be particularly useful as research tools to identify cases with these complications in large datasets and to begin to link specific care practices with these complications.

Another concern cited was the lack of specificity available in the codes used for identifying these complications. Both retinopathy of prematurity and necrotizing enterocolitis have only one diagnosis code. Thus, for example, an infant who has a mild form of retinopathy is assigned the same ICD-9 code as an infant whose vision is threatened by severe retinopathy of prematurity.

Detailed Results

<table>
<tr><td colspan="2">INTRAVENTRICULAR HEMORRHAGE</td></tr>
<tr><td colspan="2">Indicator definition:
Number of patients with intraventricular hemorrhage (see definition and exclusions below) per 1000 eligible admissions (population at risk).</td></tr>
<tr><td>Definition of intraventicular hemorrhage:</td><td>Definition of population at risk:
Patients eligible to be included in this indicator:</td></tr>
</table>

Any diagnosis code for: • Intraventricular hemorrhage, Grade III [772.13] • Intraventricular hemorrhage, Grade IV [772.14]	***a. All <u>inborn</u> infants with a birthweight less than 1500 g except exclusions (see below).*** ***b. Stratify by birthweight as below.*** ***d. Exclude infants with a birth weight less than 500g.*** ***e. Exclude infants who were transferred out before 1 week of age.*** ***f. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.***

Rates based on year 2003 Kids' Inpatient Sample:

OVERALL	50.32		
Birthweight stratified rates:			
500 – 749 g	108.06		
750 – 999 g	75.50		
1000 – 1249 g	31.74		
1250 – 1499 g	14.67		
Rates by grade and birthweight			
500 – 749 g			
Grade III	51.72		
Grade IV	60.81		
750 – 999 g			
Grade III	44.05		
Grade IV	33.42		
1000 – 1249 g			
Grade III	19.79		
Grade IV	12.12		
1250 – 1499 g			
Grade III	10.02		
Grade IV	4.85		
Overall			
Grade III	28.53		
Grade IV	24.31		
Hospital Type			
Children's	65.29		
Non-children's	43.65		
Distribution of Hospital Rates			
***Hospital type**	**Range of Hospital Rates**	**Mean**	**SD**
Children's	0 – 250 per 1000	62.3	45.8
Non-children's	0 – 330 per 1000	31.2	48.7

*The data shown excluded hospitals (both children's and non-children's) with less than 11 very low birthweight births per year, as these hospitals were less likely to have neonatal intensive care facilities.

Source and clinical rationale

Many children's hospitals are using IVH rates as a means of evaluating outcomes through the Child Health Corporation of America (CHCA) and the National Perinatal Information Center (NPIC).

The CHCA rates are stratified by birthweight (< 1000 grams, and 1000 – 1499 grams), but are not otherwise risk-adjusted. Transferred infants who stayed for up to five days at the birth hospital are included in the CHCA population – to ensure inclusion of their member hospitals that do not have a labor and delivery service.

The NPIC measure gives hospital rates for grades III and IV hemorrhages only. The proposed AHRQ measure's definition is similar to the CHCA's measure, but excludes infants with birthweights less than 500 grams due to their very high risk nature and bias related to delivery practices (i.e. attempting emergent delivery vs. allowing fetal death). Infants who are transferred out before one week of age are also excluded from the denominator definition, as it is highly likely that these patients would not be screened for IVH before transfer. This approach avoids the bias caused by assuming that neonates do not have IVH when they actually did not have the opportunity to be screened (as standard screening takes place at roughly one week of age). As in the NPIC measure, only grades III and IV are measured, given their impact on long term infant outcomes.

The proposed AHRQ measure also stratifies rates by 250 gram birthweight increments and includes only inborn infants - given the weight of evidence showing the importance of antenatal and perinatal (as opposed to postnatal) care in decreasing rates of IVH and severe IVH. Risk adjustment will be used.

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Pre-panel definition	Post-panel indicator definition	Reason implemented
All infants included	Infants transferred out before one week of age excluded.	This group of patients has a high likelihood of not being screened prior to transport.

Changes considered, but not implemented

Description of change	Reason not implemented
Excluded infants that expired before one week of age.	It was possible, in theory, that these infants would not have received a head ultrasound to screen for IVH and therefore might expire with an IVH that had not been discovered. During subsequent data analyses, however, it was found that 500 – 1499 gram infants who died before one week of age actually had twice the rate of IVH as those who survived past one week of age (82.22 per 1000 vs. 40.27 per 1000, respectively). This finding suggested that a significant portion of the expired infants had, indeed, been screened and that excluding them would actually remove an important cadre of patients from the analysis. By contrast, excluding infants transferred out before one week of age removed from the denominator a group of patients who were not screened before

	transfer. Unless these infants are excluded, they would be assigned to the transferring hospital as having not developed IVH (even if they were found to have it later at the accepting facility).

Post-conference call panel ratings - IVH

Question	Median	Agreement status
Overall rating – internal QI area	6	Indeterminate
Overall rating – comparative purposes	6	Indeterminate
Importance	8	Agree
Preventability	4	Indeterminate
Likelihood of Medical Error	3	Indeterminate
Charting	8	Agree
Bias	3	Indeterminate
Final recommendation	Internal QI: Not recommended	Comparative purposes: Not recommended

Literature based evidence

Intraventricular hemorrhage (IVH) remains a major issue in the care and management of preterm infants. IVH involves hemorrhage into the germinal matrix tissues, with possible rupture into the ventricular system and parenchyma of the developing preterm brain. It is thought to be the result of changes in blood flow to an injured capillary bed in the germinal matrix. IVH lesions are seen in preterm infants, as the germinal matrix involutes at 34 weeks of gestation. IVH is graded according to degree of hemorrhage, with grade I being the least severe, and grade IV being the most severe. If the hemorrhage is moderate or severe (grades III or IV), developmental delay, and long-term cognitive and motor disabilities can result.[6] The key risk factors for grade III or IV IVH in case-control studies include lower gestational age at delivery, sepsis within 72 hours of birth, fertility treatment, vaginal delivery, prolonged labor (>10-12 hours), no or insufficient antenatal steroids, and a high PaCO2 during the first 24 hours of life.[7, 8]

Preterm infants have been shown to have significantly less, and less severe, IVH when they are optimally managed pre- and post-natally. Antenatal transfer of mothers to tertiary care centers, appropriate administration of antenatal corticosteroids,[7-21] optimizing delivery and delivery room resuscitation, and judicious prophylactic use of postnatal indomethacin[7-21] are some examples of interventions and management that have been shown to reduce the incidence and severity of IVH.[7-21] Use of anenatal corticosteroids reduces the risk of any IVH by 46%, and severe IVH by 72%, according to a recent meta-analysis of 12 randomized controlled trials.[22] In one observational study, postnatal corticosteroid use to treat hypotension was associated with IVH, although the key causative factor may be postnatal hypotension rather than corticosteroid use.[7-21] The evidence regarding other aspects of delivery room care is limited and based largely on cohort or case-control studies. In a multi-center Canadian study,[7-21] for example, 31% of the variation in rates of grade III-IV IVH across 17 NICUs was attributable to unit characteristics such as the annual volume and the neonatologist-housestaff ratio. Thus, the incidence and severity of IVH in infants' discharge data may reflect the quality of care that these infants received during the perinatal period.

Even with optimal management and ideal quality of care, however, many preterm infants, especially the smallest and most premature, will develop some level of IVH. Data from the Vermont Oxford Network showed that while there was a decrease in IVH rates from 1991 to 1995, the rates from 1995 to 1999 did not change significantly.[23] However, inter-hospital variability can be significant. Rates of grade III or IV IVH ranged from 10% to 46% of extremely low birth weight infants cared for at different centers participating in the Neonatal Research Network of the National Institute of Child Health and Human Development between 1993 and 1994.[24] Those hospitals that care for smaller and sicker infants are expected to have higher rates of IVH. Therefore, it is proposed that reporting on this indicator should be stratified by narrow (250 g) birth weight strata, with adjustment for gestational age and other risk factors ascertainable from hospital discharge data.

Meconium Aspiration Syndrome	
Indicator definition: Number of patients with meconium aspiration syndrome (see definition and exclusions below) per 1000 eligible admissions (population at risk).	
Definition of meconium aspiration syndrome:	**Definition of population at risk:** Patients eligible to be included in this indicator:
Any diagnosis code for: • Meconium aspiration with respiratory symptoms [770.12]	***a. All <u>inborn</u> infants with a birthweight greater than or equal to 1500 grams.*** ***b. Stratify by birthweight as below.*** ***c. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.***

Rates based on year 2003 Kids' Inpatient Sample:

NOTE: Because 770.12 was implemented in October 2005 these data are estimates based on the code 770.1 (which was defined as "Meconium aspiration syndrome: Aspiration of contents of birth canal NOS; Meconium aspiration below vocal cords; Pneumonitis: fetal aspiration, meconium.")

OVERALL	5.02		
Birthweight stratified rates:			
1500 – 1999 g	4.02		
2000 – 2499 g	4.46		
all others	5.07		
Hospital Type			
Children's	5.80		
Non-children's	4.91		
Distribution of Hospital Rates			
***Hospital type**	**Range of Hospital Rates**	**Mean**	**SD**
Children's	0 – 65 per 1000	7.14	7.97
Non-children's	0 – 61 per 1000	5.53	6.17

***The data shown excluded hospitals (both children's and non-children's) with less than 11 very low birthweight births per year, as these hospitals were less likely to have neonatal intensive care facilities.

Source and clinical rationale

The National Perinatal Information Center currently uses MAS rates as a measure for their member institutions. Rates are calculated separately for inborn infants and transfers.[25]

The proposed AHRQ measure's definition is very similar to the National Perinatal Information Center's measure, but excludes infants with birthweights less than 1500 grams due to the very

low incidence of MAS in those infants. It also stratifies rates by 500 gram birthweight increments, and includes only inborn infants - given the weight of evidence showing the importance of antenatal and perinatal care in decreasing rates of MAS. Risk adjustment will be used.

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Pre-panel definition	Post-panel indicator definition	Reason implemented
All infants included	Include only infants with birthweights greater than or equal to 1500 grams	These patients are the primary group at risk for this complication.

Post-conference call panel ratings – Meconium aspiration

Question	Median	Agreement status
Overall rating – internal QI area	3	Indeterminate
Overall rating – comparative purposes	3	Indeterminate
Importance	6	Disagree
Preventability	6	Disagree
Likelihood of Medical Error	3	Indeterminate
Charting	7	Agree
Bias	4	Indeterminate
Final recommendation	Internal QI: Not recommended	Comparative purposes: Not recommended

Literature based evidence

Meconium aspiration syndrome (MAS) is a common cause of severe respiratory failure in term or post-term infants. It occurs in 2% to 33% (depending on factors such as diagnosis criteria and the population studied) of infants born through meconium stained amniotic fluid. Approximately 30% of infants with MAS require mechanical ventilation, and 4% to 19% of MAS infants die.[26-30]

Debates on whether delivery room practices can truly impact the incidence of MAS are ongoing. Practices previously favored and felt to reduce the risk of developing MAS such as amnioinfusion[31-33] and intrapartum oropharyngeal and nasopharyngeal suctioning[26, 34] have recently been shown in international randomized controlled trials to not have a significant impact on the incidence of MAS in meconium-stained infants.[28, 35-38] Recommendations for endotracheal intubation (for suctioning meconium) have also changed in the last decade, after an international randomized controlled trial and a meta-analysis showed no benefits among infants who were vigorous at birth.[26, 36, 38-42] While tracheal suctioning remains the standard delivery room intervention among depressed infants and those with respiratory symptoms, the benefits of tracheal suctioning in this population have not been systematically studied.[36, 38]

A study in 2002 by Yoder, et al found that the most important factor in reducing MAS from 5.8% of meconium-stained infants in 1990-92 to 1.5% in 1998 (at one academic medical center) may have been a reduction in post-term deliveries (greater than 41 weeks), although more frequent diagnosis of nonreassuring fetal heart rate patterns, early antenatal ultrasound evaluation and higher cesarean delivery rates were also temporally associated with lower rates of MAS.[43] Thus it is not only delivery room practices that impact MAS rates, but prenatal monitoring and perinatal interventions also play an important role.

Necrotizing Enterocolitis	
Indicator definition: Number of patients with necrotizing enterocolitis (see definition and exclusions below) per 1000 eligible admissions (population at risk).	
Definition of necrotizing enterocolitis:	**Definition of population at risk:** Patients eligible to be included in this indicator:
Any diagnosis code for: • Necrotizing enterocolitis in fetus or newborn [777.5]	***a. All <u>inborn and outborn</u>* infants with a birthweight less than 1500 g except exclusions (see below).*** ***b. Stratify by birthweight as below.*** ***c. Stratify by inborn / outborn status*** ***d. Exclude patients with a principal diagnosis of NEC.*** ***e. Exclude infants with a birth weight less than 500g.*** ***f. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.*** * ***"outborn" = transferred in first 2 days of life***

Rates based on year 2003 Kids' Inpatient Sample:

OVERALL	47.58		
Birthweight stratified rates:			
500 – 749 g	61.38		
750 – 999 g	64.92		
1000 – 1249 g	47.13		
1250 – 1499 g	27.78		
Stratified by inborn/outborn status			
Inborn	45.73		
Outborn	60.42		
Hospital Type			
Children's	64.71		
Non-children's	39.05		
Distribution of Hospital Rates			
***Hospital type**	**Range of Hospital Rates**	**Mean**	**SD**
Children's	0 – 230 per 1000	62.1	44.6
Non-children's	0 – 290 per 1000	28.2	45.5

*****The data shown excluded hospitals (both children's and non-children's) with less than 11 very low birthweight births per year, as these hospitals were less likely to have neonatal intensive care facilities.

Source and clinical rationale

Many children's hospitals are using NEC rates as a means of evaluating quality of care through the Child Health Corporation of America (CHCA). These rates are stratified by birthweight (< 1000 grams, and 1000 – 1499 grams), but are not otherwise risk-adjusted. Transferred infants who stayed for up to five days at the birth hospital are included in the CHCA population – to ensure inclusion of their member hospitals that do not have a labor and delivery service.

The National Perinatal Information Center also tracks hospital rates for NEC.

The proposed AHRQ measure's definition is similar to both of the above measures, but excludes infants with birthweights less than 500 grams due to their very high risk nature and bias related to delivery practices (i.e. attempting emergent delivery vs. allowing fetal death). It also stratifies rates by 250 gram birthweight increments and includes inborn and outborn (transferred in first 2 days of life) infants. Transfers are limited to the first 2 days of life to minimize the influence of hospitals' referral practices on the outcome, which can develop and become symptomatic within a few days after birth. Risk adjustment will be used.

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Pre-panel definition	Post-panel indicator definition	Reason implemented
None.		

Post-conference call panel ratings – NEC

Question	Median	Agreement status
Overall rating – internal QI area	6	Indeterminate
Overall rating – comparative purposes	6	Indeterminate
Importance	8	Agree
Preventability	6	Indeterminate
Likelihood of Medical Error	2	Indeterminate
Charting	8	Indeterminate
Bias	4	Indeterminate
Final recommendation	Internal QI: Not recommended	Comparative purposes: Not recommended

Literature based evidence

Necrotizing Enterocolitis (NEC) is a major cause of morbidity and mortality in premature infants. It is a serious gastrointestinal illness seen mainly in very low birth weight (VLBW) infants. In the U.S. approximately 10% of VLBW infants will develop NEC, but rates as low as 2% and as high as 22% have been reported.[24, 44-52] Once diagnosed with NEC, infants have significantly increased lengths of stay and costs of care.[47]

NEC appears to be a multi-factorial disease; no single cause has been identified, aside from prematurity. It does, however, appear to be associated with bowel injury and intestinal mucosal disruption with enteric feedings, immature immune responses, and possibly infection by a

pathogenic organism.[44-46, 49-56] Centers report different rates of NEC,[24] but rates can often vary within each institution, at times occurring in clusters that suggest transmission of a pathogen among the patients.[46, 50]

There is ongoing controversy regarding effective preventive measures for NEC. Currently, the use of antenatal corticosteroids, human milk feeding, and slow advancement of feeding volumes are common practices.[46, 49-52, 55, 57] Use of anenatal corticosteroids reduces the risk of NEC by 54%, according to a recent meta-analysis of eight randomized controlled trials.[22] In another meta-analysis of four small trials, feeding of donor human milk (versus formula) was associated with a 66% reduction in the risk of NEC and a 75% reduction in the risk of confirmed NEC.[58] However, the proper velocity of feeding volume advancement continues to be debated in the literature,[46, 49, 50, 59, 60] and 10% of infants who develop NEC do so before being fed,[59] emphasizing the multi-factorial etiology of this disease. One study from a single center found that trophic (20 ml/kg/d x 10 days) feeding, as opposed to advancing (by 20 ml/kg/d to a target of 140 ml/kg/d) feeding, significantly reduced the incidence of NEC among infants born at <32 weeks gestational age.[61] Despite controversy about the optimal regimen, meta-analysis of six quasi-experimental studies showed that implementation of any standardized feeding regimen was associated with an 87% reduction in the risk of NEC.[62]

Other measures that have been suggested and continue to be discussed and investigated are oral immunoglobulin, enteral antibiotics, arginine supplementation, restricted parenteral water intake, and enteral probiotics.[44, 46, 49, 50, 52-54, 63] Oral immunoglobulins appear to be ineffective, based on three randomized controlled trials.[53] Enteral antibiotics appear more promising, based on five small trials, but legitimate concerns persist concerning potentially harmful effects, such as the development of resistant bacteria.[54] Arginine supplementation was highly effective and free of side effects in a single trial,[64, 65] but confirmation is essential before this treatment can be widely adopted. Restricting parenteral water intake for at least the first 3-5 days of life reduced the risk of NEC by 70% in a meta-analysis of four randomized controlled trials.[66] Finally, probiotic therapy appears to be a particularly promising intervention, based on consistent and substantial protective effects in three randomized controlled trials.[44, 46, 49, 50, 52-54, 63, 67] The optimal formulation and regimen for probiotic therapy has not yet been determined.

Given the fragility of the patient population at risk, there will most likely be some baseline level of NEC expected, even with the best medical care. However, appropriate use of treatments such as antenatal steroids, standardized enteric feeding regimens with human milk, and probiotics, along with careful monitoring, could substantially reduce the incidence of this serious disease.

Retinopathy of Prematurity	
Indicator definition: Number of patients with retinopathy of prematurity (see definition and exclusions below) per 1000 eligible admissions (population at risk).	
Definition of retinopathy of prematurity:	**Definition of population at risk:** Patients eligible to be included in this indicator:
Any diagnosis code for: • Retrolental fibroplasias (ROP) [362.21]	***a. All <u>inborn and outborn</u>* infants with a birthweight less than 1500 g except exclusions (see below).*** ***b. Stratify by birthweight as below.*** ***d. Exclude infants with a birth weight less than 500g.*** ***e. Exclude infants who were transferred out before 1 week of age.*** ***f. Exclude infants who died before 1 week of age.*** ***g. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.*** * ***"outborn" = transferred in first 2 days of life***

Rates based on year 2003 Kids' Inpatient Sample:

OVERALL	126.32		
Birthweight stratified rates:			
500 – 749 g	166.99		
750 – 999 g	181.70		
1000 – 1249 g	134.40		
1250 – 1499 g	68.48		
Stratified by inborn/outborn status			
Inborn	125.03		
Outborn	134.22		
Hospital Type			
Children's	121.51		
Non-children's	125.24		
Distribution of Hospital Rates			
***Hospital type**	**Range of Hospital Rates**	**Mean**	**SD**
Children's	0 – 1000 per 1000	129.4	13.9
Non-children's	0 – 1000 per 1000	99.9	13.3

*****The data shown excluded hospitals (both children's and non-children's) with less than 11 very low birthweight births per year, as these hospitals were less likely to have neonatal intensive care facilities.

In further data analyses comparing observed ROP rates in hospitals with breakdowns by volume of VLBW births, non-children's hospitals were found to have higher rates of ROP when compared to children's hospitals in very high volume facilities (>150 VLBW births per year) – 0.125 vs. 0.118, respectively. In facilities with 51-100 VLBW births per year the children's hospitals had a rate of 0.117 while the non-children's facilities had a rate of 0.148.

Source and clinical rationale

ROP rates as a means of evaluating quality of care are being used by two organizations.

Through the Child Healthcare Corporation of America, many children's hospitals are monitoring their rates of ROP. These rates are stratified by birthweight (< 1000 grams, and 1000 – 1499 grams), but are not otherwise risk-adjusted. Transferred infants who stayed for up to five days at the birth hospital are included in the population – to ensure inclusion of their member hospitals that do not have a labor and delivery service. The National Perinatal Information Center also tracks hospital rates for ROP and includes rates of ROP with ROP procedures. The proposed AHRQ measure's definition is similar to both of the above measures, but excludes infants with birthweights less than 500 grams due to the very high risk nature and bias related to delivery practices (i.e. attempting delivery vs. allowing fetal death). It also stratifies rates by 250 gram birthweight increments and includes only inborn infants and infants transferred in the first two days of life (outborns). Transfers from another hospital are limited to those occurring in the first 2 days of life to minimize the influence of referring hospitals' practices on the outcome, which is ascertained much later in the hospital stay. Infants who are transferred out or die before one week of age are excluded from the denominator definition as it is highly likely that these patients would not be screened for ROP before transfer or death. This then avoids the bias caused by assuming that neonates do not have ROP when they actually did not have the opportunity to be screened. Given the high volume of patients who are transferred to other units for ROP procedures, and the limits of the administrative data, the proposed definition does not utilize the linking of ROP diagnoses with procedures for ROP. Risk adjustment will be used.

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Pre-panel definition	Post-panel indicator definition	Reason implemented
Include all infants	Exclude infants transferred out before one week of age.	These infants are unlikely to have been screened for ROP before transfer.
Include all infants	Exclude infants who died before one week of age.	These infants are unlikely to have been screened for ROP before death.

These changes reflect the current practice of screening for ROP later than one week of age. Patients who are transferred or die before one week of age would not have had the opportunity to be diagnosed with ROP. We confirmed through empirical analyses that these exclusions, while eliminating substantial denominator cases do not eliminate many numerator cases.

Post-conference call panel ratings – ROP

Question	Median	Agreement status
Overall rating – internal QI area	4	Disagree
Overall rating – comparative purposes	3	Disagree

Importance	7	Indeterminate
Preventability	4	Disagree
Likelihood of Medical Error	3	Indeterminate
Charting	8	Agree
Bias	4	Indeterminate
Final recommendation	Internal QI: Not recommended	Comparative purposes: Not recommended

Literature based evidence

Retinopathy of prematurity (ROP) is a leading cause of blindness in children. It is a serious vasoproliferative disorder involving the developing retina in premature infants. Approximately 84% of surviving infants born at <28 weeks gestation will develop ROP. While mild forms regress with little or no loss of visual function, more severe forms can lead to vision loss due to retinal scarring and damage. Approximately 6% of infants ≤1250g will develop severe ROP requiring treatment to prevent visual loss.[68-72]

Major risk factors associated with developing ROP include prematurity, low birth weight, and severity of respiratory disease. Despite advances in neonatal technologies and an understanding of the role that high concentrations of oxygen early in life have in the development of ROP, the incidence of the disease has remained relatively stable over the past 2 decades.[69, 73] Antenatal dexamethasone administration was associated with a significantly lower risk of ROP (stage 2 or higher) in a single-center observational study, but this finding has not been confirmed in randomized controlled trials.[74] Higher arterial oxygen saturation (on room air) at the time of prethreshold diagnosis has been associated with a lower risk of progression to threshold disease.[71]

Despite these known and potentially modifiable risk factors, efforts at reducing the incidence of ROP have had mixed success. While tertiary level neonatal intensive care units vary in their rates and outcomes of ROP,[24] infants delivered at subspecialty perinatal centers have lower rates of ROP than those infants born in other hospitals, showing some benefit of optimal perinatal management.[74] In terms of medical care of the infant, aside from avoiding premature birth and indiscriminant use of high levels of oxygen, factors involved in preventing ROP in premature infants remain controversial. Vitamin E supplementation and ambient light reduction have been shown to be ineffective and are no longer used to prevent ROP.[68, 69] The effectiveness of supplemental oxygen to maintain 96-99% arterial oxygen saturation after prethreshold diagnosis, as a method of inhibiting angiogenesis and thereby preventing progression to threshold ROP, continues to be debated in the literature. The largest controlled trial of this intervention (STOP-ROP) suggested a beneficial effect (1-tailed $p=0.032$, higher than the design $\alpha=0.025$), especially among infants without plus disease (posterior pole vascular dilation and tortuosity) at baseline ($p=0.004$), but at the cost of longer hospital stays and more adverse pulmonary events.[70, 71, 75-77] Strict clinical practice guidelines on the management of oxygen to avoid hyperoxia and repeated episodes of hypoxia-hyperoxia have shown promise in reducing severe ROP in very low birth weight infants in a study involving one tertiary care unit.[73]

Even with optimal management and ideal quality of care, however, many preterm infants, especially the smallest and most premature, will develop some level of ROP. Those hospitals that care for smaller infants will have higher rates of ROP, although it is possible to adjust for differences in birthweight distribution across hospitals. Given the emphasis on interdiction in recent controlled trials, it must be emphasized that this indicator cannot separate early-stage or

prethreshold ROP from threshold or severe ROP, because all stages of ROP are assigned to the same ICD-9-CM diagnosis code.

Nosocomial Blood Stream Infections in Pre-term Neonates	
Indicator definition: Number of patients with specific infections (see definition and exclusions below) per 1000 eligible admissions (population at risk).	
Definition of nosocomial infections (specific infections):	**Definition of population at risk:** Patients eligible to be included in this indicator:

Any diagnosis code for: • Staphylococcal septicemia, unspecified [038.10] • Staphylococcus aureus septicemia [038.11] • Other staphylococcal septicemia [038.19] • Gram-negative organism NOS [038.40] • Septicemia due to other gram-negative organisms, Escherichia coli [038.42] • Septicemia due to other gram-negative organisms, Pseudomonas [038.43] • Septicemia due to other gram-negative organisms, Serratia [038.44] • Septicemia due to other gram-negative organisms, Other [038.49] • Disseminated candidiasis / Systemic candidiasis [112.5] **OR Patients with one of the following diagnosis codes:** • Septicemia [sepsis] of newborn [771.81] **OR** • Bacteremia of newborn [771.83] **OR** • Bacteremia [790.7] **AND one of the following diagnosis codes:** • Streptococcus Group D (Enterococcus) [041.04] • Staphylococcus, unspecified [041.10] • Staphylococcus aureus [041.11] • Other Staphylococcus [041.19] • Friedländer's bacillus (Klebsiella pneumoniae) [041.3] • Escherichia coli [041.4] • Pseudomonas [041.7] • Other gram negative organisms [041.85]	***a. All <u>inborns and outborns</u>* with a birthweight 500 to 1499g OR gestational age between 24 and 30 weeks, except exclusions (see below).*** ***b. Include also <u>inborns and outborns</u> with a birthweight greater than or equal to 1500g, if the infant experienced death, major surgery, mechanical ventilation, or transfer in or out from/to an acute care facility.*** ***c. Exclude patients with a principal diagnosis of sepsis or infection.*** ***d. Stratify by birthweight as below.*** ***e. Stratify by inborn / outborn status*** ***f. Exclude infants with a birth weight less than 500g.*** ***g. Exclude patients with a length of stay less than 2 days*** ***h. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.*** * *"outborn" = transferred in first 2 days of life*

Rates based on year 2003 Kids' Inpatient Sample:			
OVERALL	311.91		
Birthweight stratified rates (includes only inborns and outborns):			
500 – 749 g	545.29		
750 – 999 g	470.93		
1000 – 1249 g	335.44		
1250 – 1499 g	250.74		
1500 – 1749 g	256.63		
1750 – 1999 g	229.10		
2000 – 2499 g	208.47		
2500 g +	135.61		
Stratified by inborn/outborn status			
Inborn	319.17		
Outborn	284.71		
Hospital Type			
Children's	325.28		
Non-children's	298.80		
Distribution of Hospital Rates			
***Hospital type**	**Range of Hospital Rates**	**Mean**	**SD**
Children's	0 – 850 per 1000	234.1	171.3
Non-children's	0 – 1000 per 1000	226.0	194.0

*The data shown excluded hospitals (both children's and non-children's) with less than 11 very low birthweight births per year, as these hospitals were less likely to have neonatal intensive care facilities.

Source and clinical rationale

The California Perinatal Quality of Care Collaborative tracks rates of nosocomial infections for its members. The population includes all patients weighing 401 – 1500 grams and/or gestational age 22 weeks to 29 weeks, 6 days regardless of location of care in a hospital. Infants greater than 1500 grams are included if they died, were transported into or out of a hospital's NICU, had major surgery, were ventilated for greater than 4 hours, or experienced early bacterial sepsis. The measure is risk adjusted based on detailed clinical data obtained from its member institutions. It also offers a "toolkit" to help institutions implement proven interventions / models that could help reduce their rates of infections.[5]

The proposed AHRQ measure attempts to closely approximate the California Perinatal Quality of Care Collaborative's definition. Due to the limitations of administrative data, their early bacterial sepsis inclusion criterion is not used, the gestational ages included were 24 to 30 weeks, and transfers with a principal diagnosis of sepsis or infection (indicating that the infection was present at admission) are excluded. Also, the lower birthweight limit of 500 grams was applied to remain consistent with other indicators. Only inborn and outborn (transferred in the first two days of life) infants are included to avoid penalizing receiving hospitals with infections acquired during a longer stay at a transferring facility. Patients with a hospital stay of less than 2 days are excluded as any infection they might have was probably present at admission, and less likely to be due to a nosocomial source. To avoid confusion on about the meaning of the rates, only

culture-confirmed bloodstream infections are be flagged by this indicator. Risk adjustment will be used.

Changes made after panel discussions

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Pre-panel definition	Post-panel indicator definition	Reason implemented
Indicator entitled Nosocomial Infection.	Indicator renamed Nosocomial Blood Stream Infections	For clarity of flagged infections.
Admissions from home or late transfers included.	Include only inborn or outborns (infants born at another facility, transferred before day 2 of age)	Patients admitted from home may have acquired the infection at home. Likewise, patients transferred on or after day two of age, may have acquired the infection at the transferring facility.
No length of stay exclusion	Exclude patients with a length of stay of less than 2 days	It is unlikely that these patients would acquire a nosocomial pathogen in such a short timespan.

Post-conference call panel ratings – Nosocomial BSI

Question	Median	Agreement status
Overall rating – internal QI area	8	Agree
Overall rating – comparative purposes	8	Agree
Importance	8.5	Agree
Preventability	7	Indeterminate
Likelihood of Medical Error	6.5	Indeterminate
Charting	8	Agree
Bias	5	Indeterminate
Final recommendation	Internal QI: Recommended	Comparative purposes: Recommended

Literature based evidence

Nosocomial bacteremia is significant problem for infants admitted into neonatal intensive care units (NICUs) and other hospital units. This is especially true for very low birth weight infants who are at high risk for these infections due to their immature immune systems and need for invasive monitoring and supportive care.[78-85] Reported nosocomial infection rates range from 6% to 33%, but the rate varies widely among different centers.[79-82, 84] Mortality rates are high and infections result in increased length of stay as well as increased hospital costs and charges.[79-82, 84-86]

The incidence of nosocomial bacteremia increases with decreasing birthweight. Other risk factors include central venous catheter use, prolonged time using parenteral nutrition, prolonged time on mechanical ventilation, use of H2-blocking agents, and overcrowding or heavy staff loads.[78, 80, 81, 86] The most common causative organisms are coagulase-negative staphylococci, *Staphylococcus aureus*, enterococci, *Enterobacter* sp, and *Escherichia coli*.[78-81, 84, 85, 87]

Effective preventive measures range from simple hand-washing protocols or closed medication delivery systems to more elaborate multidisciplinary quality improvement plans involving hand-washing, nutrition, skin care, respiratory care, vascular access, and diagnostic practices. All of

these interventions have been shown to substantially reduce infection rates, albeit in nonrandomized studies using historical or concurrent control units.[80, 82, 83, 87-93] For example, six Vermont Oxford Network NICUs reduced their rates of coagulase-negative staphylococcus infections from 22.0% in 1994 to 16.6% in 1996 after implementing a quality improvement model (versus a much smaller decrease from 15.4% to 14.5% at 66 comparison NICUs).[87] A similar reduction from 24.6% to 16.4% was achieved with a multi-modality, multi-hospital intervention focusing on hand hygiene with an effective agent before and after every patient contact, eliminating hand jewelry and artificial nails, using maximal barrier precautions during central venous catheter insertion, decreasing the number of skin punctures, reducing the duration of intravenous lipid and deep line use, and improving the diagnosis of nosocomial infections.[89, 90]

Given the fragility and susceptibility of the patient population, a baseline level of nosocomial infections will be expected, even with good protocols in place. However, those centers that have prevention protocols, and are able to encourage health-care workers to adhere to these protocols, will probably have success in reducing their rates of nosocomial bacteremia in their neonatal population. Indeed, several quasi-experimental studies have demonstrated that NICUs can lower their infection rates (based on positive blood cultures) from as high as 13.5 per 1,000 patient days to as low as 3.0 per 1,000 patient days.[80, 82, 83, 87-93]

Neonatal Mortality

Indicator definition:

Number of deaths per 1000 eligible admissions (population at risk).

Definition of population at risk:

Patients eligible to be included in this indicator:

a. All inborn and outborn* infants.

b. Exclude transfers to another acute care facility.

c. Exclude patients with ANY diagnosis for trisomy 13, trisomy 18, anencephaly, and polycystic renal disease.

d. Stratify by birthweight as below.

e. Stratify by inborn / outborn status

f. Exclude infants with a birth weight less than 500g.

g. Risk adjustment will be available using general model for neonatal risk factors identifiable using administrative data.

* ***"outborn" = transferred in first 2 days of life***

Rates based on year 2003 Kids' Inpatient Sample:

OVERALL	2.72
Birthweight stratified rates:	
500 – 749 g	467.11
750 – 999 g	148.70
1000 – 1249 g	45.90
1250 – 1499 g	28.02
1500 – 1749 g	15.54
1750 – 1999 g	8.76
2000 – 2499 g	3.66
2500 g +	3.04
Stratified by inborn/outborn status	
Inborn	2.13
Outborn	45.85
Hospital Type	
Children's	9.70
Non-children's	1.75

Source and clinical rationale

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) offers an Inpatient Neonatal Mortality Measure. This measure looks at neonates who expire at a facility before 28 days of age. All live-born neonates are included, as are transfers in (no limit set on the day of transfers). Transfers out are excluded. The measure is risk adjusted for gender, certain congenital anomalies, degree of prematurity, gestational age and birth weight.

The proposed AHRQ indicator includes only inborn and outborn (transferred in first 2 days of life) infants. Transfers were limited to the first 2 days of life to minimize the influence of referring hospitals' practices on the outcome. Admissions from home were also excluded, again as many factors might have contributed to the probability of death that were out of control of the admitting hospital. Infants with birthweights less than 500 grams were excluded due to the very high risk nature and bias related to delivery practices (i.e. attempting emergent delivery vs. allowing fetal death). Also excluded are infants with trisomy 13, trisomy 18, anencephaly, and polycystic renal disease, given the extremely high mortality rates and focus on palliative care associated with these diagnoses. Risk adjustment will be used.

Changes Implemented to Pediatric Indicator as a Result of Pediatric Panel Review

Panelists were presented with both the proposed AHRQ indicator and the JCAHO Inpatient Neonatal Mortality Indicator. Panelists widely preferred the proposed AHRQ Inidcator, citing that the JCAHO measure may be too prone to bias due to the inclusion of transfers. Panelists also preferred the exclusion of anomalies which are almost always fatal.

Pre-panel definition	Post-panel indicator definition	Reason implemented
Admissions from home or late transfers included.	Include only inborn or outborns (infants born at another facility, transferred before day 2 of age)	Receiving hospitals have less control over important factors affecting mortality in patients admitted from home or patients transferred on or after day or of age.

Post-conference call panel ratings – Neonatal Mortality

Question	Median	Agreement status
Overall rating – internal QI area	6	Indeterminate
Overall rating – comparative purposes	7	Indeterminate
Importance	9	Agree
Preventability	5	Disagree
Likelihood of Medical Error	3	Disagree
Charting	9	Agree
Bias	7	Indeterminate
Final recommendation	Internal QI: Not considered as useful Comparative purposes: Recommended	

Literature based evidence specific to pediatric population

Neonatal issues encompass a clinically diverse group of patients. When discussing neonatal mortality one must consider the problems facing a 500 gram premature infant as well as a full term newborn. This makes developing a quality indicator for neonatal mortality a complex task.

The five leading causes of neonatal mortality in 1999 were prematurity / low birth weight, birth defects, maternal pregnancy complications, respiratory distress syndrome (RDS), and placenta or cord complications.[94, 95] Prematurity, and complications of prematurity, such as RDS account for at least 20% of neonatal deaths despite the fact that only 1.43 percent of infants delivered in 2000 were less than 1500 grams.[96]

Therefore, interventions to reduce neonatal mortality focus either on improving the distribution of birth weight, largely by preventing preterm delivery, or on improving mortality given birth weight. The former problem has proven to be somewhat intractable, as debate continues on medicine's ability to prevent preterm births. Epidemiologic evidence strongly suggests that smoking / substance abuse cessation, decreasing the number of embryos implanted in assisted reproduction, and decreasing teen pregnancy rates should reduce the rate of preterm delivery; clinical trials have confirmed modest benefits from smoking cessation interventions.[97-101] Randomized controlled trials of tocolytic therapy to stop preterm labor[102, 103] and antibiotic therapy for women with asymptomatic bacterial vaginosis[104] have yielded disappointing results. However, antibiotic therapy has been proven effective at delaying delivery among women with preterm prelabor rupture of membranes,[105] and aspirin,[99] home-based prenatal support,[106, 107] and intramuscular progesterone look promising in small controlled trials involving high-risk women.[108, 109]

Because of the ongoing controversy about whether medical interventions can prevent preterm delivery,[110] this proposed indicator focuses on mortality WITHIN narrow (250 g) birth weight strata. RDS rates, and survival in general, have been dramatically improved with the proper use of medical therapies such as antenatal corticosteroids and surfactant replacement.[21, 111-113] Additionally, studies (both in the United States and Europe) have shown that when low-birth weight infants are delivered at tertiary level hospitals their outcomes are significantly improved.[114-116] Thus, while it is not possible to eradicate mortality due to prematurity and its complications, there are medical interventions that can help these patients. Similarly, avoidance of certain therapies can also affect outcomes. For example, use of postnatal steroids for hypotension (in the absence of chronic lung disease) has been associated with higher rates of death.[8] Mortality rates can therefore reflect the quality of care provided to these infants.

In the larger neonates, congenital anomalies and infections are the most important causes of neonatal mortality.[95] Though recommendations for prenatal consumption of folic acid have decreased the incidence of spina bifida significantly,[117] other serious anomalies are not as preventable, even with prenatal diagnosis.[118] However, recent improvements in surgical care for selected anomalies, such as hypoplastic left heart syndrome,[119] and more aggressive treatment of complications,[120] have reduced anomaly-specific neonatal mortality. Infections and sepsis are also problems that can be affected by good medical care. For example, the incidence of early-onset group B streptococcal infections can be dramatically reduced through screening and appropriate pre-natal and post-natal treatment.[121-124] An associated reduction in neonatal mortality is suspected, but has not been clearly demonstrated.[125] Here again, interventions are available and mortality rates could reflect the quality of care provided to these infants, although eliminating all or even most mortality is not possible given current knowledge.

Discussion

These measures, both those recommended for reporting and those that will be available for research efforts, offer those interested in neonatal outcomes an opportunity to investigate rates for these outcomes at multiple different levels of care (e.g. hospital vs. regional rates).

Consistent with previous indicator sets, the two endorsed indicators are particularly applicable to quality improvement efforts. Hospitals may use existing data to identify indicators with higher than expected rates, flagging potential quality concerns. These areas of concern may be investigated further in order to identify the underlying cause of the poorer than expected performance. In some cases, incorrect coding practices may be identified, in other cases closer examination of system-level factors may be in order. Interventions may be devised to improve performance, and hospitals may track their own performance over time to identify areas of improvement.

In anticipation of the potential use of these measures for inter-hospital comparison, each indicator was assessed for overall usefulness for two dimensions, internal quality improvement and comparative purposes. Only Nosocomial Bloodstream Infections and Neonatal Mortality were rated by panelists as useful for inter-hospital comparisons. These ratings provide additional information to policy makers interested in inter-hospital comparisons. Of course additional factors may also influence the selection of indicators, and risk adjustment for case mix will remain an important consideration.

Despite concerns over use of the candidate indicators for inter-hospital comparisons, the panelists did consistently promote the development of all indicators for research practices. Although for the most part specific interventions have not been shown to improve rates for those indicators examined in this study, in many cases research simply has not been conducted to examine why some hospitals perform better than others. This type of research is one example of how all the candidate indicators may be useful in improving quality of care.

Future Directions

These indicators extend our previous indicator development efforts. Along with this expansion of the indicator set, the Neonatal QIs will benefit from additional validation efforts. As the indicators are utilized, needed improvements to the indicators will be illuminated. Chart review efforts will provide better information on the sensitivity and specificity of the indicators, and may guide further the most appropriate applications of the indicators. Validation efforts may also demonstrate the usefulness of the indicators for facilitating quality improvement. Finally, further investigation and refinement of the risk adjustment system will be essential both for quality improvement and comparative reporting efforts.

Application of the indicator set requires high quality data. Currently few data standards exist for pediatrics, and since pediatric data in general does not fall under the auditing authority of the Centers for Medicare and Medicaid Services (CMS), variation in coding practices is of particular concern. Implementation of data standards for pediatrics would aid in further development and utility of the AHRQ Pediatric QIs. In addition, expansion of data sets to include data elements such as "present on admission," linked data sets, or limited clinical data, such as laboratory or pharmacy data, would also allow for improvement in the sensitivity and specificity of existing indicators.

Given their use of relatively easily accessible administrative data, the nosocomial BSI & mortality measures have the potential to help prioritize quality improvement efforts for neonates at both local and national levels. Even those measures not recommended have the potential as tools to help identify potentially best practices. Taken together, these measures offer another tool to help in the effort to improve quality of care for these smallest of patients.

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