National Quality Measures in Perinatal Medicine

Scott A. Lorch, MD, MSCE[a,b,c,d,e,*]

KEYWORDS

• Quality measure • Perinatal care • Readmission • Mortality • Cesarean section

KEY POINTS

- There are a wide variety of quality measures that assess the quality of perinatal care at a hospital center.
- Ideal perinatal quality measures should be easy to classify and measure, show adequate reliability, and have adequate face and construct validity.
- Currently endorsed measures from the National Quality Foundation focus primarily on preventive care, mode and timing of delivery, and hospital infection rates.
- Future work should address what aspect of quality is assessed by current measures and research gaps including drivers of high quality care.

As health care costs continue to increase in both the developed and developing world, stakeholders and providers have placed an increased emphasis on providing improved outcomes at the lowest possible cost.[1] A key element to this goal is the development of quality measures to assess how well the system provides high-value care and best outcomes. National groups, such as the National Quality Forum (NQF), serve as a source for collating and endorsing measures of perinatal quality.[2] Although these measures may assess an individual hospital's care, these measures may also be used for other purposes, such as the public reporting of data[3,4] and payment strategies, such as pay-for-performance programs.[5–8]

Financial Disclosure: No financial relationships relevant to this article to disclose.
Conflict of Interest: No conflicts of interest to disclose.
Funding Source: Funded in part by AHRQ U18HS020508.
[a] Department of Pediatrics, Division of Neonatology, The Children's Hospital of Philadelphia, 2716 South Street, Room 10-251, Philadelphia, PA 19146, USA; [b] PolicyLab, The Children's Hospital of Philadelphia, 2716 South Street, Room 10-251, Philadelphia, PA 19146, USA; [c] Center for Perinatal and Pediatric Health Disparities Research, The Children's Hospital of Philadelphia, 2716 South Street, Room 10-251, Philadelphia, PA 19146, USA; [d] Department of Pediatrics, The University of Pennsylvania School of Medicine, 2716 South Street, Room 10-251, Philadelphia, PA 19146, USA; [e] Leonard Davis Institute of Health Economics, University of Pennsylvania, 3641 Locust Walk, Philadelphia, PA 19104, USA
* Corresponding author. The Children's Hospital of Philadelphia, 3535 Market Street, Suite 1029, Philadelphia, PA 19104.
E-mail address: lorch@email.chop.edu

Clin Perinatol 44 (2017) 485–509
http://dx.doi.org/10.1016/j.clp.2017.05.001
perinatology.theclinics.com

The sheer number of endorsed metrics may lead to confusion about what these measures truly assess; how to interpret variation in these measures across hospitals, health care systems, and geographic regions; and how to use measures to drive performance improvement. This review presents the differences between *quality assessment* and *quality improvement*, as it pertains to assessing the validity and use of specific quality measures, a conceptual model for the endorsement of numerous measures of perinatal care, an overview of the types of measures endorsed for perinatal quality by NQF in 2016, and potential measures currently absent in recommendations from these national bodies. Unique challenges to the development of such measures for perinatal care, and ideal characteristics of quality metrics for quality assessment also are presented.

QUALITY ASSESSMENT VERSUS QUALITY IMPROVEMENT

Quality measures, as traditionally used by policy makers and insurers, are meant to assess quality of health care providers. Quality assessment identifies low-performing or high-performing health care providers for further intervention by a state or national public health agency; for the purposes of reimbursement, such as pay-for-performance plans in which some part of a facility's payment is tied to their outcomes on a specific set of quality measures; or for public reporting of information.[3,4] States often publicly report such statistics as the mortality rates of cardiothoracic surgeons in New York State[9] and hospital infection rates.[10] For a measure to be used for quality assessment, research needs to show (1) evidence of variation between sites, (2) adequate risk adjustment, (3) reliability and reproducibility of the measure, and (4) measure validity (**Box 1**).

Measures also may be used for quality improvement. As we see in several articles in this issue, quality improvement improves the performance of a specific health care organization, typically a single center or institution, on a measure using PDSA, or plan-do-study-act cycles. Improvement is typically assessed using run charts or other forms of evaluation at the level of the specific institution. Measures used for quality improvement need to be consistently measurable at the level of that institution, with interventions tailored to the specific issues that may be associated with a poor performance at that institution.

Thus, measures typically need to meet a different set of standards when applied across a number of centers for the purposes of quality assessment compared with

Box 1
Quality assessment versus quality improvement

Quality Assessment

- Measures the care of a specific health care entity, whether provider, facility, or region
- Used by public health agencies and insurers
- Recommended data and research include
  - Variation in measure across health care entities
  - Reproducibility and reliability of the measure
  - Validity of measure

Quality Improvement

- Measures improvement in process or outcome at a specific institution or set of institutions
- Used by individual hospitals, public health agencies, and insurers
- A facility's performance on the measure is assessed using run charts and other statistical processing tools

quality improvement at a single center. Despite the differences in quality assessment and quality improvement, measures may be used for both depending on their characteristics.

CONCEPTUAL MODEL FOR QUALITY MEASURES

A significant challenge faced by providers and stakeholders is the proliferation of measures either endorsed by a national group, such as NQF, or unendorsed but used by other stakeholders, such as the Vermont Oxford Network. This proliferation of measures is not confined to perinatal care; there is a similar landscape of quality measures for pediatric and adult care. Why is this? It helps to examine quality measures within the lens of a conceptual framework, such as a "flashlight" theory of quality (**Fig. 1**).[11]

First, we start with the idea that "quality" of care for a given health care provider or facility is a black box. Each quality measure is a flashlight that illuminates some aspect of this box. We can assess the measure based on 2 characteristics. First, we determine how much of the quality box the measure illuminates. It may illuminate a very small part of the box and thus assess a specific aspect of quality, or it may illuminate a much larger part of the box and thus capture many areas of quality that overlap with other quality measures. Second, we can assess how clearly the measure illuminates the box. Some measures may provide a very clear and accurate picture, with strong accuracy and reliability. Other measures provide a blurry assessment of the box, with less reliability and more noise.

Ideally, we would have a measure that illuminated the entire box, with perfect clarity. Because such a measure is not available for neonatal medicine, we see how there are numerous measures of "quality of care," which may have strong or poor correlations between them.

CHARACTERISTICS OF AN IDEAL PERINATAL QUALITY MEASURE

Stakeholders, such as NQF, use certain characteristics to assess perinatal measures (**Box 2**). These characteristics include the following:

1. *Easy to classify*: The definition of a measure should be clear to all stakeholders.
2. *Easy to measure*: Accurate data about a measure should be easy to collect. Data can come from a range of sources, including birth certificates or hospital administrative data, insurance data, or medical record/patient or provider report, ordered by the ease of obtaining such information.

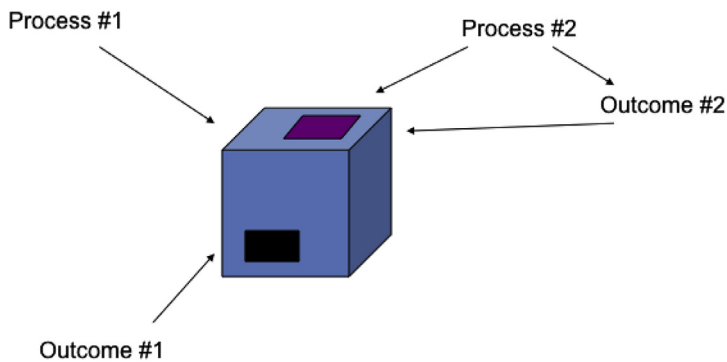

Fig. 1. Conceptual model for the use of multiple measures of perinatal quality. Different measures assess different aspects of the quality box, with different breadth and accuracy.

Box 2
Characteristics of an ideal quality measure

- Easy to classify
- Easy to measure
- High reliability and reproducibility
- Face and construct validity
- Present in sufficient numbers to minimize loss of statistical power to detect significant differences between health care providers or facilities
- Adequate risk adjustment

3. *Show adequate reliability*: Reliability of a measure assesses the consistency of the results. It is affected by the randomness of a measure. For example, measures that vary over time without any change in casemix or care delivery would have a lower reliability.
4. *Show adequate validity*: Validity of a measure assesses how well the measure assesses care quality. A measure should have face validity and construct validity. *Face validity* refers to the idea that stakeholders believe that the measure assesses quality of care. *Construct validity* refers to the idea that the measure is associated with some other measure of care quality. Construct validity may be easy or difficult to demonstrate depending on how broadly the measure illuminates the quality box and whether there are other measures that assess a similar aspect of quality to the measure of interest.

There are additional challenges specific to perinatal care. These include the following:

1. *Small number of patients and outcomes*: Although there are more than 4 million deliveries in the United States, fewer than 2% of these deliveries have a birth weight of less than 1500 g. These high-risk deliveries are not distributed equally across hospitals with obstetric services. Thus, the power to detect a difference in care between hospitals for this popular group of infants may be limited.
2. *Need for risk adjustment:* For some quality metrics, the baseline risk of developing the condition may be affected by factors outside the control of a provider, such as gestational age at birth or coexisting maternal medical conditions. The percentage of patients with these high-risk conditions measures the *casemix* of a health care provider or hospital. Any differences in casemix need to be adjusted to provide a valid assessment of a hospital's quality.
3. *Difficulty defining the measure accurately*: Clear definitions for a particular measure may be difficult. For example, bronchopulmonary dysplasia may use clinical judgment or the use of an oxygen reduction test to make a diagnosis. Similarly, measures such as neonatal death provide an incomplete assessment of a hospital's performance if fetal death, an alternative outcome of pregnancy, is not included in the assessment.

MEASURES ENDORSED BY THE NATIONAL QUALITY FORUM

NQF is a not-for-profit organization that convenes committees made up of multiple stakeholders to review and recommend submitted quality measures for endorsement along numerous topic areas, including perinatal health. There are currently 22 measures endorsed by NQF that apply to perinatal health as of 2016. These measures can be divided into 4 time periods (Appendix 1, **Box 3**):

Box 3
Endorsed measures by National Quality Forum, 2016

Time Period 1: Prenatal/Periconception
- Adult current smoking prevalence

Time Period 2: Intrapartum/Postpartum Care
- Appropriate deep venous thrombosis prophylaxis in women undergoing cesarean delivery
- Appropriate prophylactic antibiotic received within 1 hour before surgical incision: cesarean delivery
- Contraceptive care: postpartum
- Contraceptive care: most and moderately effective methods
- Contraceptive care: access to long-acting reversible method of contraception
- Incidence of episiotomy
- Intrapartum antibiotic prophylaxis for group B *Streptococcus*
- PC-01 elective delivery
- PC-02 cesarean birth
- PC-03 antenatal steroids
- Percentage of low birthweight births
- Rh immunoglobulin (Rhogam) for Rh-negative pregnant women at risk of fetal blood exposure.
- Unexpected complications in term newborns

Time Period 3: Newborn Care
- Gains in patient activation measure scores at 12 months
- Hepatitis B vaccine coverage among all live newborn infants before hospital or birthing facility discharge
- PC-05 exclusive breast milk feeding
- Pediatric all-condition readmission measure

Time Period 4: Care of the Very Low Birthweight (VLBW) Infant
- Late sepsis or meningitis in VLBW neonates (risk-adjusted)
- Neonatal blood stream infection rate (NQI 03)
- PC-04 health care–associated bloodstream infections in newborns
- Proportion of infants 22 to 29 weeks' gestation screened for retinopathy of prematurity.

Time period 1: Prenatal/Preconception: Measures in this time period focus on counseling and access to care.

Time period 2: Intrapartum/Postpartum care: Measures in this time period focus primarily on preventive therapies around delivery, mode and timing of delivery, and the outcomes of healthy term infants.

Time period 3A: Newborn care: Measures in this time period focus on general newborn care, all-condition readmission, and patient activation.

Time period 3B: Care of the very low birthweight (VLBW) infant: These measures assess hospital infection rates and screening for retinopathy of prematurity (ROP).

An overview of these measures as of 2016 follows, organized roughly by these areas. The endorsement status of these measures changes continually, so there could be the inclusion or exclusion of a specific measure. The reliability of most measures is difficult to assess given the lack of published information on this topic.

Prenatal/Preconception Time Period

Specific measures in this time period focus on processes of care including adequacy of prenatal care and counseling. A recent revision to the perinatal group of measures

resulted in the unendorsement of the adequacy of prenatal care and counseling of women of childbearing age with epilepsy measures, leaving only the general smoking-cessation measure that applies to all adults as a quality measure reflective of care in this time period. As the prenatal care and counseling of women of childbearing age with epilepsy measures were only recently unendorsed, we include them in this review.

Ease of classification: Easy, as counseling and prenatal care visits either occur or do not.

Ease of measurement: Moderately difficult to difficult. Prenatal care visits are generally straightforward to measure by either self-report of the mother (as noted in birth certificates) or insurance data. On the other hand, counseling variables require specific information from patients or providers about the receipt of such counseling. This information is frequently only found in electronic health records or by self-report. Smoking prevalence can be obtained via birth certificate data[12]; but, despite the ability to easily measure and report smoking prevalence, information on cessation counseling is not easily obtained.

Validity: Moderate to strong. Counseling data are important to reduce the risk of associated congenital anomalies in women taking antiepileptic medications[13] and potential adverse neurocognitive outcomes particularly with valproate exposure.[14] Similarly, smoking cessation is important both for the health of the woman,[15] and to reduce the risk of fetal death,[16] preterm birth, and intrauterine growth retardation.[17] Adequate prenatal care has strong face validity as evidenced by publications such as *Healthy People 2020.*[18] However, there are limited data to support an association between receipt of prenatal care and improved pregnancy outcomes.[19,20] There are no studies to show variation in the rate of counseling of women taking antiepileptic drugs. In statewide studies of smoking counseling, there is variation between providers.[21]

Number of eligible patients: Generally large. These measures generally include all deliveries with the exception of some counseling measures specific to different exposures. For example, the recently retired measure of counseling of women with epilepsy applies to only 1% of the childbearing population,[22] or approximately 500,000 to 1 million women annually.[23]

Need for risk adjustment: None, as there are no known factors that should influence whether women receive recommended counseling or prenatal care.

Intrapartum/Postpartum Time Period

Mode and timing of deliveries

These measures focus on limiting early elective delivery (ie, delivery at a gestational age at 38 weeks or less without medical indications) and reducing cesarean delivery rates in nulliparous singleton pregnancies.

Ease of classification: Easy to moderately difficult. Cesarean deliveries are easy to classify based on mode of delivery. On the other hand, correctly classifying deliveries at a gestational age of less than 38 weeks is more challenging, depending on the accuracy of the data to determine the medical necessity of the early delivery.

Ease of measurement: Easy to moderately difficult. Claims datasets are typically used for these measures, with well-validated *International Classification of Diseases, Ninth Revision* (ICD-9) codes or delivery fields to identify cesarean deliveries in claims or birth certificate datasets respectively. One primary challenge is obtaining accurate gestational age data because most insurance and hospital discharge datasets do consistently not include this information through ICD-9

codes. Although gestational age is typically well coded in data that use birth certificates, data on maternal comorbidities used to help determine medical indication for an early delivery are less accurate on birth certificates than hospital administrative data.[24,25] Some endorsed measures recommend paper record collection to assess the medical necessity of early deliveries, which is more difficult to implement.

Validity: Moderate to strong. Early elective delivery at 37 to 38 weeks' gestation is associated with higher rates of respiratory distress, transient tachypnea of the newborn, and admission to the neonatal intensive care unit (NICU) compared with infants born at 39 weeks or later.[26–28] Hospital-level and provider-level variation in the rate of these deliveries exist.[29] One concerning aspect of this measure is the possible association between the passage of state and hospital policies that ban such early deliveries, the so-called "hard stop" rules and higher rate of fetal death, which would replace one set of adverse outcomes with another set.[30] Two other studies have not found such an association.[31,32]

There is more controversy related to the validity of higher cesarean delivery rates as a measure of poor care, even though national reductions in cesarean delivery rates have been the hallmark of public health campaigns for decades.[18] Hospital data from studies during the 1980s and 1990s show an association between higher hospital cesarean delivery rates and several adverse outcomes, including asphyxia and infection.[33,34] More recent multistate data from 1995 to 2005 found that hospitals with lower-than-expected rates of cesarean deliveries actually had higher rates of poorer maternal outcomes as measured by a maternal adverse composite measure, worse neonatal outcomes as measured by a neonatal adverse composite measure, and poorer patient safety as measured by 4 Agency for Healthcare Research and Quality patient safety indicators (PSIs 17–20).[35] Other studies have found an association between lower-than-expected rates of cesarean deliveries and higher rates of asphyxia.[36] Thus, although this measure has strong face validity, there are conflicting data on the construct validity of this measure.[37]

Numbers of eligible patients: Large, as all deliveries are included in the denominator and cesarean deliveries are performed at high rates in most developed countries.

Need for risk adjustment: No.

Therapies

Endorsed measures addressing therapies in the intrapartum and postpartum period are related to prophylaxis for Group B *Streptococcus* (GBS), deep vein thrombosis (DVT), or surgical infections; use of antenatal corticosteroids; provision of contraception after delivery; avoiding episiotomy; and offering of Rhogam for women whose blood type is Rh-negative.

Ease of classification: Easy, as each of these treatments are medications or therapies that are either given or not.

Ease of measurement: Difficult. None of these measures are available in standard administrative datasets except for episiotomy, and as a result, collection of these measures typically uses pharmacy claims or paper records. Some of this information, especially antenatal corticosteroid use, is now available on the most recent version of birth certificates, but the reliability of such data fields has not been published.

Validity: Strong. There is ample evidence for both the prevalence and importance of each condition that the therapies are preventing, including the following:

- High risk of neonatal infection in women not receiving antibiotic prophylaxis for GBS[38]
- High rates of DVT[39] or surgical site infections[40–42] in women receiving cesarean deliveries without appropriate prophylaxis
- High rate of mortality and neonatal morbidity in prematurely born infants who did not receive antenatal corticosteroids[43]
- Risk of iso-immunization and the development of hemolytic anemia, hydrops fetalis, and jaundice in future infants of iso-immunized Rh-negative women
- Higher risk of preterm birth and low birth weight in women with short interconception interval[44,45]

In addition, variations in each measure across facilities, states, and countries have been reported.[46]

Numbers of eligible patients: Large, as eligible women include all deliveries, those with GBS colonization, Rh-negative women, or cesarean deliveries.

Need for risk adjustment: No.

Pregnancy outcomes

Two endorsed measures focus on outcomes of pregnancy. First, the NQF-endorsed metric related to outcomes of healthy term deliveries[47] is the only outcome measure for low-risk term deliveries, identifying several potential adverse outcomes, including neonatal intensive care admission, respiratory distress, perinatal depression, and need to transfer for higher level of care.

Ease of classification: Moderately difficult, depending on the accuracy of the specified ICD-9 codes included in the measure.

Ease of measurement: Moderately difficult. The measure is designed for hospital administrative data, and thus it can be difficult to obtain the information needed to classify the infant as older than 37 weeks and heavier than 2500 g. Linking administrative data with birth certificates to obtain gestational age and birthweight information can solve this problem, but is difficult to implement.

Validity: Poor to moderate. A recent study from Florida found a 14-fold variation in hospital rates of this measure between 2004 and 2013. Hospital factors such as birth volume, level of care, and Medicaid volume were associated with higher rates.[48,49] Aside from this study, there is limited additional published information on the validity of this measure.

Numbers of eligible patients: Large. All term singleton deliveries without other serious fetal conditions are included in the denominator, although rates of these outcomes (numerator) are generally very low.

Need for risk adjustment: No, based on the measure guidelines, although the need for accurate coding to determine a low-risk delivery is essential for this measure.

Second, the measure of percentage of low birth weight deliveries is the only endorsed population health measure. Designed explicitly for state and larger population regions, it uses birth certificate data to quantify the percentage of infants born with a birth weight less than 2500 g in a region. This measure is not designed for insurers or health care providers within a given facility.

Newborn Measures

Measures for healthy newborns focus primarily on receipt of hepatitis B vaccine and exclusive breastfeeding rates. Although newborn infants fit into the pediatric all-condition readmission measure and the parents fit into the general patient activation

measure, these groups per se are not a specific focus or subgroup of this metrics (see Appendix 1 for additional details), and these measures are not discussed further.

Ease of classification: Easy as receipt of the hepatitis B vaccine and formula to determine exclusive breastfeeding are either given or not.

Ease of measurement: Difficult. Both metrics require patient report or electronic health record data to obtain information.

Validity: Strong. Hepatitis B vaccine is associated with lower rates of seroconversion in newborns delivered to mothers with hepatitis B, as well as protection against contracting hepatitis B during adolescence and adulthood.[50] Similarly, exclusive breastfeeding has been associated with lower rates of asthma, allergic disease, mortality especially in developing countries, and improved growth.[51–54]

Numbers of eligible patients: Large, as all deliveries are included in the measure.

Need for risk adjustment: No.

Measures for Very Low Birthweight Infants

Measures for VLBW infants focus on infections and screening for ROP.

Infections

Infections are the most common assessment of quality of care for VLBW infants. NQF-endorsed measures include late sepsis or meningitis after 3 days of life, any neonatal bloodstream infection, and health care–associated bloodstream infections. The challenge comes in harmonizing across each of these measures of infection that are defined differently with different data sources and the absence of a measure of central-line associated bloodstream infections (CLABSI).

Ease of classification: Moderately difficult, primarily surrounding how to approach infections with coagulase-negative *Staphylococcus* rates, which are generally considered contaminants in other populations but may be a true pathogen in premature infants, and the phenomenon of "culture-negative" sepsis.

Ease of measurement: Moderately difficult to difficult. Measures that use administrative data rely on accurate coding of infections in their ICD-9 code list. However, this may be a challenge given the large number of diagnoses experienced by these infants and the limited number of ICD-9/10 code slots (12–24) included in a typical administrative dataset. Alternatively, studies may use pathology records or registry data through such organizations as the Vermont Oxford Network or the California Perinatal Quality Care Collaborative to identify eligible patients.

Validity: Moderate to strong, given that there is variation in infection rates across institutions, and that these rates vary by hospital characteristics, such as level of care.[55–58] Infants who experience 1 or more of these infections have worse outcomes, including mortality, prolonged length of stay, and chronic lung disease.[59–62] However, at the level of the facility, there are scant data to show a correlation between a facility's infection rate and rates of other adverse outcomes, such as bronchopulmonary dysplasia (BPD) or necrotizing enterocolitis (NEC).[56]

Numbers of eligible patients: Small. Overall VLBW infants account for only 1.4% to 2.0% of all deliveries in the United States. Therefore, measures that focus solely on VLBW infants suffer from the power issues around small numbers.

Need for risk adjustment: Yes, based on the measures currently endorsed that include a risk-adjustment tool that accounts for the association between infection risk and gestational age at birth. CLABSI rates have typically not been risk-adjusted.

Screening for retinopathy of prematurity

This measure assesses the percentage of infants born 22 0/7 weeks' gestation to 29 6/7 weeks' gestation who received at least 1 screening examination for ROP while hospitalized.

Ease of classification: Easy, because the screening examination was either completed or not.

Ease of measurement: Moderately difficult. Completion of this measure using the Vermont Oxford Network data requires manual data collection of the electronic or paper record. Insurance-based datasets may capture this information using CPT codes from an ophthalmologist.

Validity: Poor to moderate. Variation in screening rates has not been published, although a recent study did find variation in the method of screening between units.[63] Screening reduces the adverse visual outcomes of ROP.[64,65]

Numbers of eligible patients: Small. Measures that focus solely on VLBW infants suffer from the power issues around small numbers.

Need for risk adjustment: No.

Unendorsed Measures: Mortality and Hospital Readmission

There are a number of proposed quality measures that are not endorsed by national guidelines, but have been used either by national networks of NICUs (eg, the Vermont Oxford Network) or for other patient populations (readmission rates). The next section discusses the metrics of mortality and hospital readmission and describes potential challenges in using them as quality metrics.

Mortality as a quality measure

Neonatal death is a frequently proposed measure of quality of care because, in most medical situations, death is an easy-to-measure, easy-to-classify outcome that may reflect differences care practices after adjusting for a given patient's medical condition. However, perinatal medicine is more challenging, as pregnancies may end in a fetal death, a live birth with a neonatal death, or a live birth with a surviving infant. Also, the very low rates of neonatal and fetal death in the developed world limit the statistical power of mortality rates.

Ease of classification: Difficult. The division between a fetal death and neonatal death has been challenging, as these 2 measures are frequently assessed separately from each other. First, there is no universally accepted minimum gestational age needed to be considered a potential live birth: some states use a threshold as low as 16 weeks' gestation, whereas other states use a threshold as high as 24 weeks.[66] Differences in this definition may artificially increase or decrease a hospital's neonatal death rate by changing which infants are included in the measure.[56,67,68] Second, when assessing the care of a hospital, fetal deaths may be related to the quality of care provided by obstetricians, pediatricians, or neonatologists (preventable fetal deaths), or may be inevitable on presentation to medical care (nonpreventable fetal deaths). Because some proportion of fetal deaths may be preventable, ignoring these deaths in a neonatal death metric may again artificially increase the rates at hospitals that successfully resuscitate an infant (changing them from a fetal death to a live birth), but ultimately have the infant die.[56,67,69,70]

Ease of measurement: Moderately difficult. Mortality is easy to capture regardless of the data source. However, assigning deliveries and deaths to hospitals can be difficult depending on the percentage of infants transferred from their birth hospital. Also, sicker infants, with a younger gestational age at birth and/or greater illness severity, are more likely to be transferred, which biases against hospitals that receive

large numbers of transfers. When care is split between centers for substantial periods of time at each hospital, it is difficult to assign the outcome to one or the other hospital. Most studies in this topic assign patients to the birth hospital regardless of where the death occurred, which may overestimate the impact of birth hospital on outcomes.

Validity: Strong. There is ample evidence of variation in mortality rates by the level and volume of care of the birth hospital.[56,67,69,70] Also, data from the Vermont Oxford Network shows wide variation in mortality rates from the 1990s,[71] although recently published data show a narrowing of this variation across hospitals.[55]

Number of eligible patients: Small, as typically these measures again include only VLBW infants. Even all-infant neonatal death measures are challenging given the relative rareness of neonatal death as an outcome.

Need for risk adjustment: Yes. Younger and sicker infants are more likely to die, but are not randomly distributed across perinatal hospitals in a given region.[56,67,71] Standard risk adjustment models include variables present at delivery, such as gestational age, birth weight, singleton or multiple birth, and gender. Although these models have relatively good reliability, one recent study found that mortality rates between these different levels of NICUs were only statistically significant using methods that accounted for unmeasured casemix differences, here an instrumental variables approach, and not with traditional risk-adjustment models.[56] Such findings are concerning given the need to adjust for casemix with this measure.

Although an intuitively appealing measure of quality, concerns about the small numbers, need for risk adjustment, and the need to include some but not all fetal deaths at a given hospital have raised concerns about the ability of neonatal mortality rates to assess care quality at a specific facility.

Readmissions from neonatal intensive care units as a quality measure

Readmissions are a common group of quality measures endorsed by NQF and other national bodies. As of 2016, there are 54 readmission measures endorsed by NQF for patients of all ages and health. Besides the added health care costs associated with hospital readmissions, readmissions may assess different areas of health care compared with other process or outcome measures. Many of the other measures we have discussed focus specifically on medical care, either the prevention and early identification of illness, or the provision of prophylactic treatment with strong benefit to patients. Unlike these measures, hospital readmission rates may assess the quality of discharge planning,[72,73] and the effective transition of care between the inpatient and outpatient care providers. But why have readmission rates not been endorsed for neonatal care?

Ease of classification: Moderately difficult to difficult. Most readmission metrics are all-condition measures; that is, any readmission that occurs within a specific time window postdischarge. For neonatal patients, this may include febrile illnesses or other infectious diseases that are unpreventable, and thus introduce random noise into the measure. Attempts to identify "preventable" readmissions have failed because of the lack of agreement about what constitutes a preventable readmission between study teams.[74–78]

Ease of measurement: Moderately difficult. Administrative data require linkages between hospitalizations to identify infants who were readmitted. Registry data typically cannot capture all readmissions, because many infants are readmitted to hospitals that did not discharge them from the NICU, based on data from California (**Fig. 2**).

Validity: Moderate. There is substantial variation in NICU readmission rates, with a sixfold to sevenfold difference in hospital readmission rates in California NICUs, and

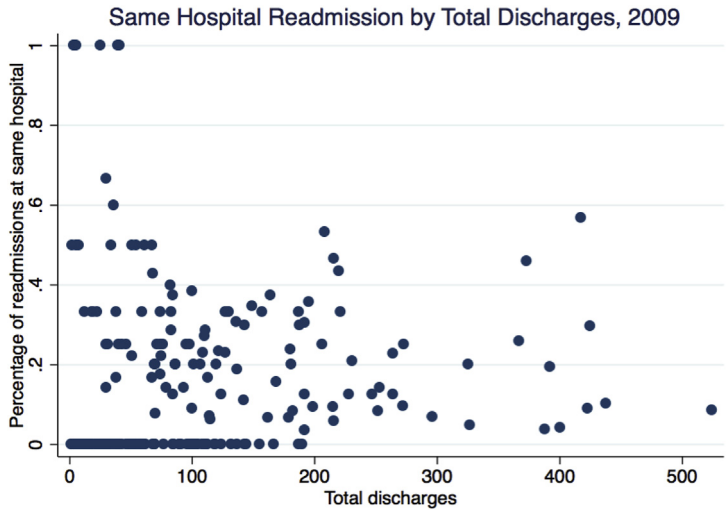

Fig. 2. Percentage of hospital readmissions readmitted to discharge hospital, California linked birth certificate–hospital discharge data, 2009.

a fivefold to sixfold difference in state readmission rates for Medicaid patients requiring NICU care.[79] This variation in readmission rates persists after controlling for differences in casemix. There are data from adults that show an association between readmissions and a hospital's performance in discharge planning[72,73] and transitions of care, but not other measures of poor care, such as hospital complication rates. Data in prematurely born infants find no correlation between a hospital's 30-day readmission rate and the hospital's rate of BPD, intraventricular hemorrhage (IVH), ROP, or NEC (**Fig. 3**), with no studies of the association between readmissions and either discharge planning or transitions of care.

Number of eligible patients: Moderate, although like most measures of perinatal care, readmission rates are relatively low with a hospital average of 2% to 5% by 7 days after discharge to 5% to 7% by 90 days after discharge. Medicaid patients showed higher readmission rates compared with privately insured patients.

Need for risk adjustment: Possibly. Younger infants and infants discharged with chronic conditions, such as BPD, are at higher risk of readmission.[80] As a result, most stakeholders expect to find readmission rates adjusted for these factors. Including these factors in a risk adjustment model, though, does not substantively change a hospital's performance on this measure. Readmission risk adjustment models in adults and children also have lower reliability than other measures, with c-statistics between 0.6 to 0.7, possibly because social and community factors are not included in the models.[75,81,82]

Although used for other patient populations, using readmissions as a quality measure for NICUs remains controversial, with limited validity at the current time. Also, this measure currently is limited to insurance-based datasets because most infants are admitted to a different hospital from where they were discharged (see **Fig. 2**). These datasets are lacking in other data elements, such as an accurate gestational age, which are necessary to calculate a valid readmission measure.[79] Collecting accurate data, and assessing the association of readmission rates with other measures of care such as the discharge process, will be important to validating the measure for neonatal care.

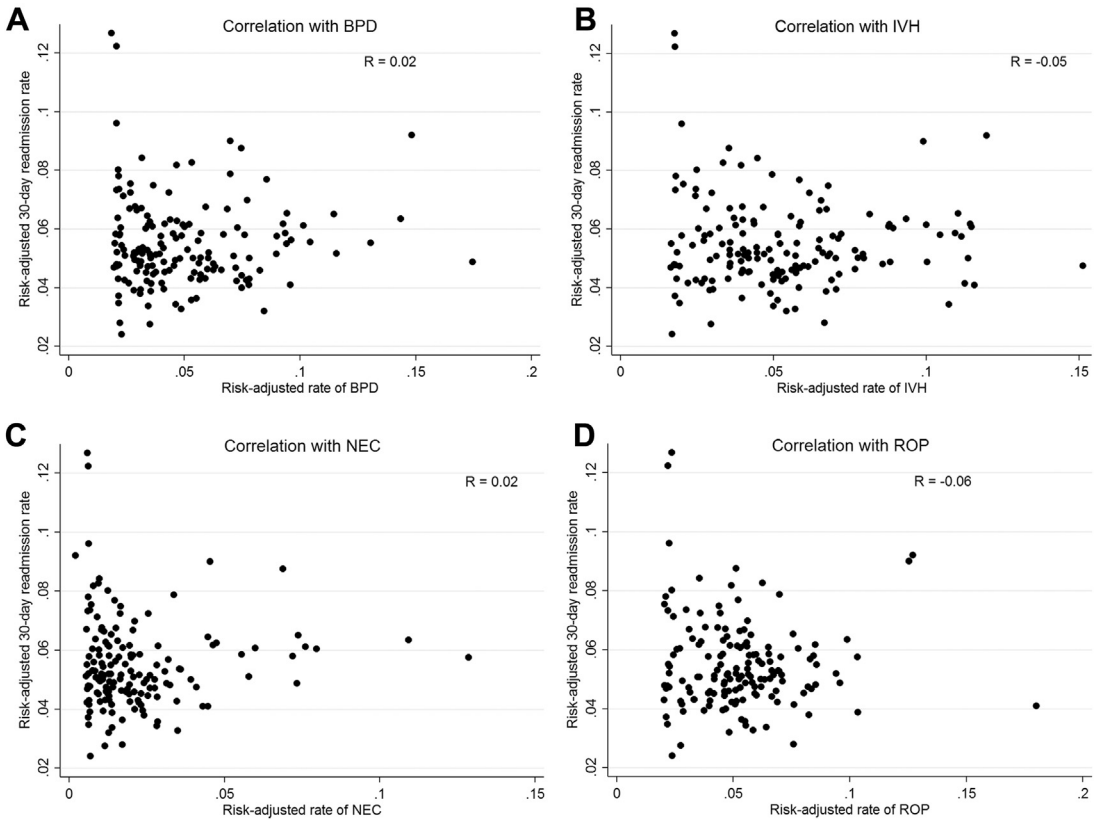

Fig. 3. Lack of correlation between 30-day all-cause hospital readmission rates and rates of BPD, IVH, NEC, and ROP, California linked birth certificate–hospital discharge data. All data risk-adjusted for gestational age, birth weight, maternal comorbid conditions, gender, and race/ethnicity. (*A*) Correlation with BPD. (*B*) Correlation with any IVH. (*C*) Correlation with NEC. (*D*) Correlation with any ROP.

SUMMARY

There are a plethora of quality measures, both endorsed and unendorsed, that assess different aspects of a hospital's "quality box." The process to obtain endorsement is rigorous and has resulted in a set of measures that focus primarily on preventive care, mode and timing of delivery, and hospital infection rates. Further work is needed to assess what these measures truly assess about care quality at the hospital level, and what is missing from our assessment of a hospital's quality of care. Such topics include parental education, transitions of care, and methods to address factors such as social determinants of health on pregnancy outcomes. With better understanding of what these measures truly say about the care provided at an individual NICU, we can identify metrics to optimize the outcomes of high-risk pregnancies.

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APPENDIX 1: PERINATAL QUALITY MEASURES ENDORSED BY NATIONAL QUALITY FORUM, 2017

Measure	Numerator	Denominator	Risk Adjustment	Data Sources[a]
Time period 1: prenatal/periconception				
Adult current smoking prevalence	The numerator is current adult smokers (age 18 and older) in the United States who live in households.	The adult (age 18 and older) population of the United States who live in households. One adult per household is interviewed.	No	Other
Time period 2: intrapartum/postpartum care				
Appropriate DVT prophylaxis in women undergoing cesarean delivery	Number of women undergoing cesarean delivery who receive either fractionated or unfractionated heparin or heparinoid, or pneumatic compression devices before surgery.	All women undergoing cesarean delivery.	No	Other, paper records, pharmacy
Appropriate prophylactic antibiotic received within 1 hour before surgical incision – cesarean delivery	Percentage of women who receive recommended antibiotics within 1 hour before the start of cesarean delivery. This requires that (1) the antibiotic selection is consistent with current evidence and practice guidelines, and (2) that the antibiotics are given within an hour before delivery.	All patients undergoing cesarean delivery without evidence of prior infection or already receiving prophylactic antibiotics for other reasons. Patients with significant allergies to penicillin and/or cephalosporins AND allergies to gentamicin and/or clindamycin are also excluded.	No	Claims, electronic health record, other, paper records
Contraceptive care postpartum	Women ages 15 through 44 who had a live birth and were provided the most (sterilization, intrauterine device, implant) or a moderately (pill, patch, ring, injectable, diaphragm) effective method of contraception within 3 and 60 d of delivery.	Women ages 15 through 44 who had a live birth in a 12-mo measurement year.	No	Claims
Contraceptive care: most and moderately effective methods	Women aged 15–44 y of age at risk of unintended pregnancy who are provided a most (sterilization, intrauterine device, implant) or moderately (pill, patch, ring, injectable, diaphragm) effective method of contraception.	Women aged 15–44 y of age who are at risk of unintended pregnancy.	No	Claims

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Measure	Numerator	Denominator	Risk Adjustment	Data Sources[a]
Contraceptive care: access to LARC	Women aged 15–44 y of age at risk of unintended pregnancy who were provided an LARC, that is, intrauterine device or implant.	All women aged 15–44 y of age who are at risk of unintended pregnancy.	No	Claims
Incidence of episiotomy	Number of episiotomy procedures (ICD-9 code 72.1, 72.21, 72.31, 72.71, 73.6; ICD-10 PCS:0W8NXZZ) performed on women undergoing a vaginal delivery (excluding those with shoulder dystocia ICD-10; O66.0).	All vaginal deliveries during the analytical period (ie, monthly, quarterly, yearly), excluding those coded with a shoulder dystocia ICD-1: O66.0).	No	Claims, paper records
Intrapartum antibiotic prophylaxis for GBS	All eligible patients who receive intrapartum antibiotic prophylaxis for GBS.	All women delivering live infants, except certain classes who are specifically deemed not to be at risk of vertical transmission of GBS.	No	Claims, electronic health record, other, paper records
PC-01 elective delivery	Patients with elective deliveries with ICD-10-PCS Principal Procedure Code or ICD-10-PCS Other Procedure Codes for 1 or more of the following: • Medical induction of labor as defined in Appendix A, Table 11.05 available at: http://manual.jointcommission.org/releases/TJC2016A/ while not in labor before the procedure • Cesarean birth as defined in Appendix A, Table 11.06 available at: http://manual.jointcommission.org/releases/TJC2016A/ and all of the following: ○ Not in labor ○ No history of a prior uterine surgery	Patients delivering newborns with ≥37 and <39 wk of gestation completed with ICD-10-PCS Principal or Other Procedure Codes for delivery and with ICD-10-CM Principal Diagnosis Code or ICD-10-CM Other Diagnosis Codes for planned cesarean birth in labor.	No	Electronic health record, paper records

PC-02 cesarean birth	Patients with cesarean births with ICD-10-PCS Principal Procedure Code or ICD-10-PCS Other Procedure Codes for cesarean birth.	Nulliparous patients delivered of a live term singleton newborn in vertex presentation ICD-10-PCS Principal or Other Diagnosis Codes for delivery.	No	Paper records
PC-03 antenatal steroids	Patients with antenatal steroids initiated before delivering preterm newborns.	Patients delivering live preterm newborns with ≥24 and <34 wk gestation completed with ICD-10-PCS Principal or Other Procedure Codes for delivery.	No	Paper records
Percentage of low birthweight births	The number of babies born weighing <2500 g at birth in the study population.	All births in the study population.	No	Claims
Rh immunoglobulin (Rhogam) for Rh-negative pregnant women at risk of fetal blood exposure	Number of appropriate patients who receive Rhogam.	All women, confirmed pregnant, who are at significant risk of fetal blood exposure.	No	Claims, electronic health record, other, paper records
Unexpected complications in term newborns	The numerator is divided into 2 categories: severe complications and moderate complications. Severe complications include neonatal death, transfer to another hospital for higher level of care, extremely low Apgar scores (=3 at either 5 or 10 min of life), severe birth injuries such as intracranial hemorrhage or nerve injury, neurologic damage, severe respiratory and infectious complications, such as sepsis. Moderate complications include diagnoses or procedures that raise concern but at a lower level than the list for severe (eg, use of continuous positive airway pressure or bone fracture).	Singleton, liveborn infants who are at least 37.0 wk of gestation, and more than 2500 g in birth weight. The denominator excludes most serious fetal conditions that are "preexisting" (present before labor), including prematurity, multiple gestations, poor fetal growth, congenital malformations, genetic disorders, other specified fetal and maternal conditions and infants exposed to maternal drug use in utero.	No	Claims

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Measure	Numerator	Denominator	Risk Adjustment	Data Sources[a]
Time period 3: newborn care				
Hepatitis B vaccine coverage among all live newborn infants before hospital or birthing facility discharge	The number of live newborn infants administered hepatitis B vaccine before discharge (or within 1 mo of life, if the infant had an extended hospital stay) from the hospital/birthing facility.	The number of live newborn infants born at the hospital/birthing facility during the reporting window (1 calendar year).	No	Electronic health record, other, paper records, pharmacy, registry
PC-05 exclusive breast milk feeding	Newborns that were fed breast milk only since birth.	Single term liveborn newborns discharged alive from the hospital with ICD-10-CM Principal Diagnosis Code for single liveborn newborn.	No	Electronic health record, paper records
Pediatric all-condition readmission measure	The numerator consists of hospitalizations at general acute care hospitals for patients <18 years old who are followed by 1 or more readmissions to general acute care hospitals within 30 d. Readmissions are excluded from the numerator if the readmission was for a planned procedure or for chemotherapy.	Hospitalizations at general acute care hospitals for patients <18 years old.	Yes	Claims
Time period 4: care of the VLBW infant				
Late sepsis or meningitis in VLBW neonates (risk-adjusted)	Eligible infants with 1 or more of the following criteria: Criterion 1: Bacterial pathogen. A bacterial pathogen is recovered from a blood and/or cerebral spinal fluid culture obtained after day 3 of life. OR	Eligible infants who are in the reporting hospital after day 3 of life.	Yes	Registry

	Criterion 2: Coagulase-negative *Staphylococcus*. The infant has all 3 of the following: 1. Coagulase-negative *Staphylococcus* is recovered from a blood culture obtained from either a central line, or peripheral blood sample, and/or is recovered from cerebrospinal fluid obtained by lumbar puncture, ventricular tap, or ventricular drain. 2. One or more signs of generalized infection (such as apnea, temperature instability, feeding intolerance, worsening respiratory distress, or hemodynamic instability). 3. Treatment with 5 or more days of intravenous antibiotics after the previously mentioned cultures were obtained.			
Neonatal blood stream infection rate (National Quality Indicator [NQI] 03)	Discharges, among cases meeting the inclusion and exclusion rules for the denominator, with any of the following: • Any secondary ICD-9-CM or ICD-10-CM diagnosis codes for other septicemia; or • Any secondary ICD-9-CM or ICD-10-CM diagnosis codes for newborn septicemia or bacteremia; and • Any secondary ICD-9-CM or ICD-10-CM diagnosis codes for staphylococcal or gram-negative bacterial infection.	All newborns and outborns with any of the following: • A birth weight of 500–1499 g (birth weight categories 2, 3, 4 and 5); or • Any-listed ICD-9-CM or ICD-10-CM diagnosis codes for gestational age between 24 and 30 wk; or • A birth weight $\geq$ 1500 g (birth weight category 6, 7, 8, or 9) and death (DISP = 20); or • A birth weight $\geq$ to 1500 g (birth weight category 6, 7, 8, or 9) and any-listed ICD-9-CM or ICD-10-PCS procedure codes for operating room procedure; or	Yes	Claims

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Measure	Numerator	Denominator	Risk Adjustment	Data Sources[a]
		• A birth weight ≥ to 1500 g (birth weight category 6, 7, 8, or 9) and any-listed ICD-9-CM or ICD-10-PCS procedure codes for mechanical ventilation; or • A birth weight ≥ to 1500 g (birth weight category 6, 7, 8, or 9) and transferring from another health care facility within 2 days of birth.		
PC-04 health care–associated bloodstream infections in newborns	Newborns with septicemia or bacteremia with ICD-10-CM other diagnosis codes for newborn septicemia or bacteremia with a bloodstream infection confirmed OR ICD-10-CM other diagnosis codes for sepsis as defined in Appendix A, Table 11.10.1 available at: http://manual.jointcommission.org/releases/TJC2016A/ with a bloodstream infection confirmed.	The outcome target population being measured is as follows: liveborn newborns with ICD-10-CM other diagnosis codes for birth weight between 500 and 1499 g as defined in Appendix A, Table 11.12, 11.13 or 11.14 OR birth weight between 500 and 1499 g OR ICD-10-CM other diagnosis codes for birth weight ≥1500 g as defined in Appendix A, Table 11.15 or 11.16 OR Birth Weight ≥1500 g who experienced 1 or more of the following: • Experienced death • ICD-10-PCS Principal Procedure Code or ICD-10-PCS Other Procedure Codes for major surgery • ICD-10-PCS Principal Procedure Code or ICD-10-PCS Other Procedure Codes for mechanical ventilation • Transferred in from another acute care hospital or health care setting within 2 d of birth.	Yes	Paper records

Proportion of infants 22–29 wk gestation screened for ROP	Number of infants born from 22 wk, 0 d to 29 wk, 6 d gestational age who were in the reporting hospital at the postnatal age recommended for ROP screening by the AAP and who received a retinal examination for ROP before discharge.	All eligible infants born from 22 wk, 0 d to 29 wk, 6 d gestational age who were in the reporting hospital at the postnatal age recommended for ROP screening by the AAP.	No	Registry

Data taken directly from the National Quality Forum Web site, endorsed measures for perinatal health. http://www.qualityforum.org/QPS/.

Abbreviations: AAP, American Academy of Pediatrics; DISP, DISP variable, reflecting discharge status of infant in hospital claims database; DVT, deep venous thrombosis; GBS, Group B Streptococcus; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10-CM, International Classification of Diseases, 10th Revision, Clinical Modification; ICD-10-PCS, ICD-10 Procedure Coding System; LARC, long-acting reversible method of contraception; ROP, retinopathy of prematurity; VLBW, very low birthweight.

[a] Data source definitions, as classified by the measure developers: claims: administrative records, including vital statistics and hospital administrative data; electronic health records: data from electronic health record sources; registry: data specifically collected for submission to a cohort, which may come from review of any health record; paper records: data from chart review of a nonelectronic record; pharmacy: data from pharmacy records, typically within a hospital; other: other sources of data including patient or provider report.