Neonatal Intensive Care All-Condition Readmissions with Gestational Age Reported

Section 1. Basic Measure Information

1.A. Measure Name

Neonatal Intensive Care All-Condition Readmissions with Gestational Age Reported

1.B. Measure Number

0207

1.C. Measure Description

Please provide a non-technical description of the measure that conveys what it measures to a broad audience.

The Neonatal Intensive Care Readmissions metric assesses the hospital- or State-level readmission rate at 7, 14, 30, and 90 days after a stay in the neonatal intensive care unit (NICU). The optimal measure will adjust for differences in risk by infants of different birthweights and/or gestational ages. Inclusion of additional variables in the risk-adjustment model will allow for agencies to isolate the impact of inpatient NICUs and outpatient providers for observed variations in readmission rates.

1.D. Measure Owner

The Children's Hospital of Philadelphia (CHOP).

1.E. National Quality Forum (NQF) ID (if applicable)

NQF #2893.

1.F. Measure Hierarchy

Please note here if the measure is part of a measure hierarchy or is part of a measure group or composite measure. The following definitions are used by AHRQ:

1. **Please identify the name of the collection of measures to which the measure belongs (if applicable). A collection is the highest possible level of the measure hierarchy. A collection may contain one or more sets, subsets, composites, and/or individual measures.**

   Neonatal Intensive Care All-Condition Readmissions.

2. **Please identify the name of the measure set to which the measure belongs (if applicable). A set is the second level of the hierarchy. A set may include one or more subsets, composites, and/or individual measures.**

   Neonatal Intensive Care All-Condition Readmissions with Gestational Age; All-Condition Readmissions Without Gestational Age.

3. **Please identify the name of the subset to which the measure belongs (if applicable). A subset is the third level of the hierarchy. A subset may include one or more composites, and/or individual measures.**

   Not applicable.

4. **Please identify the name of the composite measure to which the measure belongs (if applicable). A composite is a measure with a score that is an aggregate of scores from other measures. A composite may include one or more other composites and/or individual measures. Composites may comprise component measures that can or cannot be used on their own.**

   Not applicable.

1.G. Numerator Statement

Number of infants with a gestational age between 23-34 weeks who were readmitted to the hospital within 7, 14, 30, and 90 days of discharge. These time periods are assessed cumulatively, such that readmissions occurring within prior time periods are included.

1.H. Numerator Exclusions

Infants missing gestational age or with a specified congenital anomaly as described in Table 1 (see Supporting Documents) are excluded.

1.I. Denominator Statement

Number of eligible newborns discharged from the NICU.

1.J. Denominator Exclusions

Infants missing gestational age or with a specified congenital anomaly as described in Table 1 (see Supporting Documents) are excluded.

1.K. Data Sources

Check all the data sources for which the measure is specified and tested.

Administrative data (e.g., claims data).

If other, please list all other data sources in the field below.

Hospital-level administrative data, either alone or linked with vital statistics records to allow for improved assessment of gestational age and/or birthweight information by patient.

Section 2: Detailed Measure Specifications

Provide sufficient detail to describe how a measure would be calculated from the recommended data sources, uploading a separate document (+ Upload attachment) or a link to a URL. Examples of detailed measure specifications can be found in the CHIPRA Initial Core Set Technical Specifications Manual 2011 published by the Centers for Medicare & Medicaid Services. Although submission of formal programming code or algorithms that demonstrate how a measure would be calculated from a query of an appropriate electronic data source are not requested at this time, the availability of these resources may be a factor in determining whether a measure can be recommended for use.

Eligible Population: Newborns with a gestational age <35 weeks, are residents of the State, and without a specified congenital anomaly as described in Table 1 (see Supporting Documents).

Numerator Statement: Number of infants with a gestational age between 23-34 weeks who were readmitted within 7, 14, 30, and 90 days of discharge. These time periods are assessed cumulatively, such that readmissions occurring within prior time periods are included.

Denominator Statement: Number of eligible newborns discharged from the NICU.

Adjusted Metric: Rates are adjusted for race, gender, education, insurance status, and complications (bronchopulmonary dysplasia [BPD], necrotizing enterocolitis [NEC], retinopathy of prematurity [ROP], intraventricular hemorrhage [IVH]). Gestational age is also included in the adjustment. Note that these variables may not be available in all datasets. The adjusted results of readmissions using all of these variables are described as Adjusted Model with complications of prematurity, which has the greatest face validity for practicing physicians, based on data that support the idea that each of these variables contributes in some way to a patient's risk for readmission. Also, the medical complication variables and/or gestational age may be excluded (Adjusted Model) from analyses that solely focus on the overall quality of care of the NICU, as some of the variation in readmission rates may occur because of differential rates of complications at the hospital level. However, these variables may be included for situations such as examining readmissions: (1) as its own measure of quality, independent of other potential measures of quality that may influence readmission rate; (2) as a measure of the outpatient system by itself, in which case these complications are part of the general health (and risk of readmission) of the infant at the time the infant enters care of the outpatient provider/system. Tables 1-5 (see Supporting Documents) provide information relevant to this section.

Section 3. Importance of the Measure

In the following sections, provide brief descriptions of how the measure meets one or more of the following criteria for measure importance (general importance, importance to Medicaid and/or CHIP, complements or enhances an existing measure). Include references related to specific points made in your narrative (not a free-form listing of citations).

3.A. Evidence for General Importance of the Measure

Provide evidence for all applicable aspects of general importance:

- **Addresses a known or suspected quality gap and/or disparity in quality (e.g., addresses a socioeconomic disparity, a racial/ethnic disparity, a disparity for Children with Special Health Care Needs (CSHCN), a disparity for limited English proficient (LEP) populations).**
- **Potential for quality improvement (i.e., there are effective approaches to reducing the quality gap or disparity in quality).**
- **Prevalence of condition among children under age 21 and/or among pregnant women.**
- **Severity of condition and burden of condition on children, family, and society (unrelated to cost).**
- **Fiscal burden of measure focus (e.g., clinical condition) on patients, families, public and private payers, or society more generally, currently and over the life span of the child.**
- **Association of measure topic with children's future health – for example, a measure addressing childhood obesity may have implications for the subsequent development of cardiovascular diseases.**
- **The extent to which the measure is applicable to changes across developmental stages (e.g., infancy, early childhood, middle childhood, adolescence, young adulthood).**

Special Health Care Needs

Preterm births account for 11-12 percent of all live births in the United States. Readmissions are particularly prevalent among premature infants, who have been shown to have an approximately three-fold increase in risk of hospital admissions after discharge across all timeframes, compared to term infants, with higher rates in infants of younger gestational age (Escobar, Joffe, Gardner, et al., 1999; Ray, Lorch, 2013). Infants with complications or other health conditions, such as BPD and NEC, also experience higher rates of readmission (Lorch, Baiocchi, Silber, et al., 2010; Morris, Gard, Kennedy, 2005).

Race/Ethnicity

Issues surrounding NICU readmissions are particularly relevant to the African American community, as a larger proportion of babies born to black mothers are premature, even after adjusting for income, education level, and socioeconomic status (Morris, et al., 2005).

Potential for Quality Improvement

Preventing hospital readmissions is an area of emphasis by insurers and public health professionals, because hospital readmissions may represent either poor quality of care during the hospitalization or poor discharge planning and transition of care from inpatient to outpatient

providers (Berry, Toomey Zaslavsky, et al., 2013; Escobar, , Greene, Hulac, 2005; Lorch, et al., 2010; Morse, Hall, Fieldston, et al., 2011; Profit, McCormick, Escobar, et al., 2007; Tsai, Joynt, Orav, et al., 2013).

Readmissions can be used to define or measure the effectiveness of infant discharge criteria (Kotagal, Perlstein, Gamblian, et al., 1995; Seki, Iwasaki, An, et al., 2011) or the effect of performance-based quality metrics (Paul, Lehman, Hollenbeak, et al., 2006). Analysis of readmissions on longer time intervals can also be used to assess quality of outpatient care, or the dyad of inpatient and outpatient care providers (Lorch, et al., 2010). These methods may also provide insight into the overall structure of the health care system for managing the care of the prematurely born infant.

Increasing access to and continuity of health insurance for mothers and infants, as well as identification of maternal risk factors (young age, first-time pregnancy, diabetes, hypertension, etc.) and targeting mothers for special education also potentially could reduce readmission rates (Bakewell-Sachs, Gennaro, 2004; Paul, et al., 2006).

Severity and Burden of Condition

The costs and stresses of an infant admitted to the NICU can have a profound effect on family well-being. Several studies have found elevated levels of hostility, anxiety, and/or depression among parents of NICU infants (Carter, Mulder, Bartram, et al., 2005; Doering, Moser, Dracup, 2000). These alterations in parental attitudes and family well-being can produce long-term effects on the development of the child and family. Caring for a premature infant also requires more maternal/family education, failure of which can further increase risk of readmission (Bakewell-Sachs, Gennaro, 2004).

Fiscal Burden of the Condition

Increased hospitalizations contribute to higher healthcare costs and utilization (Kirkby, Greenspan, Kornhauser, et al., 2007; Wade, Lorch, Bakewell-Sachs, et al., 2008). Costs and resource utilization by preterm, low birthweight infants (those at the highest risk of readmission) are substantially higher (according to Gilbert and colleagues: $224,000 at 500-600 g, vs. $1000 at 3000g or greater) (Gilbert, Nesbitt, Danielsen, 2003; Russell, Green, Steiner, et al., 2007). Although the initial NICU admission incurs the highest cost, each readmission has an average claim of approximately $8,468 (Underwood, Danielson, Gilbert, 2007). Premature infants and infants with morbidities have been shown to have a higher number of office visits (especially for higher-cost, non-well-child visits) and a greater number of prescriptions (Wade, et al., 2008). Estimated rates of outpatient visits for very-low-birthweight infants range from more than five visits/month during the first 3 months post-discharge for infants born at a gestational age under 26 weeks, to an average of 1.5 visits/month overall for the first year after discharge for infants born at a gestational age under 32 weeks.

Additionally, the extra care and attention required by a premature infant in the NICU makes it more difficult for the parents to maintain a two-income household (Gennaro, 1996). Finally, increased risk of social and behavioral problems associated with prematurity can have lingering effects over the entire life of the child. Early pediatric interventions have been shown to reduce these risks.

Association with Children's Future Health

Although readmissions are not themselves associated with a child's future health, they are more common among infants with health problems that require special healthcare attention, such as prematurity, low birthweight, and other neonatal morbidities. Readmissions as a measure can help ensure that these babies are receiving the routine and preventive care necessary to improve their health outcomes, as quality outpatient and primary pediatric care will reduce preventable readmissions.

Applicability of Measure Across Developmental Stages

Premature infants and infants with morbidities have been shown to have delayed achievement of physiologic milestones such as respiration and feeding (Bakewell-Sachs, Gennaro, 2009). In multiple studies, including multi-study reviews, of outcomes for babies born preterm versus term, preterm infants had significantly lower cognitive scores and educational ability and a greater need for medical interventions, as well as an increased relative risk of developing ADHD (Bhutta, Cleves, Casey, et al., 2002; Chapieski, Evankovich, 1997; McGowan, Szyf, 2010). Several early intervention programs aimed at reducing the developmental delay of preterm infants via parental education, family support, and pediatric follow-up have shown improved cognitive scores (Brooks-Gunn, Klebanov, Liaw, et al., 1993).

3.B. Evidence for Importance of the Measure to Medicaid and/or CHIP

Comment on any specific features of this measure important to Medicaid and/or CHIP that are in addition to the evidence of importance described above, including the following:

- **The extent to which the measure is understood to be sensitive to changes in Medicaid or CHIP (e.g., policy changes, quality improvement strategies).**
- **Relevance to the Early and Periodic Screening, Diagnostic and Treatment benefit in Medicaid (EPSDT).**
- **Any other specific relevance to Medicaid/CHIP (please specify).**

Readmission rates have been shown to be tightly linked, not only to impatient facility but also to outpatient care (Lorch, Wade, Bakewell-Sachs, et al., 2009). Insurance enrollment and continuity are important for access and timely care for a premature infant. Outpatient care can identify and address health problems before they reach the point of requiring hospital admission. For these reasons, a NICU readmissions metric should be sensitive to changes in Medicaid/CHIP policies that are designed to increase take-up and retention by reducing barriers to enrollment and redetermination. In addition, policies focused on improving infant discharge criteria and outpatient quality should also improve the measured readmission rate.

Because of the slowed development and increased potential for health complications or behavioral problems among premature/low birthweight infants, the EPSDT program will be integral in early identification and treatment of problems among these at-risk babies and children. Increased focus on regular preventive care may reduce the number of unnecessary hospital readmissions and ensure improved overall quality of outpatient care received by these infants (D'Agostino, Passarella, Saynisch, et al., 2015).

3.C. Relationship to Other Measures (if any)

Describe, if known, how this measure complements or improves on an existing measure in this topic area for the child or adult population, or if it is intended to fill a specific gap in an existing measure category or topic. For example, the proposed measure may enhance an existing measure in the initial core set, it may lower the age range for an existing adult-focused measure, or it may fill a gap in measurement (e.g., for asthma care quality, inpatient care measures).

This project fills in the gaps left by other hospital readmission measures, particularly the all-cause pediatric readmission metric proposed by the Boston Children's group. In addition, another neonatal all-cause readmission metric has been developed by the Children's Hospital of Philadelphia for use when gestational age is not included in the dataset.

Section 4. Measure Categories

CHIPRA legislation requires that measures in the initial and improved core set, taken together, cover all settings, services, and topics of health care relevant to children. Moreover, the legislation requires the core set to address the needs of children across all ages, including services to promote healthy birth. Regardless of the eventual use of the measure, we are interested in knowing all settings, services, measure topics, and populations that this measure addresses. These categories are not exclusive of one another, so please indicate "Yes" to all that apply.

Does the measure address this category?

a. **Care Setting – ambulatory:** No.
b. **Care Setting – inpatient:** Yes.
c. **Care Setting – other – please specify:** No.
d. **Service – preventive health, including services to promote healthy birth:** No.
e. **Service – care for acute conditions:** No.
f. **Service – care for children with special health care needs/chronic conditions:** Yes.
g. **Service – other (please specify):** No.
h. **Measure Topic – duration of enrollment:** No.
i. **Measure Topic – clinical quality:** Yes.
j. **Measure Topic – patient safety:** No.
k. **Measure Topic – family experience with care:** No.
l. **Measure Topic – care in the most integrated setting:** Yes.
m. **Measure Topic other (please specify):** No.
n. **Population – pregnant women:** No.
o. **Population – neonates (28 days after birth) (specify age range):** Yes; 0-28 days.
p. **Population – infants (29 days to 1 year) (specify age range):** Yes; 29-244 days.
q. **Population – pre-school age children (1 year through 5 years) (specify age range):** No.
r. **Population – school-aged children (6 years through 10 years) (specify age range):** No.

s. **Population – adolescents (11 years through 20 years) (specify age range):** No.
t. **Population – other (specify age range):** No.
u. **Other category (please specify):** Not applicable.

Section 5. Evidence or Other Justification for the Focus of the Measure

The evidence base for the focus of the measures will be made explicit and transparent as part of the public release of CHIPRA deliberations; thus, it is critical for submitters to specify the scientific evidence or other basis for the focus of the measure in the following sections.

5.A. Research Evidence

Research evidence should include a brief description of the evidence base for valid relationship(s) among the structure, process, and/or outcome of health care that is the focus of the measure. For example, evidence exists for the relationship between immunizing a child or adolescent (process of care) and improved outcomes for the child and the public. If sufficient evidence existed for the use of immunization registries in practice or at the State level and the provision of immunizations to children and adolescents, such evidence would support the focus of a measure on immunization registries (a structural measure).

Describe the nature of the evidence, including study design, and provide relevant citations for statements made. Evidence may include rigorous systematic reviews of research literature and high-quality research studies.

Hospital readmissions have been an area of particular interest for State and national policy agencies, health insurers, and caregivers because of the high costs, both financial and to families, associated with them. So-called "preventable" readmissions, described because ostensibly some change in practice at either the inpatient or outpatient level could have prevented the readmission, may provide insight into care practices that could limit hospitalizations. In pediatric medicine, there are groups of high-risk patients for whom hospital readmissions occur frequently. While the estimated readmission rate within 30 days among the 2.4 million admissions annually in the United States is approximately 6.5 percent (Berry, Toomey, Zaslavsky, 2013; Yu, Wier, Elixhauser, 2011), many conditions such as surgery, sickle cell disease, and prematurity have rates between 15 and 20 percent (Berry, Blaine, Rogers, et al., 2014; Ray, Lorch, 2013; Underwood, et al., 2007; Wade, et al., 2008). One other group is children discharged from the NICU; premature infants have an approximately three-fold increase in risk of hospital readmission after discharge compared to term infants, with higher rates in infants of younger gestational age (Ray, Lorch, 2013). These hospital readmissions contribute to the higher health care costs and utilization seen in infants born prematurely (Underwood, et al., 2007; Wade, et al., 2008). A limited number of studies show variation in readmission rates in one Canadian province (Martens, Derksen, Gupta, 2004) and a small number of hospitals (Morris, et al., 2005). Variations in other pediatric specialties have also been shown (Berry, et al., 2013, Czaja, Hosokawa, Henderson, 2013). For the preterm population, we demonstrated substantial variation in the unadjusted readmission rates among all California delivery hospitals regardless

of time period examined with a standardized difference that ranged from 578-683 percent. This persisted after adjusting for gestational age and sociodemographic factors, with standardized differences ranging between 660-724 percent (Lorch, Passarella, Ziegler, 2014).

There are a number of potential factors associated with higher or lower rates of hospital readmissions. First, differences in rates may result from differences in illness severity (Lorch 2010) or other patient characteristics across hospitals (Ambalavanan, Carlo, McDonald, et al., 2011; Lorch, et al., 2010). Readmission rates of preterm infants are approximately three- to six-fold higher compared to term infants, with the highest rates found in infants of younger gestational age (Ray, Lorch, 2013). Data from numerous adult studies show that infants of lower socioeconomic status have higher rates of hospital readmissions (Srivastava, Keren, 2013), leading to higher rates of readmissions at safety-net hospitals for surgical procedures (Hoehn, Wima, Vestal, et al., 2015) and congestive heart failure (Joynt, Jha, 2010). Other studies show associations between readmission rates within ZIP codes and rates of poverty and other measures of social deprivation (Beck, Simmons, Huang, et al., 2012; Liu, Pearlman, 2009; Ray, Lorch, 2012). Family socioeconomic status, as measured by insurance status (Auger, Kahn, Davis, et al., 2013; Bloomberg, Trinkaus, Fisher, et al., 2003; Coller, Klitzner, Lerner, et al., 2013; Liu, Pearlman, 2009; Rice-Townsend, Hall, Barnes, et al., 2013) and financial hardship (McGregor, Reid, Schulzer et al., 2006), is associated with readmission risk. Children with publicly-financed insurance have higher rates of readmission, with infants born prematurely in some States having rates as high as 30 percent (Lorch, et al., 2014). As case mix differs substantially between hospitals and providers, it is important that the readmission metric be risk-adjusted for all health care groupings smaller than the State level (Lorch, Baiocchi, Ahlberg, et al., 2012).

Readmissions may also result from differences in outpatient providers and practices post-discharge. Recent data found increased rates of hospital readmission for preterm infants receiving care at outpatient providers with a higher use of unnecessary antibiotics or other medications (Lorch, et al., 2010). Coller and colleagues, in a systematic review of pediatric hospitals, found that the primary method of preventing readmissions in children with complex health issues was improved continuity and care coordination (Coller, et al., 2014). When studies account for all aspects of the health care system, both inpatient and outpatient, it may inform observed inter-hospital differences in readmission rates shown by our data and others using Medicare (Herrin, St. Andre, Kenward, et al., 2015) or individual hospital data (McMillan, Meier, Winer, et al., 2015).

Studies exploring the association of hospital readmission rates and overall measures of quality at the hospital level have found conflicting and sometimes surprising results. Many studies have failed to show an association between hospital complication rates and readmission rates (Brown, Chang, Zhou, et al., 2014; Horwitz, Lin, Herrin, et al., 2015; Li, Armstrong, Parker, et al., 2012; Yeh, Rosenfield, Zelevinsky, et al., 2012); we show similar results for rates of BPD, NEC, and ROP. Prior work has also suggested that higher quality NICUs have higher volumes and lower complication rates than their peers (Phibbs, Baker, Caughey, et al., 1997; Phibbs, Bronstein, Buxton, et al., 2006). However, for readmissions, hospital volume has shown conflicting results, with some studies suggesting that high volume hospitals have lower rates of readmission (Brown, et al., 2014; Tsai, et al., 2013), and other studies finding the opposite association (Horwitz, et al., 2015; Joynt, Jha, 2011). As we and others have argued (Krumholz, Lin, Keenan,

2013; Lorch, 2013) this lack of association with some measures of hospital quality may reflect the theory that readmission measures a different aspect of care – the discharge/transition to home process, including education of the family – that fails to affect other quality measures such as complication or mortality rates (Coller, Nelson, Slansky, et al., 2014).

Key factors that may affect the structures or processes of care that the readmission metric assesses are (a) the cohort of patients included in the study and (b) the timeframe for readmission after hospital discharge. Compared to other readmission measures, including only infants admitted to the NICU allows us to reduce the noise within the measure because of differences in admission criteria between hospitals. All infants born under 34 weeks of gestational age are included when gestational age is in the data source or can be imputed. Ideally, gestational age is known when determining sample inclusion. The Centers for Medicare & Medicaid Services (CMS) uses a 30-day timeframe for their readmission measures (CMS 2013). However, there are no studies to support this timeframe over shorter (Escobar, et al., 1999) or longer evaluation periods used in prior work (Lorch, et al., 2010; Ray, Lorch, 2013). Shorter time periods may better reflect the care delivered by the inpatient hospital course, suggested by our reliability data, whereas longer time periods may reflect either care of outpatient providers or the overall illness severity of these infants (Lorch, et al., 2010). Thus, we define the metric with rehospitalizations for any reason within 7, 14, 30, 90, and 365 days after discharge from the birth hospitalization, depending on the goals of the group implementing the metric.

Overall, then there have been no comprehensive studies of other structural metrics or processes of care associated with differences in readmission rates, particularly at the level of the NICU. However, the observed substantial hospital and State-level variation seen in this work (Lorch, et al., 2014), which occurs after adjusting for patient-level factors such as sociodemographic factors and clinical variables, supports the idea that readmission variation reflects some part of a hospital's ability to transition care from the inpatient to outpatient setting, along with the outpatient provider's ability to accept and manage the patient. Specific areas that these measures may assess include (1) specific transition of care policies and protocols; (2) education of families; (3) choice of outpatient provider; (4) communication between inpatient and outpatient providers; (5) access to outpatient care (Misky, Wald, Coleman, 2010); or (6) quality of outpatient provider in reducing readmission risk.

5.B. Clinical or Other Rationale Supporting the Focus of the Measure (optional)

Provide documentation of the clinical or other rationale for the focus of this measure, including citations as appropriate and available.

Not applicable.

Section 6. Scientific Soundness of the Measure

Explain the methods used to determine the scientific soundness of the measure itself. Include results of all tests of validity and reliability, including description(s) of the study sample(s) and methods used to arrive at the results. Note how characteristics of other data systems, data sources, or eligible populations may affect reliability and validity.

6.A. Reliability

Reliability of the measure is the extent to which the measure results are reproducible when conditions remain the same. The method for establishing the reliability of a measure will depend on the type of measure, data source, and other factors.

Explain your rationale for selecting the methods you have chosen, show how you used the methods chosen, and provide information on the results (e.g., the Kappa statistic). Provide appropriate citations to justify methods.

For the purposes of this report, we define the reliability of the metric as the ability to produce consistent as well as precise results under similar conditions. Specifically, we determined whether the readmission rates and the rankings based on these rates were consistent upon repeated sampling. All results present information from hospitals with > 50 discharges annually to avoid issues related to small sample sizes at some of the smaller delivery hospitals.

Inter-year reliability for each measure was calculated using one-way random effects ANOVA models for 1 year from our datasets (representing hospitals in California using vital statistics linked to administrative hospital data). Briefly, data for each health care unit (hospital, State) for the specified timeframe were analyzed using one-way ANOVA, with the specific command in STATA version 14 of Loneway readmission rate time unit.

The random effects model assumes that there is a set of observed readmission rates y_{ij}, measured for *n* time frames within *k* groups of hospitals or States, such that $Y_{ij} = \mu + a_i + e_{ij,}$ where a_i and e_{ij} are independent zero-mean random variables with a measured variance for a given hospital or State *i* where *I* = 1, 2, …, *k*. a_i measures the difference between the "typical readmission rate" for hospital or State *I* from the mean readmission rate for the observed cohort, and e_{ij} represents the deviation for the *j*th observation at a specific timeframe for that hospital or State *I* from this "typical readmission rate."

We can then calculate the overall variance of these variables, as s_a^2 and s_e^2, and the reliability of the metric by first calculating the intraclass correlation, or ICC = $s_a^2/ (s_a^2+s_e^2)$. The reliability is then

Reliability = (t*ICC)/(1 + (t-1)*ICC), where t is the group size.

Additionally, we report the Spearman's rank sum correlation between readmission rates for the year time period preceding the observed rates and the "current" rates, or year (t-1) to year t, where t is a specific year within the observation window. Reliable measures should have higher values for both metrics.

Reproducibility of the results was calculated using Spearman-Brown statistics. Briefly, a 50 percent random sample of patients was drawn from each health care unit (State, hospital), and risk-adjustment models were calculated. Then, a second 50 percent sample was chosen and Spearman rank sum correlation coefficients were calculated. This metric assesses the influence of changes to the case mix of a hospital, where one assumes that the 50 percent sample provides an "alternative" insight into the measured readmission rates at each hospital or State.

The values shown in Tables 6 and 7 (see Supporting Documents) suggest that for hospital level data, the measure has modest inter-year reliability that is highest in the 30 days after discharge, with improved intra-year reliability as measured by the Spearman-Brown reliability measure as the number of readmissions increases. Such reliability is similar to that suggested in other work from adult studies (Press, Scanlon, Ryan, 2013).

6.B. Validity

Validity of the measure is the extent to which the measure meaningfully represents the concept being evaluated. The method for establishing the validity of a measure will depend on the type of measure, data source, and other factors.

Explain your rationale for selecting the methods you have chosen, show how you used the methods chosen, and provide information on the results (e.g., R2 for concurrent validity).

1. Risk-Adjustment Using a Complete Dataset: California Linked Dataset

In order to utilize NICU Readmissions to measure State or hospital performance, the measure must be effectively risk-adjusted. To explore what could be accomplished with a complete set of clinical data, we performed a risk adjustment on a cohort of infants born between 1995 and 2009 in California at a gestational age from 23 to 34 weeks. The department of health linked these infants' birth certificates to death certificates using name and date of birth and de-identified the records. Then, over 98 percent of these records were linked to maternal and newborn hospital records using prior methods (Herrchen, Gould, Nesbitt, 1997; Phibbs, et al., 2007). Over 80 percent of the unmatched live birth or fetal death certificate records were missing the delivery hospital, suggesting a birth at home or a birthing center. The unmatched records had similar gestational age and racial/ethnic distributions to the matched records. Because this dataset contains records for all hospitals in California, we can measure readmissions at any California hospital, not simply readmissions to the discharging hospital. To ensure that there were enough patients per hospital to make reliable estimates of the readmission rate (Silber, Rosenbaum, Brachet, et al., 2010), we limited the analyses to the hospitals that discharged over 50 eligible patients per year (N=343).

For risk adjustment, we include characteristics of the infant that may increase the risk of hospital readmission after discharge from the NICU, based on prior work: gestational age, birthweight, gender, and insurance status (Lorch, et al., 2010; Lorch, et al., 2012; Ray, Lorch, 2013). Gestational age and birthweight are specifically captured in birth certificate records. We also assessed how risk-adjusted hospital rates changed when we included common complications of preterm birth associated with readmissions in prior work and captured them using ICD-9-CM codes in hospital administrative records: BPD, NEC, ROP, and IVH. Including these factors is controversial when assessing a facility's quality, though, because improved inpatient quality of care may result in lower mortality rates and, thus, the potential for higher complication rates (Jensen, Lorch, 2015). However, including the individual complications allows for the isolation of the readmission rates at a given hospital controlling for complications of care, and thus improves the assessment of the factors that are explicitly related to the readmission of the

preterm infant. Gestational age, birthweight, sociodemographic information, and complications of premature birth were available in over 98 percent of records in the California State data and have been used in prior work from this dataset (Lorch, et al., 2012; Phibbs, et al., 2007).

Results

Unadjusted Variation

Among infants with a gestational age between 23 and 34 weeks, there was substantial variation in the unadjusted readmission rates among California hospitals, regardless of time period examined, with a standardized difference that ranged from 941 percent to 1129 percent over the 343 hospitals.

Adjusted Variation

The large variation among hospitals persisted after adjusting for gestational age and sociodemographic factors, with standardized differences again ranging between 667 and 1069 percent. Adding common complications of preterm birth to the risk adjustment model made little difference to the readmission rates.

Individual logistic regression models estimating the risk of readmission for each timeframe can be seen, with and without adjusting for complications, in Tables 8a-8e and Tables 9a-9e (see Supporting Documents).

2. Predictive Validity: Readmissions and Complication Rates

We present two tests of the validity of the measure. First, we examine the correlation between readmission rates and hospital volume. Correlation with volume was performed based on previous work suggesting a volume-outcome association with other potential measures of NICU quality, such as mortality rates (Phibbs, et al., 2007; Rogowski, Horbar, Staiger, et al., 2004), and thus higher volumes are a structural measure of neonatal intensive care. This work parallels other work reported in the literature suggesting that higher volume hospitals have improved outcomes, likely secondarily to seeing more patients and implementing processes of care to improve their outcomes. We hypothesize that there should be a larger association between hospital volume and readmission rates compared to complication rates.

Second, we examined other hypothesized measures of quality that may assess a different aspect of NICU quality. These structural and outcome measures include risk-adjusted rates of common complications of premature birth where variation is known, such as BPD, IVH, NEC, and ROP. Complication rates have been suggested by the Institute of Medicine as appropriate surrogates of hospital quality. These complications have also been demonstrated to be important risk factors for the development of long-term neurodevelopmental delay and cerebral palsy (Schmidt, Asztalos, Roberts, et al., 2003). However, the processes of care that may reduce the development of complications throughout the hospital stay (improved respiratory ventilator management, improved feeding programs, hand hygiene programs) may only be modestly associated with processes of care that improve readmission rates (such as improved transitions of care, improved education of families, and so forth). These intermediate process measures are not available in any large scale population-based dataset. If we find an association between readmission rates and neonatal complications, it would call into question whether the extra time needed to quantify

readmission rates should be undertaken by hospitals, insurers, State agencies, and other bodies interested in assessing the quality of neonatal intensive care (Table 10; see Supporting Documents). For further information on this topic, see Lorch (2014).

All complication rates reported in the tables are risk-adjusted using the same model as readmission rates. Spearman correlation coefficients are presented; similar results were found with Pearson's correlation coefficients (Table 11; see Supporting Documents).

For the California data, with a greater number of hospitals, we found a volume-outcome association for readmission rates up through 30 days after discharge: lower volume hospitals had higher rates of readmissions through this time period. The correlations between readmission rates was modest to very strong, with stronger correlations for rates of similar time periods (i.e., 7 days to 14 days) compared to different time periods (7 days to 365 days). As we hypothesized, there were poor to no correlations between hospital-level risk adjusted rates of complications and risk-adjusted readmission rates. Such lack of correlations is similar to that found in most studies of adult readmission rates, which hypothesize that readmission rates assess a different aspect of the quality of NICUs compared with that assessed by complication rates.

Section 7. Identification of Disparities

CHIPRA requires that quality measures be able to identify disparities by race, ethnicity, socioeconomic status, and special health care needs. Thus, we strongly encourage nominators to have tested measures in diverse populations. Such testing provides evidence for assessing measure's performance for disparities identification. In the sections below, describe the results of efforts to demonstrate the capacity of this measure to produce results that can be stratified by the characteristics noted and retain the scientific soundness (reliability and validity) within and across the relevant subgroups.

7.A. Race/Ethnicity

For these analyses, race and ethnicity were determined based on the race/ethnicity variable reported in the data and classified based on Office of Management and Budget guidelines. White was defined as "white, not of Hispanic origin." Black was defined as "black, not of Hispanic origin." For Hispanic, we combined children reported as "Hispanic" or "Latino" and "Hispanic or Latino and one or more races." The category "other" included American Indian, Alaska Native, Asian, Pacific Islander, and children with missing race/ethnicity. We stratified the readmissions metric by enrollee race/ethnicity. Readmission rates did not vary substantially among races/ethnicities at the State level, with the exception of a slight trend in higher rates in racial/ethnic minority patients 90 days and 365 days after discharge. This is similar to previous work from our group, finding no real difference in readmission rates among children of different racial/ethnic backgrounds (Ray, 2013). Results are presented in Table 12 (see Supporting Documents).

7.B. Special Health Care Needs

Based on published peer-reviewed literature, we compiled a list of pediatric chronic conditions (see Supporting Documents), where each condition was represented in all or most of the papers

we reviewed (Feudtner, Christakis, Connell, 2000; Feudtner, Hays, Haynes, et al., 2001; Ireys, Anderson, Shaffer, et al., 1997; Neuzil, Mellen, Wright, et al., 2000; Seferian, Lackore, Rahman, et al., 2006).

Readmissions by special health care needs were tested. Unsurprisingly, children with special healthcare needs were more likely than healthy children to have a readmission at all timepoints and across all hospitals. Thus, these factors were included in our risk adjustment models (Table 13; see Supporting Documents).

7.C. Socioeconomic Status

Socioeconomic measures at the individual or census-tract level are not included in the data. Although 5-digit zip code-based socioeconomic measures have significant limitations, we performed analyses using two socioeconomic variables (percent with high school degree and income level) stratified by quartiles in order to demonstrate that these analyses are feasible (Krieger, Chen, Ebel, 1997). These variables were abstracted from U.S. census 5-digit zip code-level data and merged with the data. If 9-digit zip code data were available, these analyses would produce more robust and meaningful results.

As noted, these analyses were performed for the purposes of demonstrating feasibility and not for the purposes of assessing the significance of associations. The results in Tables 14 and 15 (see Supporting Documents) underscore the limited utility of 5-digit zip code-level socioeconomic indicators in these analyses. Although there was an association between higher socioeconomic status and lower readmissions, the difference between areas within various quartiles of SES was low).

7.D. Rurality/Urbanicity

A crosswalk was performed between the data using the 2010 Census urban and rural classification (https://www.census.gov/geo/reference/ua/urban-rural-2010.html). There are two types of urban areas: urbanized areas that have 50,000 or more people residing in the area and urban clusters that have at least 2,500 and less than 50,000 people residing in the area. Rural area encompasses all population, housing, and territory not included within an urban area.

In general, there was relatively little variation between the geographic categories within the State of California (Table 16; see Supporting Documents).

7.E. Limited English Proficiency (LEP) Populations

LEP data are not available in the dataset; thus, we were unable to perform these analyses.

Section 8. Feasibility

Feasibility is the extent to which the data required for the measure are readily available, retrievable without undue burden, and can be implemented for performance measurement.

Using the following sections, explain the methods used to determine the feasibility of implementing the measure.

8.A. Data Availability

1. What is the availability of data in existing data systems? How readily are the data available?

The NICU Readmissions measure is designed to be used with administrative datasets (if sufficient data are available to identify the at-risk population, such as birthweight or gestational age, as specific fields in the administrative dataset) and birth records linked to administrative datasets – which have been used to generate this metric in this report. CPT codes allow for the identification of all inpatient admissions, whether to the NICU or to the general pediatrics floors. Insurance data allow for the calculation of readmission rates using hospitals that differ from the hospital that discharged the patient from the NICU course, which is critical for a valid measure. The admission, then, can be validated using same-time observations in the inpatient data fields using ICD-9-CM or ICD-10 codes. Most States also already collect birth records. An example of State administrative data with linked birth records is presented using the State of California; gestational age and birthweight variables are available on all State birth certificates. State hospital administrative records identify inpatient admissions both during the birth hospitalization and after discharge. Electronic health record (EHR) data collection is improving, but is not uniform across hospitals or States.

No attempts have been made to use EHR data for such a project. Such data would need to include inpatient data from not only the health system of the infant, but also all potential hospitals where an infant could be admitted – both from the NICU (to allow for accurate identification of risk-adjustment variables) and after discharge (to allow for accurate quantification of the readmission rates). To do this will require either population-based datasets from all payers and providers—similar to the all-payer datasets seen in such States as Massachusetts, Maine, New Hampshire, and Colorado—or better communication and documentation of such health care encounters within the EHR by providers, to document an inpatient or ED visit and the reasons for such a visit.

2. If data are not available in existing data systems or would be better collected from future data systems, what is the potential for modifying current data systems or creating new data systems to enhance the feasibility of the measure and facilitate implementation?

The primary mechanism to facilitate the use of this measure is to link vital statistics data to either hospital administrative data, as outlined in this report, or to insurance data. Such routine linkage will provide complementary, but necessary, data unavailable in either administrative or insurance data (such as Medicaid data) that are currently used by State agencies. Such linkages are currently being performed in several States.

Appropriate risk adjustment by gestational age and/or birthweight is extremely important to achieve a meaningful NICU readmissions measure. Gestational age was required for the California State data utilized. Therefore, we are unable to report rates of “missingness.” In short, use of State-level existing datasets will require improved clinical data collection and the linkage

of data across State lines for States with extensive numbers of patients who cross State lines to receive care, to allow for appropriate assessment of the readmission metric.

8.B. Lessons from Use of the Measure

1. Describe the extent to which the measure has been used or is in use, including the types of settings in which it has been used, and purposes for which it has been used.

This is a new measure that has not been used.

2. If the measure has been used or is in use, what methods, if any, have already been used to collect data for this measure?

This is a new measure that has not been used.

3. What lessons are available from the current or prior use of the measure?

This is a new measure that has not been used.

Section 9. Levels of Aggregation

CHIPRA states that data used in quality measures must be collected and reported in a standard format that permits comparison (at minimum) at State, health plan, and provider levels. Use the following table to provide information about this measure's use for reporting at the levels of aggregation in the table.

For the purpose of this section, please refer to the definitions for provider, practice site, medical group, and network in the Glossary of Terms.

If there is no information about whether the measure could be meaningfully reported at a specific level of aggregation, please write "Not available" in the text field before progressing to the next section.

Level of aggregation (Unit) for reporting on the quality of care for children covered by Medicaid/ CHIP†:

State level* Can compare States

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Other geographic level: Can compare other geographic regions (e.g., MSA, HRR)

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Medicaid or CHIP Payment model: Can compare payment models (e.g., managed care, primary care case management, FFS, and other models)

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Health plan*: Can compare quality of care among health plans.

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Provider Level
Individual practitioner: Can compare individual health care professionals

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
No.

Data Sources: **Are data sources available to support reporting at this level?**
No.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
Not applicable.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
Not applicable.

Provider Level
Hospital: Can compare hospitals

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Provider Level
Practice, group, or facility:** Can compare: (i) practice sites; (ii) medical or other professional groups; or (iii) integrated or other delivery networks

Intended use: **Is measure intended to support meaningful comparisons at this level? (Yes/No)**
Yes.

Data Sources: **Are data sources available to support reporting at this level?**
Yes.

Sample Size: **What is the typical sample size available for each unit at this level? What proportion of units at this level of aggregation can achieve an acceptable minimum sample size?**
This information is not yet available.

In Use: **Have measure results been reported at this level previously?**
No.

Reliability & Validity: **Is there published evidence about the reliability and validity of the measure when reported at this level of aggregation?**
No.

Unintended consequences: **What are the potential unintended consequences of reporting at this level of aggregation?**
This information is not yet available.

Section 10. Understandability

CHIPRA states that the core set should allow purchasers, families, and health care providers to understand the quality of care for children. Please describe the usefulness of this measure toward achieving this goal. Describe efforts to assess the understandability of this measure (e.g., focus group testing with stakeholders).

At this time, no efforts have been made to assess the understandability of this measure by an external group of stakeholders. In theory, this measure can be used by purchasers, health care providers, and others to determine rates of NICU readmissions and potentially identify areas to be the focus of prevention efforts and to improve quality of care for children.

Section 11. Health Information Technology

Please respond to the following questions in terms of any health information technology (health IT) that has been or could be incorporated into the measure calculation.

11.A. Health IT Enhancement

Please describe how health IT may enhance the use of this measure.

In order for a NICU Readmissions metric to be maximally accurate, administrative datasets such as hospital discharge records should increasingly incorporate the data necessary to adjust the measure, such as gestational age and birthweight – either through linkage of data or by adding a field into the dataset. Currently, these variables can only be found in birth records and EHR data, which requires appropriate linkage of vital statistics data with either EHR data, hospital administrative data, or other population-based datasets. Such linkage typically will use probabilistic matching techniques given the limitations with either names (based on maternal last name for birth records, may change afterwards) or social security numbers (not typically present in birth records). However, our work and the work of others suggests well over 98 percent linkage of such data using probabilistic techniques including dates of service, birth dates, and address information.

11.B. Health IT Testing

Has the measure been tested as part of an electronic health record (EHR) or other health IT system?

Yes.

If so, in what health IT system was it tested and what were the results of testing?

The measure has been tested using a dataset from the California Department of Health. These data consisted of hospital records linked to birth and death certificates. Because of the linkage with birth certificates, this dataset also contained valuable data for metric adjustments, such as gestational age.

11.C. Health IT Workflow

Please describe how the information needed to calculate the measure may be captured as part of routine clinical or administrative workflow.

Currently, the information required to compute this measure is captured by States in administrative Medicaid and CHIP files that are also reported to CMS on a quarterly basis. Hospitals, States, and insurance plans also collect birth record data, which can be very useful for adjusting this measure.

11.D. Health IT Standards

Are the data elements in this measure supported explicitly by the Office of the National Coordinator for Health IT Standards and Certification (ONC) criteria (see healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__standards_ifr/1195)?

Yes.

If yes, please describe.

Data elements in this measure are supported explicitly by ONC criteria. The rules about electronically calculating all of the clinical and ambulatory quality measures specified by CMS for eligible hospitals and critical access hospitals will allow this measure to be validated. The rule about the ability to retrieve patient demographic data, including preferred language, gender, race, ethnicity, and date of birth, is essential for identifying disparities among these subgroups.

11.E. Health IT Calculation

Please assess the likelihood that missing or ambiguous information will lead to calculation errors.

Not applicable.

11.F. Health IT Other Functions

If the measure is implemented in an EHR or other health IT system, how might implementation of other health IT functions (e.g., computerized decision support systems in an EHR) enhance performance characteristics on the measure?

Because appropriate discharge is one of the primary factors associated with lowering readmissions, a computerized decision support system could improve performance on the NICU readmission metric by improving standardization of and adherence to discharge criteria. Additionally, better linking of an individual's health records via a comprehensive cross-provider EHR system could help physicians provide better post-discharge outpatient care and thus reduce preventable readmissions.

Section 12. Limitations of the Measure

Describe any limitations of the measure related to the attributes included in this report (i.e., availability of measure specifications, importance of the measure, evidence for the focus of the measure, scientific soundness of the measure, identification of disparities, feasibility, levels of aggregation, understandability, health information technology).

Our tests of the measure show a high degree of variation across States and hospitals, even after our attempts to adjust for differences in NICU case mix. However, that implementation may be difficult due to missing data from administrative datasets in use at the State and Federal levels. Important adjusting variables, such as gestational age and birthweight, are not currently recorded consistently in MAX or like datasets; thus, accurate implementation of this metric will require new data collection, linkage with birth certificates, or more widespread and standardized use of the EHR for publicly reported measures. Use of State-based data also cannot follow infants

admitted to centers in another State. No mechanism exists in administrative data to capture these readmissions, which can be low in some situations and high in others (Lorch, 2015).

An additional complication with the NICU readmission measure, like any metric based on readmissions, is that it is very difficult to identify preventable readmissions from those that are necessary. There has not yet been a determination of the "optimal" level of readmissions in a State or hospital, so we cannot necessarily suggest that the lowest or highest observed rates are ideal, or where they fall relative to what we "should" observe. Many established quality metrics, including those of the CHIPRA Initial Core Set, strive for a 0 percent or 100 percent performance rate. Identification of a baseline number of expected events is a much more difficult prospect and thus complicates the identification of outliers or underperformers. Additionally, we currently do not know what factors underlie the variation in readmission rates. While some of the variation could be related to the quality of care provided during the inpatient stay or discharge process, some might also be related to outpatient care quality or a child's access to services. (Lamarche-Vadel, Blondel, Truffer, et al., 2004; Lorch, et al., 2010; Morris, et al., 2005) Lastly, some variation due to severity may persist even after risk adjustment.

Finally, even if a target rate could be identified, it is unclear how much scope there would be for policy action aimed at improving performance at a given level of measurement. Even with financial incentives, State policymakers may not have much ability to improve the overall rate of readmissions in their State. Even at the hospital level, outpatient care has been shown to have a significant effect on readmission rates, possibly accounting for more variation than the NICU care quality (Lorch, et al., 2010).

Section 13. Summary Statement

Provide a summary rationale for why the measure should be selected for use, taking into account a balance among desirable attributes and limitations of the measure. Highlight specific advantages that this measure has over alternative measures on the same topic that were considered by the measure developer or specific advantages that this measure has over existing measures. If there is any information about this measure that is important for the review process but has not been addressed above, include it here.

Hospital readmissions has been an area of particular interest for State and national policy agencies, health insurers, and caregivers because of the high costs, both financial and to families, associated with them. So-called "preventable" readmissions, described as such because ostensibly some change in practice at either the inpatient or outpatient level could have prevented the readmission, may provide insight into care practices that could limit readmissions. In pediatric medicine, there are groups of high-risk patients for whom hospital readmissions occur frequently. For example, while the estimated readmission rate within 30 days among the 2.4 million admissions annually in the United States is approximately 6.5 percent (Berry, et al., 2013; Yu, et al., 2011), many conditions such as surgery, sickle cell disease, and prematurity have rates between 15 and 20 percent (Berry, 2014; Ray, Lorch, 2013; Underwood, et al., 2007; Wade, et al., 2008). One other group is children discharged from the NICU; premature infants have an approximately three-fold increase in risk of hospital readmission after discharge compared to term infants, with higher rates in infants of younger gestational age (Ray, Lorch,

2013). These hospital readmissions contribute to the higher health care costs and utilization seen in infants born prematurely (Underwood, et al., 2007; Wade, et al., 2008).

References

Ambalavanan N, Carlo WA, McDonald SA, et al. Identification of extremely premature infants at high risk of rehospitalization. Pediatrics 2011; 128:e1216-25.

Auger KA, Kahn RS, Davis MM, et al. Medical home quality and readmission risk for children hospitalized with asthma exacerbations. Pediatrics 2013; 131:64-70.

Bakewell-Sachs W, Gennaro S. Parenting the post-NICU premature infant. MCN Am J Matern Child Nurs 2004; 29(6):398-403.

Beck AF, Simmons JM, Huang B, et al. Geomedicine: Area-based socioeconomic measures for assessing risk of hospital reutilization among children admitted for asthma. Am J Public Health 2012; 102:2308-14.

Berry JG. 30-Day Pediatric Readmissions: Measurement and Prevention. 2013. Available at www.ehcca.com/presentations/readsummit3/berry_ms4.pdf. Accessed February 6, 2019.

Berry JG, Blaine K, Rogers J, et al. A framework of pediatric hospital discharge care informed by legislation, research, and practice. JAMA Pediatr 2014; 168(10):955-62.

Berry JG, Toomey SL, Zaslavsky AM, et al. Pediatric readmission prevalence and variability across hospitals. JAMA 2013; 309:372-80.

Bhutta AT, Cleves MA, Casey PH, et al. Cognitive and behavioral outcomes of children who were born preterm: A meta-analysis. JAMA 2002; 288(6):728-37.

Bloomberg GR, Trinkaus KM, Fisher Jr EB, et al. Hospital readmissions for childhood asthma: A 10-year metropolitan study. Am J Respir Crit Care Med 2003; 167:1068-76.

Brooks-Gunn J, Klebanov PK, Liaw F, et al. Enhancing the development of low-birthweight, premature infants: Changes in cognition and behavior over the first three years. Child Dev 1993; 64(3):736-53.

Brown JR, Chang CH, Zhou W, et al. Health system characteristics and rates of readmission after acute myocardial infarction in the United States. J Am Heart Assoc 2014; 3(3):e000714.

Carter JD, Mulder RT, Bartram AF, et al. Infants in a neonatal intensive care unit: Parental response. Arch Dis Child Fetal Neonatal Ed 2005; 90(2):F109-13.

Centers for Medicare & Medicaid Services. Readmissions Reduction Program. 2013; updated 2019. Available at https://www.cms.gov/Medicare/Medicare-Fee-for-Service-

Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html. Accessed February 7, 2019.

Chapieski ML, Evankovich KD. Behavioral effects of prematurity. Semin Perinatol 1997; 21(3):221-39.

Coller RJ, Klitzner TS, Lerner CF, et al. Predictors of 30-day readmission and association with primary care follow-up plans. J Pediatr 2013; 163:1027-33.

Coller RJ, Nelson BB, Sklansky DJ, et al. Preventing hospitalizations in children with medical complexity: A systematic review. Pediatrics 2014; 134(6):e1628-47.

Czaja AS, Hosokawa PW, Henderson WG. Unscheduled readmissions to the PICU: Epidemiology, risk factors, and variation among centers. Pediatr Crit Care Med 2013; 14:571-9.

D'Agostino JA, Passarella M, Saynisch P, et al. Preterm infant attendance at health supervision visits. Pediatrics 2015; 136(4):794-802.

Doering LV, Moser DK, Dracup K. Correlates of anxiety, hostility, depression, and psychosocial adjustment in parents of NICU infants. Neonatal Netw 2000; 19(5):15-23.

Escobar GJ, Greene JD, Hulac P, et al. Rehospitalization after birth hospitalization: Patterns among infants of all gestations. Arch Dis Child 2005; 90(2):125-31.

Escobar GJ, Joffe S, Gardner MN, et al. Rehospitalization in the first two weeks after discharge from the neonatal intensive care unit. Pediatrics 1999; 104(4 pt 1):894-9.

Feudtner C, Christakis DA, Connell FA. Pediatric deaths attributable to complex chronic conditions: A population-based study of Washington State, 1980-1997. Pediatrics 2000; 106(1 Pt 2):205-9.

Feudtner C, Hays RM, Haynes G, et al. Deaths attributed to pediatric complex chronic conditions: National trends and implications for supportive care services. Pediatrics 2001; 107(6):e99.

Gennaro S. Leave and employment in families of preterm low birthweight infants. Image J Nurs Sch 1996; 28(3):193-8.

Gilbert WM, Nesbitt TS, Danielsen B. The cost of prematurity: Quantification by gestational age and birth weight. Obstet Gynecol 2003; 102(3):488-92.

Herrchen B, Gould JB, Nesbitt TS. Vital statistics linked birth/death and hospital discharge record linkage for epidemiological studies. Comput Biomed Res 1997; 30(4):290-305.

Herrin J, St Andre J, Kenward K, et al. Community factors and hospital readmission rates. Health Serv Res 2015; 50(1):20-39.

Hoehn RS, Wima K, Vestal MA, et al. Effect of hospital safety-net burden on cost and outcomes after surgery. JAMA Surg 2016; 151(2):120-8.

Horwitz LI, Lin Z, Herrin J, et al. Association of hospital volume with readmission rates: A retrospective cross-sectional study. BMJ 2015; 350:h447.

Ireys HT, Anderson GF, Shaffer TJ, et al. Expenditures for care of children with chronic illnesses enrolled in the Washington State Medicaid program, fiscal year 1993. Pediatrics 1997; 100(2 Pt 1):197-204.

Jensen EA, Lorch SA. Effects of a birth hospital's neonatal intensive care unit level and annual volume of very low-birth-weight infant deliveries on morbidity and mortality. JAMA Pediatr 2015; 169(8):e151906.

Joynt KE, Jha AK. Which hospitals have higher readmission rates for patients with heart failure? J Am Coll Cardiol 2010; 55(10):A143-E1348

Joynt KE, Jha AK. Who has higher readmission rates for heart failure, and why? Implications for efforts to improve care using financial incentives. Circ Cardiovasc Qual Outcomes 2011; 4(1):53-9.

Kirkby S, Greenspan JS, Kornhauser M, et al. Clinical outcomes and cost of the moderately premature infant. Adv Neonatal Care 2007; 7(2):80-7.

Kotagal UR, Perlstein PH, Gamblian V, et al. Description and evaluation of a program for the early discharge of infants from a neonatal intensive care unit. J Pediatr 1995; 127(2):285-90.

Krieger N, Chen JT, Ebel G. Can we monitor social inequalities in health? A survey of U.S. health departments' data collection and reporting practices. Public Health Rep 1997; 112(6):481-91.

Krumholz HM, Lin Z, Keenan PS. Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. JAMA 2013; 309(6):587-93.

Lamarche-Vadel A, Blondel B, Truffer P, et al. Re-hospitalization in infants younger than 29 weeks' gestation in the EPIPAGE cohort. Acat Pediatr 2004; 93(10):1340-5.

Li Z, Armstrong EJ, Parker JP, et al. Hospital variation in readmission after coronary artery bypass surgery in California. Circ Carciovasc Qual Outcomes 2012; 5(5):729-37.

Liu SY, Pearlman DN. Hospital readmissions for childhood asthma: The role of individual and neighborhood factors. Public Health Rep 2009; 124:65-78.

Lorch SA. Quality measurements in pediatrics: What do they assess? JAMA Pediatr 2013; 167(1):89-90.

Lorch SA. The importance of understanding hospital and county-specific case mix for neonatal patients. J Pediatr 2015; 91(3):207-9.

Lorch SA, Baiocchi M, Ahlberg CE, et al. The differential impact of delivery hospital on the outcomes of premature infants. Pediatrics 2012; 130:270-8.

Lorch SA, Baiocchi M, Silber JH, et al. The role of outpatient facilities in explaining variations in risk-adjusted readmission rates between hospitals. Health Serv Res 2010; 45(1):24-41.

Lorch SA, Passarella M, Zeigler A. Challenges to measuring variation in readmission rates of neonatal intensive care patients. Acad Pediatr 2014; 14:S47-53.

Lorch SA, Wade KC, Bakewell-Sachs S, et al. Antibiotic use in premature infants after discharge from the neonatal intensive care unit. Clin Pediatr 2009; 49(3):249-57.

Martens PJ, Derksen S, Gupta S. Predictors of hospital readmission of Manitoba newborns within six weeks postbirth discharge: A population-based study. Pediatrics 2004; 114:708-13.

McGowan PO, Szyf M. The epigenetics of social adversity in early life: Implications for mental health outcomes. Neurobiol Dis 2010; 39(1):66-72.

McGregor MJ, Reid RJ, Schulzer M, et al. Socioeconomic status and hospital utilization among younger adult pneumonia admissions at a Canadian hospital. BMC Health Serv Res 2006; 6:152.

McMillan JE, Meier ER, Winer JC, et al. Clinical and geographic characterization of 30-day readmissions in pediatric sickle cell crisis patients. Hospital Pediatr 2015; 5(8):423-31.

Misky GJ, Wald HL, Coleman EA. Post-hospitalization transitions: Examining the effects of timing of primary care provider follow-up. J Hosp Med 2010; 5(7):392-7.

Morse RB, Hall M, Fieldston ES, et al. Hospital-level compliance with asthma care quality measures at children's hospitals and subsequent asthma-related outcomes. JAMA 2011; 306:1454-60.

Morris BH, Gard CC, Kennedy K. Rehospitalization of extremely low birth weight (ELBW) infants: Are there racial/ethnic disparities? J Perinatol 2005; 25:656-63.

Neuzil KM, Mellen BG, Wright PF, et al. The effect of influenza on hospitalizations, outpatient visits, and courses of antibiotics in children. New Engl J Med 2000; 342(4):225-31.

Paul IM, Lehman EB, Hollenbeak CS, et al. Preventable newborn readmissions since passage of the Newborns' and Mothers' Health Protection Act. Pediatrics 2006; 118(6):2349-58.

Phibbs CS, Baker LC, Caughey AB, et al. Level and volume of neonatal intensive care and mortality in very-low-birth-weight infants. New Engl J Med 2007; 356(21):2165-75.

Phibbs CS, Bronstein JM, Buxton E, et al. The effects of patient volume and level of care at the hospital of birth on neonatal mortality. JAMA 1996; 276(13):1054-9.

Press MJ, Scanlon DP, Ryan AM, et al. Limits of readmission rates in measuring hospital quality suggest the need for added metrics. Health Aff 2013; 32(6):1083-91.

Profit J, McCormick MC, Escobar GJ, et al. Neonatal intensive care unit census influences discharge of moderately premature infants. Pediatrics 2007; 119(2):314-9.

Ray KN, Lorch SA. Hospitalization of rural and urban infants during the first year of life. Pediatrics 2012; 130:1084-93.

Ray KN, Lorch SA. Hospitalization of early preterm, late preterm, and term infants during the first year of life by gestational age. Hosp Pediatr 2013; 3:194-203.

Rice-Townsend S, Hall M, Barnes JN, et al. Variation in risk-adjusted hospital readmission after treatment of appendicitis at 38 children's hospitals: An opportunity for collaborative quality improvement. Ann Surg 2013; 257:758-65.

Rogowski JA, Horbar JD, Staiger DO, et al. Indirect vs. direct hospital quality indicators for very low-birth-weight infants. JAMA 2004; 291(2):202-9.

Russell RB, Green NS, Steiner CA, et al. Cost of hospitalization for preterm and low birth weight infants in the United States. Pediatrics 2007; 120(1):e1-9.

Schmidt B, Asztalos EV, Roberts RS, et al. Impact of bronchopulmonary dysplasia, brain injury, and severe retinopathy on the outcome of extremely low-birth-weight infants at 18 months: Results from the trial of indomethacin prophylaxis in preterms. JAMA 2003; 289(9):1124-9.

Seferian EG, Lackore KA, Rahman AS, et al. Comparison of chronic illness among children receiving mechanical ventilation in a cohort of children’s hospitals in 1991 and 2001. J Pediatr 2006; 149(6):788-92.

Seki K, Iwasaki K, An H, et al. Early discharge from a neonatal intensive care unit and rates of readmission. Pediatr Int 2011; 53(10):7-12.

Silber JH, Rosenbaum PR, Brachet TJ, et al. The Hospital Compare mortality model and the volume-outcome relationship. Health Serv Res 2010; 45(5 Pt 1):1148-67.

Srivastava R, Keren R. Pediatric readmissions as a hospital quality measure. JAMA 2013; 309(4):396-8.

Tsai TC, Joynt KE, Orav EJ, et al. Variation in surgical-readmission rates and quality of hospital care. N Engl J Med 2013; 369:1134-42.

Underwood MA, Danielsen B, Gilbert WM. Cost, causes and rates of rehospitalization of preterm infants. J Perinatol 2007; 27:614-9.

Wade KC, Lorch SA, Bakewell-Sachs S, et al. Pediatric care for preterm infants after NICU discharge: High number of office visits and prescription medications. J Perinatol 2008; 28:696-701.

Yeh RW, Rosenfield K, Zelevinsky K, et al. Sources of hospital variation in short-term readmission rates after percutaneous coronary intervention. Circ Cardiovasc Intervent 2012; 5(2):227-36.

Yu H, Wier LM, Elixhauser A. Hospital Stays for Children, 2009. HCUP Statistical Brief #118. Rockville, MD: Agency for Healthcare Research and Quality; August 2011. Available at http://www.hcup-us.ahrq.gov/reports/statbriefs/sb118.jsp. Accessed February 7, 2019.

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The CHIPRA Pediatric Quality Measures Program (PQMP) Candidate Measure Submission Form (CPCF) was approved by the Office of Management and Budget (OMB) in accordance with the Paperwork Reduction Act.

The OMB Control Number is 0935-0205 and the Expiration Date is December 31, 2015.

Public Disclosure Requirements

Each submission must include a written statement agreeing that, should U.S. Department of Health and Human Services accept the measure for the 2014 and/or 2015 Improved Core Measure Sets, full measure specifications for the accepted measure will be subject to public disclosure (e.g., on the Agency for Healthcare Research and Quality [AHRQ] and/or Centers for Medicare & Medicaid Services [CMS] websites), except that potential measure users will not be permitted to use the measure for commercial use. In addition, AHRQ expects that measures and full measure specifications will be made reasonably available to all interested parties. "Full measure specifications" is defined as all information that any potential measure implementer will need to use and analyze the measure, including use and analysis within an electronic health record or other health information technology. As used herein, "commercial use" refers to any sale, license or distribution of a measure for commercial gain, or incorporation of a measure into any product or service that is sold, licensed or distributed for commercial gain, even if there is no actual charge for inclusion of the measure. This statement must be signed by an individual authorized to act for any holder of copyright on each submitted measure or instrument. The authority of the signatory to provide such authorization should be described in the letter.

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