RESEARCH ARTICLE

Variation in NICU Admission Rates Without Identifiable Cause

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ABSTRACT

OBJECTIVES: Admission to the NICU is influenced by physiologic compromise and by hospital care protocols. Providing appropriate care must be balanced with adverse consequences of NICU admission, such as interrupting maternal–infant bonding and unnecessary interventions. This study aims to determine the variation in NICU admissions in term and late preterm infants among 19 hospitals.

METHODS: We used the Consortium on Safe Labor (CSL) database to determine NICU admission rates. This database includes data from 217 442 infants aged 35 to 42 weeks within 19 US maternal delivery hospitals from 2002 to 2008. NICU admission rates were evaluated for absolute factors including, but not limited to, sepsis, asphyxia, respiratory distress, and intracranial hemorrhage, as well as relative factors, such as maternal drug use, chorioamnionitis, and infant birth weight ≤2500 g.

RESULTS: Percentage of infants 35 to 42 weeks' gestation admitted to the NICU without an identifiable absolute or relative cause for intensive care services ranged from 0% to 59.4% (mean, 10.8%; $P < .001$). Among infants 35 to 42 weeks' gestation and ≥2500 g, infants without absolute or relative identified cause accounted for 9.1% of total NICU days and had lower length of stays (−2.7 days; 95% confidence interval −3.4; −2.1) compared to those with an identified reason.

CONCLUSIONS: There is significant variation in admission rates among NICUs that cannot be explained by infant health conditions. Further analysis is needed to determine the cause of between-site variation and potential opportunities to refine protocols and optimize use of NICU services.

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NICU admission rates may be influenced by multiple factors, including hospital care protocols as well as infant physiologic compromise. Physicians are challenged to appropriately triage infants to critical and noncritical care units. Balancing safety, effectiveness, equity, timeliness, patient-centeredness, and efficiency in today's health care environment is increasingly challenging, and triaging infants with comorbidities falls within this challenge.[1] Specifically, neonatal care providers are tasked with balancing multiple factors such as infant physiologic needs, patient safety, hospital care protocols, and health care utilization and costs.

Utilization of health care resources in the United States is under much scrutiny,[2] and health care providers are faced with financial decisions on a daily basis. Given the high cost of neonatal intensive care, optimizing NICU utilization is important. There has been minimal research on neonatal triage and use of NICU resources. Previous studies have shown that infants with limited physiologic compromise account for 9.5% of NICU costs.[3]

The purpose of the present study was to evaluate a recent cohort of infants born between 35 and 42 weeks to compare between-hospital NICU admission rates. We hypothesized that NICU admission rates would differ between centers after controlling for infant physiologic compromise.

METHODS

Information from the Consortium on Safe Labor (CSL) database was analyzed.[4] The CSL included 12 clinical centers with 19 hospitals across 9 American College of Obstetricians and Gynecologists US districts. These districts were designed to represent all regions of the country. The CSL created the database by using information provided to it from the electronic medical records of the 19 participating hospitals. Centers included 8 university teaching hospitals, 9 community teaching hospitals, and 2 nonteaching community hospitals. The CSL collected data from the electronic medical records of the participating hospitals and stored the data in a validated comprehensive database. A total of 228 668 deliveries with 233 844 newborns delivered between 2002 and 2008 were included in the data. Due to participating institutions' initiation of electronic medical records, a majority of the births in the database (87%) occurred between 2005 and 2007.[4]

The CSL abstracted the data from newborn discharge summaries as *International Classification of Diseases, Ninth Revision,* codes. A level 0 NICU was defined as no NICU. A level I NICU was defined as basic care, a level II NICU was a specialty nursery, and a level III NICU was a subspecialty care unit. All of the included NICUs have associated maternity centers. None of the included NICUs were referral children's hospitals. By definition, all infants included in the CSL database are inborn to 1 of the participating delivery hospitals. The CSL collected data, including maternal demographic characteristics, maternal medical conditions, and labor and delivery information. The CSL determined gestational age by using best obstetrical estimate. The CSL abstracted data on birth weight, infant diagnoses such as sepsis, intracranial hemorrhage, periventricular hemorrhage, intraventricular hemorrhage, pneumonia (infectious or aspiration), asphyxia, hypoxic-ischemic encephalopathy, respiratory distress syndrome, seizures, transient tachypnea of the newborn, chromosomal anomalies, oxygen use in the NICU, mechanical ventilation or continuous positive airway pressure use in the NICU, maternal chorioamnionitis, and maternal recreational drug use from each institution's electronic medical record; this information was added to the database. The CSL performed data cleaning, logic checking, and validation checks, and a high level of accuracy was confirmed. All participating institutions obtained institutional review board approval. The data set did not provide a NICU diagnosis of hypoglycemia, and there are no cost data available from this data set. Further details about the CSL database, including methods of data abstraction and validation of the database, have been previously reported.[4]

For the purposes of the present study, we examined a cohort of infants from 35 to 42 weeks' gestation because most centers routinely admit infants to the NICU outside of those parameters. We selected an a priori list of conditions that commonly necessitate NICU admission (Table 1). The list was then subdivided into absolute indications (ie, aspects in which it would be reasonable to agree that neonatal intensive care services were required) and relative aspects (ie, in which some, but not all, neonatal care providers and institutions admit to the NICU). We considered infants admitted to the NICU, but not having 1 of the listed conditions, as having an unidentifiable cause for admission. Infants with missing data for 1 or more conditions, but who had an identified reason for other variables, were included in the data set as an admission with an identified cause. Infants not having at least 1 of the listed absolute or relative conditions and missing data fields for conditions were removed from the list. This list and the inclusion of infants were designed to be overly inclusive. Not every credited diagnosis would require an infant to be in the NICU but having that diagnosis would be a reasonable indication for NICU admission. Conversely, the absence of at least 1 of these diagnoses creates the

TABLE 1 Identifiable Causes for NICU Admission

Absolute Criteria	Relative Criteria
Sepsis	Birth weight ≤2500 g
Pneumonia, infectious	Maternal chorioamnionitis
Pneumonia, aspiration	Maternal recreational drug use
Intrapartum aspiration	
Hypoxic-ischemic encephalopathy	
Asphyxia	
Seizures	
Intracranial hemorrhage	
Intraventricular/periventricular hemorrhage	
Respiratory distress syndrome	
Transient tachypnea of the newborn	
Congenital anomaly	
Any oxygen use	
Any mechanical ventilation	
Any continuous positive airway pressure	

possibility that a NICU admission was unwarranted. Potential reasonable diagnosis for NICU admission not accounted for in the analysis exists. If the common reasons for NICU admission in the study population are accounted for in Table 1, the degree of inter-NICU variation should then be small.

The study analysis included descriptive statistics, χ^2 tests for unadjusted site comparison and categorical data, and mixed linear analysis for the NICU length of stay comparison based on identified cause (adjusting for gestational age). Generalized logistical regression allowed for modeling of comparative NICU admission percentages based on absolute/absolute + relative diagnosis, hospital characteristic (eg, hospital type, NICU level, in-house neonatology coverage, number of annual deliveries in 2006), and demographic characteristics (eg, public versus private insurance, maternal race/ethnicity, year of birth, gestational age). Generalized regression models allowed for adjusted site comparison (Wald χ^2 tests with estimated margin means). Model comparisons included comparative Akaike information criterion and dispersion characteristics (value/df). There was redundancy in hospital subcharacteristics, with individual hospital de-identified site used in multivariate modeling. Use of this variable improved model characteristics compared with inclusion of subcharacteristics in modeling of NICU admission percentages based on absolute + relative diagnosis.

RESULTS

The complete CSL database consisted of 233 844 live births from 19 hospitals. Characteristics of the 19 hospitals/NICUs are presented in Table 2. Among the 217 442 infants 35 to 42 weeks' gestation, there were 19 213 NICU admissions. There was a wide range between hospitals in NICU admission rates (NICU admission/total hospital births) among infants who were ≥35 weeks' gestation at birth according to birth weight, maternal chorioamnionitis, and maternal recreational drug use (Table 3). Among infants admitted to the NICU, the percentage of infants admitted without an absolute or relative identifiable cause (as defined earlier) is presented in Table 4. There was wide variation in the percentage of NICU admissions without an absolute or relative identifiable cause among the 19 NICUs (Fig 1); this variation was statistically significant for all absolute and relative categories for NICU admission (range, 0%–59.4%; mean, 10.8%; $P < .001$).

In multivariate modeling, hospital site was the most important variable associated with percentage of NICU admissions with absolute or relative causes. Interhospital variation for percent NICU admissions without an identifiable cause remained statistically significant across all models when controlling for birth gestational age, race/ethnicity, and insurance. Inclusion of birth gestational age slightly improved model characteristics. Year of birth was not statistically significant.

Among infants ≥35 weeks' gestation, infants without an identified cause (most inclusive category) for NICU admission accounted for 9.1% of the total NICU admission days. Controlling for gestational age, the mean NICU length of stay was 2.7 days shorter (95% confidence interval, –3.4 to –2.1; $P < .001$) for infants with no identifiable cause (most inclusive category) compared with those infants with an identifiable cause.

TABLE 2 Hospital Site Characteristics

Site	NICU Level	Hospital Type	No. of Deliveries/Year
1	3	University	4647
2	3	Teaching community	6730
3	3	Teaching community	4172
4	2	University	2810
5	3	University	3665
6	3	University	3472
7	0	Nonteaching	2251
8	2	Nonteaching	3856
9	3	Teaching community	4417
10	3	Teaching community	4390
11	3	University	6883
12	3	Teaching community	4063
13	3	Teaching community	2731
14	3	Teaching community	3782
15	3	University	6513
16	2	Teaching community	1689
17	3	Teaching community	7124
18	3	University	1309
19	3	University	2536

DISCUSSION

This study found that there was a high rate of unexplained variability in the percentage of NICU admissions among infants 35 to 42 weeks' gestation without an identifiable

TABLE 3 NICU Admission by Birthweight, Maternal Chorioamnionitis, and Recreational Drug Use

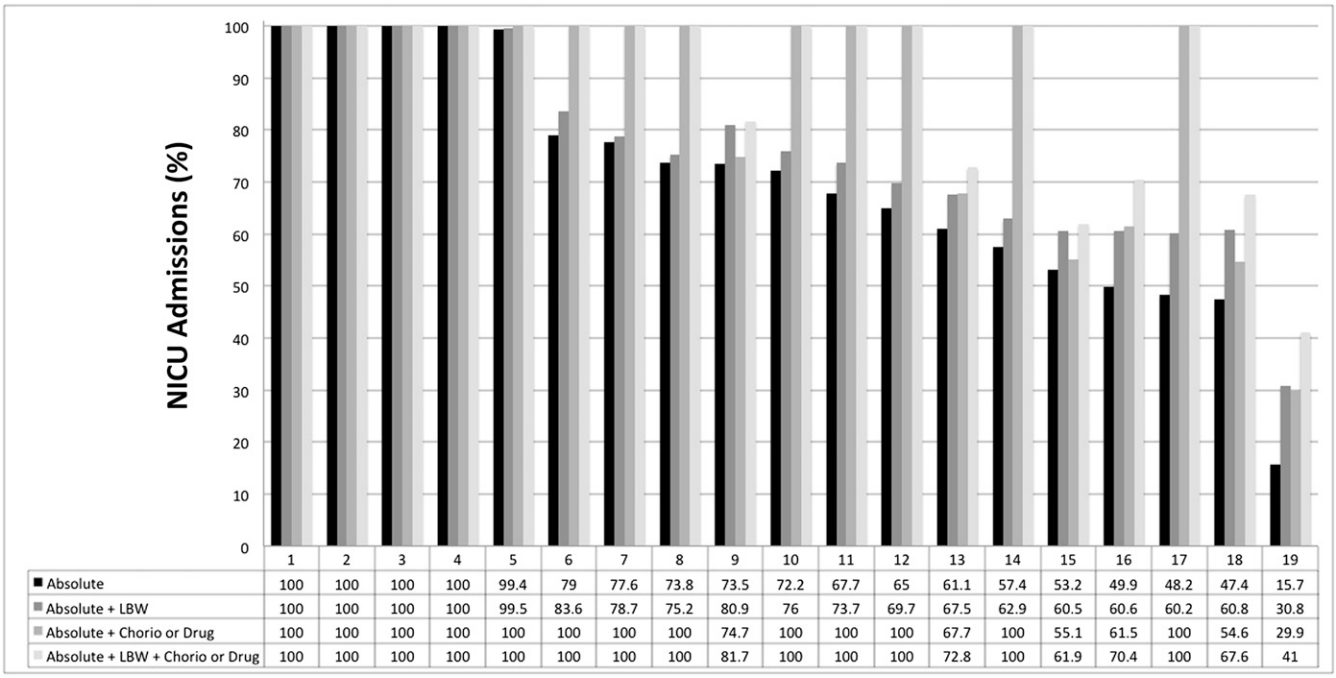
Data for All NICUs ($N = 19$)	% of Hospital Births ≥35 Weeks' Gestation Admitted to the NICU			
	Birth Weight		Maternal Chorioamnionitis	Maternal Recreational Drug Use
	≤2000 g	≤2500 g		
Range, %	9.1–98.6	7.0–58.6	6.0–91.7	2.8–71.1
P	<.001	<.001	<.001	<.001

TABLE 4 NICU Admission by Absolute and Relative Criteria

Variable	Criteria for Identifiable Cause for Admission	Admitted Without Identified Cause, %		
		Mean ± SD	Range	*P*
Absolute criteria for NICU admission	Identified intensive care service need (n = 17 327)	29.4 ± 23.0	0–84.3	<.001
Relative criteria for NICU admission	Identified intensive care service need or ≤2500 g (n = 17 604)	24.2 ± 18.6	0–69.2	<.001
	Identified intensive care service need or maternal chorioamnionitis or recreational drug use (n = 13 558)	13.5 ± 21.9	0–70.1	<.001
	Identified intensive care service need or ≤2500 g or maternal chorioamnionitis or recreational drug use (n = 14 472)	10.8 ± 17.8	0–59.0	<.001

cause in 19 hospitals (university, community-teaching, and community) from a geographically diverse database. Admission to the NICU can be lifesaving for those infants requiring intensive care services. For infants who are unnecessarily admitted to the NICU, in addition to separation from the mother, there are associated higher care expenditures. These data suggest that reducing institutional variability in NICU utilization may be an important target for cost reduction.

Because potential causes were gleaned from care provider declaration, institutional coding, and chart review, the data from this study represent a conservative analysis of NICU admissions without identifiable causes. We could not determine from our analysis the reasons behind the variability in NICU admissions without an identifiable cause. The sites themselves were diverse: they included 8 university teaching hospitals, 9 community teaching hospitals, and 2 nonteaching community hospitals. When determining the conditions included in the identifiable causes for NICU admission, we attempted to err on the more conservative side in developing the criteria, and we stratified the analysis along reasonable absolute and relative reasons for the need for NICU services. For example, 2500 g was chosen as the weight cutoff as a reason for an infant to be admitted to the NICU. By setting the weight threshold to 2500 g, we attempted to give sites more leeway in an acceptable reason to admit to the NICU, thereby decreasing variability. As evident in Table 3, some sites used a lower weight or



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Absolute	100	100	100	100	99.4	79	77.6	73.8	73.5	72.2	67.7	65	61.1	57.4	53.2	49.9	48.2	47.4	15.7
Absolute + LBW	100	100	100	100	99.5	83.6	78.7	75.2	80.9	76	73.7	69.7	67.5	62.9	60.5	60.6	60.2	60.8	30.8
Absolute + Chorio or Drug	100	100	100	100	100	100	100	100	74.7	100	100	100	67.7	100	55.1	61.5	100	54.6	29.9
Absolute + LBW + Chorio or Drug	100	100	100	100	100	100	100	100	81.7	100	100	100	72.8	100	61.9	70.4	100	67.6	41

FIGURE 1 Percentage of NICU admissions with an absolute or relative cause for NICU admission stratified according to site (de-identified 1–19); 100% indicates that an identified cause was met for all sites. The difference between 100% and the value is the percentage of infants admitted to the NICU without an identifiable absolute or relative cause. Chorio, chorioamnionitis; Drug, maternal recreational drug use; LBW, low birth weight.

did not use weight at all in determining NICU admission. We also included all recreational maternal drug use as an acceptable reason for NICU admission regardless of infant symptoms.

Despite being relatively "lenient" with our admission criteria, our study continued to show unexplained variability in NICU admissions without an identifiable cause between hospitals. Relative admission criteria may be a starting place to attempt to limit variability and deliver higher value care. Based on the criteria we used to determine unexplained NICU admissions, the variability between NICUs may be even greater then portrayed by our conservative analysis. Although our data are representative of geographically diverse NICUs, we did not assess utilization based on geography. Our data highlight the possibility that NICU utilization may be related to hospital-level factors in addition to infant-level factors.

Infants admitted to the NICU without identifiable cause had a shorter length of stay than those infants who had reason to be admitted. This finding provides further, although indirect, support that some of these infants may not have required NICU admission. It also illustrates the need to determine the multitude of potential factors influencing variation in NICU admissions. Decreasing variation may also allow the creation of a length of stay prediction model as previously described in the PICU population.[5,6] Such a tool would be important for benchmarking allowing institutional comparison of NICU utilization. Alternatively, the excess admissions without an identifiable cause may also be an appropriate medical decision for an individual infant based on a particular birth hospital's system-wide care plan. The fact that other birth hospitals can have lower unexplained admission percentages illustrates that opportunities exist for an individual hospital with elevated rates to improve their processes related to NICU admission.

To date, variability in NICU care has focused on specific therapies or bundles of care. Variability has been shown in provision of transfusions, respiratory care, and discharge policies.[7–10] Admission to the NICU and reasons for admission have been understudied. The high level of variability that exists between the NICUs (and within each individual NICU) when analyzing the absolute and different relative admission criteria indicate potential opportunities to reduce unnecessary NICU admissions. There are many potential explanations for why variability exists between hospitals in NICU admissions without an identifiable cause. Hospital-specific policies for NICU admission may play an important role in the observed variability. Our data suggest that further dialogue and standardization of these types of clinical pathways are needed to optimize NICU utilization.

Our study has a number of other important limitations. Although we obtained the potential causes through chart abstraction, inadequate chart documentation and chart-specific extraction may account for some degree of unexplained variation. We attempted to develop a comprehensive list of diagnoses that are common and would necessitate NICU admission. An important omission from our admission criteria was hypoglycemia requiring intravenous fluids or hyperbilirubinemia requiring phototherapy. These diagnoses may or may not be distributed equally across the 19 hospitals. The diagnoses would unlikely account for the wide variation seen between the highest and the lowest hospitals (maximum inter-NICU range, 83%). We cannot determine from these data whether infants truly needed admission to the NICU. Because we could not measure illness severity, there were likely infants outside of our set diagnostic criteria that warranted admission. There are likely further rare diagnoses that would warrant admission to the NICU that differ according to study center, but given the broadly comprehensive list (Table 1), this scenario is unlikely to explain more than a small proportion of the detected variability. We also acknowledge that data abstraction for this database commenced in 2002 and concluded in 2008.

Unwarranted variation in NICU admissions may represent poor utilization of health care systems and a suboptimal family–infant–birth hospital interaction. The data from this large cohort cannot be used to determine if different admission criteria between NICUs are appropriate given the individual systems of care within various hospital systems. NICU admission criteria may vary appropriately across centers to meet underlying patient safety needs due to nonequivalent systems of care characteristics between hospitals. The high level of variability indicates that there are potential opportunities to safely reduce a portion of the detected variability through NICU admission criteria and hospital system changes. Efficient use of NICU services has the potential to improve patient care and patient satisfaction and to reduce costs without compromising care. These findings indicate the need to initiate discussions among hospital centers, hospital leadership, neonatologists, and pediatric hospitalists regarding admission requirements for individual NICUs and systems of care to optimize non-NICU supportive maternal–newborn practices.

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