Original Investigation

# Epidemiologic Trends in Neonatal Intensive Care, 2007-2012

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**IMPORTANCE** Neonatal intensive care has been highly effective at improving newborn outcomes but is expensive and carries inherent risks. Existing studies of neonatal intensive care have focused on specific subsets of newborns and lack a population-based perspective.

**OBJECTIVES** To describe admission rates to neonatal intensive care units (NICUs) for US newborns across the entire continuum of birth weight and how these rates have changed across time, as well as describe the characteristics of infants admitted to NICUs.

**DESIGN, SETTING, AND PARTICIPANTS** An epidemiologic time-trend analysis was conducted on April 1, 2015, of live births (≥500 g) from January 1, 2007, to December 31, 2012, to residents of 38 US states and the District of Columbia, recorded using the 2003 revision of the US Standard Certificate of Live Birth (N = 17 896 048).

**EXPOSURE** Birth year.

**MAIN OUTCOMES AND MEASURES** Crude, stratified (by birth weight), and adjusted admission rates. Trends in birth weight, gestational age, weight for gestational age, and use of assisted ventilation are presented to describe the cohort of admitted newborns.

**RESULTS** In 2012, there were 43.0 NICU admissions per 1000 normal-birth-weight infants (2500-3999 g), while the admission rate for very low-birth-weight infants (<1500 g) was 844.1 per 1000 live births. Overall, admission rates during the 6-year study period increased from 64.0 to 77.9 per 1000 live births (relative rate, 1.22; 95% CI, 1.21-1.22 [*P* < .001]). Admission rates increased for all birth weight categories. Trends in relative rates adjusted for maternal and newborn characteristics showed a similar 23% increase (95% CI, 1.22-1.23 [*P* < .001]). During the study period, newborns admitted to a NICU were larger and less premature, although no consistent trend was seen in weight for gestational age or the use of assisted ventilation.

**CONCLUSIONS AND RELEVANCE** After adjustment for infant and maternal risk factors, US newborns at all birth weights are increasingly likely to be admitted to a NICU, which raises the possibility of overuse of neonatal intensive care in some newborns. Further study is needed into the causes of the increased use observed in our study as well as its implications for payers, policymakers, families, and newborns.

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Since the establishment of the first US neonatal intensive care unit (NICU) in 1960,[1] the neonatal mortality rate has fallen more than 4-fold, from 18.73 per 1000 live births to 4.04 per 1000 live births in 2012.[2] Much of this decline can be attributed to the highly specialized care provided to premature and sick infants by neonatologists and multidisciplinary teams working in NICUs.[3,4]

This success has been the result of highly effective specific interventions,[4] as well as improved identification of risk factors coupled with regional efforts to ensure birth in hospitals with the appropriate level of newborn care.[5] Many NICUs have also engaged in long-standing research and quality improvement activities, most notably through the Vermont Oxford Network.[6] Most NICU research studies, however, have examined care within the NICU itself and are limited to specific populations of newborns (eg, <1500 g).[6] These infants are most likely to benefit from neonatal intensive care, and their delivery at a hospital with a level III NICU is considered a system performance measure.[7,8] However, few studies have looked beyond very low-birth-weight infants admitted to the NICU to examine how neonatal intensive care relates more broadly to newborn care.[9,10]

Newborns, including those who are full term and of normal birth weight, are admitted to a NICU for many types of illness. Every newborn admitted to a NICU experiences the benefits of such highly specialized care and is exposed to the associated risks and high costs. Despite the published research into interventions or patterns of care for specific populations, there has been no published study examining NICU admission rates across the entire range of newborn morbidity because the necessary data have, until recently, been unavailable or difficult to access. The 2003 revision to the US Standard Certificate of Live Birth, however, includes a new field indicating whether a newborn is admitted to a NICU.[11] This data element presents an opportunity to examine the epidemiologic trends of neonatal intensive care for the majority of the US newborn population across time.

This study represents a population-based examination of the epidemiologic trends of NICU admissions in the United States. Using vital statistics data from the Centers for Disease Control and Prevention (CDC), we report the risk of admission for the US birth cohort and the characteristics of newborns admitted to NICUs in the United States; in addition, we examine the trends in admissions from 2007 to 2012.

**At a Glance**

- Using national vital statistics data, this population-based study describes the risk of NICU admission for US newborns across the entire birth weight spectrum and how this risk changed during a 6-year study period.
- In 2012, there were 77.9 NICU admissions per 1000 live births, ranging from 43.0 for normal-birth-weight infants (2500-3999 g) to 844.1 per 1000 for very low-birth-weight infants (<1500 g).
- Between 2007 and 2012, overall admission rates demonstrated a relative increase of 23% (64.0 to 77.9 per 1000) after adjustment for maternal and newborn characteristics.
- Newborns admitted to NICUs are increasingly likely to be full term and of normal birth weight. By 2012, more than half of all newborns admitted to a NICU were at least 2500 g at birth.

## Methods

### Data Source and Study Population

We conducted a retrospective study on April 1, 2015, using the Birth Public Use Data Files[12] representing the US live birth cohort from January 1, 2007, to December 31, 2012. Individual births represent both the unit of observation and analysis. Our analysis is limited to births recorded using the 2003 US Standard Certificate of Live Birth, as the previous version did not contain a field indicating whether an infant was admitted to a NICU (subsequently referred to as the revised and unrevised certificates). A total of 17 896 048 newborns from January 1, 2007, to December 31, 2012, from 38 states and the District of Columbia, representing 72.9% of the total birth cohort, were included, which ranged from 22 states and 55.2% of the total birth cohort in 2007 to 39 states and 88.3% of the total birth cohort in 2012. Infants weighing less than 500 g were excluded from analysis since they are not always considered viable and are inconsistently recorded as live births. Consistent with CDC reporting, we also excluded births to mothers who were not US residents (residents include citizens, legal residents, and undocumented residents). These 2 exclusions applied to 26 769 (0.15%) and 38 753 (0.22%) births, respectively. This study was determined to be exempt from institutional review board approval by the Dartmouth College Committee for the Protection of Human Subjects.

### Outcome Measures

Our primary outcome was admission to a NICU. The American Academy of Pediatrics designates 4 levels of neonatal care.[8] Level I nurseries represent well newborn nurseries and provide ongoing care for stable term infants. Level II units are alternately referred to as *intermediate* or *special care* nurseries and sometimes as *level II NICUs*. These units are capable of providing comprehensive care for moderately ill or preterm infants, initial supportive care for high-risk infants before transfer to a level III unit, or convalescent care following postnatal growth and maturation at a level III or IV nursery. These units are able to "provide mechanical ventilation for brief duration (<24 h) or continuous positive airway pressure or both."[8(p592)] Level III units are identified as NICUs and are capable of providing comprehensive care for high-risk infants, including "a full range of respiratory support."[8(p592)] Level IV NICUs have the added availability of pediatric surgical subspecialists. For the purposes of birth certificate reporting, the CDC defines NICU admission as "admission into a facility or unit staffed and equipped to provide *continuous* mechanical ventilator support for the newborn."[11(p195)] This definition approximates the American Academy of Pediatrics designation of a level III or IV nursery.

Our prespecified secondary outcome measures were the birth weight and gestational age composition of US NICU admissions. We also examined trends in the NICU cohort by weight for gestational age and the use of assisted ventilation for more than 6 hours.

### Statistical Analysis

We first calculated crude rates and proportions. For admission rates, the denominator was live births of infants weighing 500 g or more. For proportions, the denominator was live births of infants weighing 500 g or more admitted to a NICU.

We performed a time-trend analysis of crude, stratified (by birth weight), and adjusted admission rates by year from 2007 to 2012. Birth weight stratifications used were 500 to 1499 g, 1500 to 2499 g, 2500 to 3999 g, and 4000 g or more. These stratifications approximate standard epidemiologic definitions of very low birth weight (≤1499 g), low birth weight (≤2499 g), normal birth weight (2500-3999 g), and high birth weight (≥4000 g). Modified Poisson regression with robust error variance was used to determine adjusted relative rates.[13] Covariates used for adjustment were adapted from a model developed by the CDC to describe admission rates for infants weighing 1499 g or less.[14] These covariates included infant characteristics of gestational age (≤27, 28-31, 32-36, or ≥37 weeks), plurality (singleton, twin, or triplet or more), delivery mode (vaginal or cesarean), and sex. Maternal characteristics included parity (0, 1, 2, or ≥3 previous deliveries), race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic Black, or non-Hispanic other), age (≤19, 20-24, 25-29, 30-34, 35-39, or ≥40 years), and educational level (<12, 12, 13-15, or ≥16 years). Priority for assigning gestational age was given to the obstetric estimate as opposed to that calculated from the last menstrual period since the former has been shown to be more accurate.[15] We included the following 3 additional variables in our full model: weight for gestational age (small, appropriate, or large),[16] 5-minute Apgar scores (≤3, 4-6, or 7-10), and birth weight (500-999 g, 1000-1499 g, 1500-2499 g, 2500-3999 g, and ≥4000 g). Weight for gestational age and Apgar scores were included to represent indicators of newborn health status that are reliably reported in birth certificate data. Different methods for categorizing the variables for birth weight and gestational age were tested, including higher-order polynomials of continuous variables, which failed to meaningfully affect our findings. We tested other potential covariates including maternal smoking, prenatal care, complications of pregnancy and delivery, and obstetric procedures. Adding these covariates failed to alter our findings. In addition, there are concerns about their reliability from birth certificate data, and so they were not included in our final models.[17-21]

For our secondary outcome, we performed a time-trend analysis using unadjusted percentages to show how the composition of the NICU cohort changed between 2007 and 2012. Simple linear regression (ie, treating each year as an observation) was used to test for significance in the observed trends by year. This regression is similar to conducting a $\chi^2$ test of trend but decreases the potential of a type I error owing to the large number of observations.

Statistical testing of population characteristics in **Table 1** is not reported because the large sample size causes nonmeaningful differences to be statistically significant. Instead, maternal and newborn characteristics of the study population during the study period were examined, as well as births occurring in states using the unrevised birth certificate. Statistical analysis was performed using Stata, version 13.1 (StataCorp). More information on the specifications of birth certificate variables is available from the CDC.[11]

## Results

### Study Population

The study population in the first and final years of observation is shown in Table 1. In general, newborn characteristics were consistent throughout the study period 2007 to 2012. Of particular note, birth weight and gestational age, the most important indicators of newborn risk, did not appreciably differ from year to year. However, within the study population, the percentage of infants born to Hispanic mothers decreased while those to non-Hispanic mothers of all races increased. Maternal age and educational level increased slightly.

Evaluating the source of these changes requires comparing births recorded using the revised vs unrevised certificates during the study period. Trends in maternal age from 2007 to 2012 are similar between states using the revised and unrevised certificates, suggesting that these represent secular trends of fewer births to teenage mothers and those in their early 20s. Maternal educational level was not reported for states using the unrevised certificate from 2009 forward, and so the source of these changes could not be examined directly, although it is likely that they are related to the trends seen in maternal age. Conversely, the states using the revised vs unrevised certificates appeared different in regard to maternal race/ethnicity, with complementary trends such that the percentages converged to look more similar in 2012 than in 2007, suggesting that these changes are the result of demographic differences between states implementing the revised birth certificate earlier compared with later. However, any differences in the maternal and newborn characteristics shown in Table 1 are accounted for in the adjusted model.

### 2012 NICU Admissions by Birth Weight

**Figure 1** plots the risk of NICU admission by birth weight for newborns in 2012 (the most recent year of our study and for which the most complete data were available). While admission rates for newborns weighing less than 1500 g are the highest of any birth weight category, they comprise only 13.8% of total NICU admissions. Newborns weighing between 3000 and 3999 g are the least likely to be admitted, while the likelihood of admission then rises again for macrosomic infants, particularly those weighing 5000 g or more (17.8%). Infants weighing more than 2500 g represent more than half of all admissions despite their lower risk of serious illness owing to the fact that they comprise more than 90% of the live birth cohort.

### NICU Admission Time Trends

Crude admission rates increased steadily during the study period, from 64.0 per 1000 live births in 2007 to 77.9 per 1000 live births in 2012 (**Table 2**), representing an absolute increase in the admission rate of 13.9 and a relative increase of 22% in 5 years (relative rate, 1.22; 95% CI, 1.21-1.22 [$P < .001$]). Adjusted rates differed little from crude rates and showed a similar relative increase of 23% (relative rate, 1.23; 95% CI, 1.22-

Table 1. Newborn and Maternal Characteristics

| Characteristic | 2007 (n = 4 309 359) | | 2012 (n = 3 946 894) | |
|---|---|---|---|---|
| | Unrevised (1 930 890)[a] | Revised (2 378 469) | Unrevised (463 343) | Revised (3 483 551) |
| Use of revised form | | | | |
| States, No. | 22 | | 39[b] | |
| Births, % | 55.2 | | 88.3 | |
| Newborn characteristics, %[c] | | | | |
| Birth weight, g[d] | | | | |
| 500-1499 | 1.4 | 1.3 | 1.3 | 1.3 |
| 1500-2499 | 6.9 | 6.6 | 6.9 | 6.5 |
| 2500-3999 | 84.1 | 84.4 | 84.2 | 84.2 |
| ≥4000 | 7.7 | 7.7 | 7.6 | 8.0 |
| Gestational age, wk | | | | |
| ≤27 | 0.6 | 0.6 | 0.6 | 0.6 |
| 28-31 | 1.0 | 1.0 | 0.9 | 0.9 |
| 32-36 | 8.8 | 8.7 | 8.5 | 8.1 |
| ≥37 | 89.6 | 89.7 | 89.9 | 90.4 |
| Size for gestational age | | | | |
| Small | 10.6 | 10.1 | 10.6 | 10.3 |
| Appropriate | 79.8 | 79.9 | 79.9 | 79.9 |
| Large | 9.5 | 10.0 | 9.6 | 9.8 |
| Male sex | 51.1 | 51.2 | 51.0 | 51.2 |
| Multiple gestations | 3.4 | 3.2 | 3.5 | 3.4 |
| Cesarean delivery | 31.2 | 32.3 | 33.8 | 32.7 |
| 5-Minute Apgar score | | | | |
| ≤3 | 0.3 | 0.5 | 0.3 | 0.5 |
| 4-6 | 0.8 | 1.3 | 0.9 | 1.4 |
| ≥7 | 98.9 | 98.3 | 98.8 | 98.1 |
| Maternal characteristics, %[c] | | | | |
| Race/ethnicity | | | | |
| Hispanic | 18.2 | 30.2 | 19.1 | 23.7 |
| White non-Hispanic | 56.7 | 51.7 | 54.9 | 54.4 |
| Black non-Hispanic | 17.8 | 12.0 | 16.4 | 14.6 |
| Other non-Hispanic | 7.3 | 6.1 | 9.6 | 7.3 |
| Maternal age, y | | | | |
| ≤19 | 10.1 | 10.7 | 8.2 | 7.8 |
| 20-24 | 24.8 | 25.3 | 24.0 | 23.1 |
| 25-29 | 28.1 | 27.9 | 28.0 | 28.5 |
| 30-34 | 22.6 | 22.0 | 25.1 | 25.7 |
| 35-39 | 11.8 | 11.4 | 11.8 | 12.0 |
| ≥40 | 2.6 | 2.6 | 2.9 | 3.0 |
| Maternal educational level[e] | | | | |
| <12 | 19.0 | 22.9 | NR | 17.0 |
| 12 | 30.1 | 27.1 | NR | 24.9 |
| 13-15 | 22.0 | 26.1 | NR | 28.9 |
| ≥16 | 29.0 | 23.9 | NR | 29.2 |
| Primaparous | 40.5 | 39.9 | 40.2 | 39.9 |

Abbreviation: NR, not reported.

[a] Since admission to a neonatal intensive care unit appears only on the 2003 certificate, births recorded using the revised certificate represent the study population. Characteristics from states using the 1989 certificate, unrevised, are presented here for comparison.

[b] Thirty-eight states and the District of Columbia.

[c] Percentages may not total 100% owing to rounding.

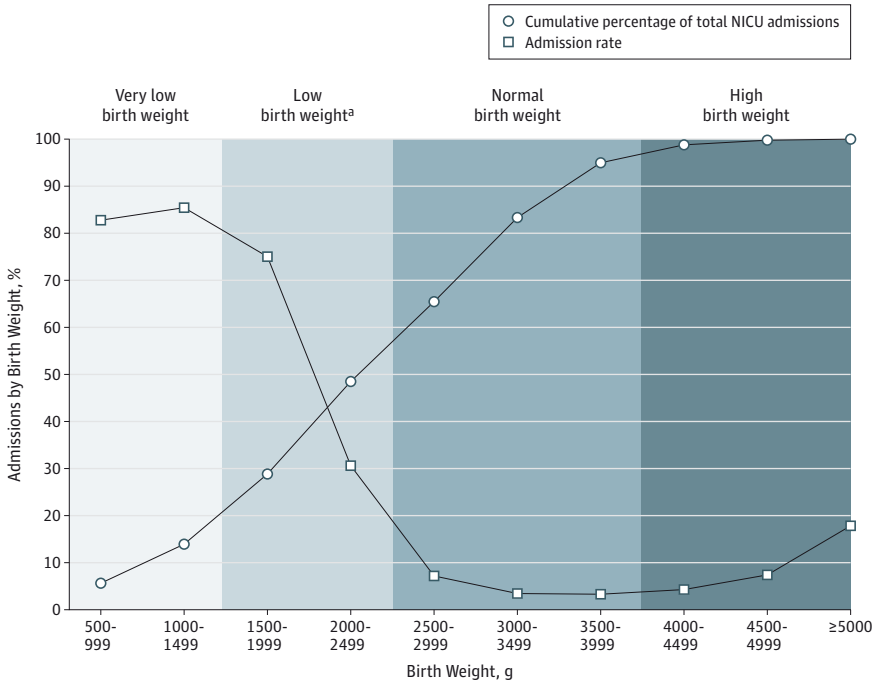
[d] As noted in the Methods section, these stratifications approximate the definitions of very low birth weight (≤1499 g), low birth weight (≤2499 g), normal birth weight (2500-3999 g), and high birth weight (≥4000 g).

[e] This information was not available for states using the 1989 birth certificate from 2009 forward.

1.23 [$P < .001$]). Admission rates increased during the study period within each birth weight classification as well. Absolute changes were greatest for lower birth weights, while relative increases were greater for larger infants. Sensitivity testing limiting our analysis to the same 22 states showed similar results (eTable 1 in the Supplement).

**Figure 2** shows how the cohort of newborns admitted to a NICU changed during the study period. From 2007 to 2012, NICUs increasingly admitted term infants of higher birth weights; by 2012, nearly half of all NICU admissions were for normal-birth-weight infants or for those born at 37 weeks gestational age or older. These changes in proportions of infants

Figure 1. Level III and IV NICU Admissions by Birth Weight for the 2012 US Birth Cohort




The admission rate uses the total 2012 US birth cohort as the denominator, whereas the denominator for the cumulative percentage of total neonatal intensive care unit (NICU) admissions represents only US newborns admitted to a NICU.

[a] Indicates low birth weight exclusive of very low-birth-weight designation.

Table 2. Crude, Stratified, and Adjusted Level III and IV Neonatal Intensive Care Unit Admission Rates

| Admission by Weight | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| All newborns | | | | | | |
| Crude rate[a] | 64.0 | 66.7 | 70.7 | 74.7 | 75.3 | 77.9 |
| Crude RR | 1 [Reference] | 1.04[c] (1.04-1.05) | 1.10[c] (1.10-1.11) | 1.17[c] (1.16-1.18) | 1.18[c] (1.17-1.19) | 1.22[c] (1.21-1.22) |
| Adjusted RR[b] | 1 [Reference] | 1.04[c] (1.04-1.05) | 1.11[c] (1.10-1.11) | 1.17[c] (1.16-1.17) | 1.18[c] (1.18-1.19) | 1.23[c] (1.22-1.23) |
| Stratified by birth weight | | | | | | |
| 500-1499 g | | | | | | |
| Crude rate[a] | 800.1 | 800.9 | 811.8 | 821.5 | 833.5 | 844.1 |
| Adjusted RR[b] | 1 [Reference] | 1.00[d] (0.99-1.01) | 1.01[e] (1.00-1.02) | 1.02[c] (1.01-1.03) | 1.03[c] (1.03-1.04) | 1.05[c] (1.04-1.05) |
| 1500-2499 g | | | | | | |
| Crude rate[a] | 361.2 | 367.9 | 383.4 | 394.5 | 401.0 | 411.8 |
| Adjusted RR[b] | 1 [Reference] | 1.02[c] (1.02-1.03) | 1.07[c] (1.06-1.08) | 1.10[c] (1.09-1.11) | 1.12[c] (1.11-1.13) | 1.15[c] (1.14-1.16) |
| 2500-3999 g | | | | | | |
| Crude rate[a] | 32.0 | 34.4 | 37.5 | 40.6 | 40.6 | 43.0 |
| Adjusted RR[b] | 1 [Reference] | 1.07[c] (1.06-1.08) | 1.18[c] (1.16-1.19) | 1.27[c] (1.26-1.28) | 1.28[c] (1.27-1.30) | 1.35[c] (1.34-1.36) |
| ≥4000 g | | | | | | |
| Crude rate[a] | 36.5 | 39.6 | 42.9 | 46.6 | 48.5 | 49.3 |
| Adjusted RR[b] | 1 [Reference] | 1.06[c] (1.03-1.10) | 1.15[c] (1.12-1.19) | 1.26[c] (1.23-1.30) | 1.33[c] (1.29-1.36) | 1.34[c] (1.30-1.38) |

Abbreviation: RR, relative rate.

[a] Rates are per 1000 live births ≥500 g to US residents.

[b] Adjusted for birth weight (unless stratified), gestational age, weight for gestational age, sex, multiple gestation, delivery method, Apgar score, race/ethnicity, maternal age, educational level, and parity.

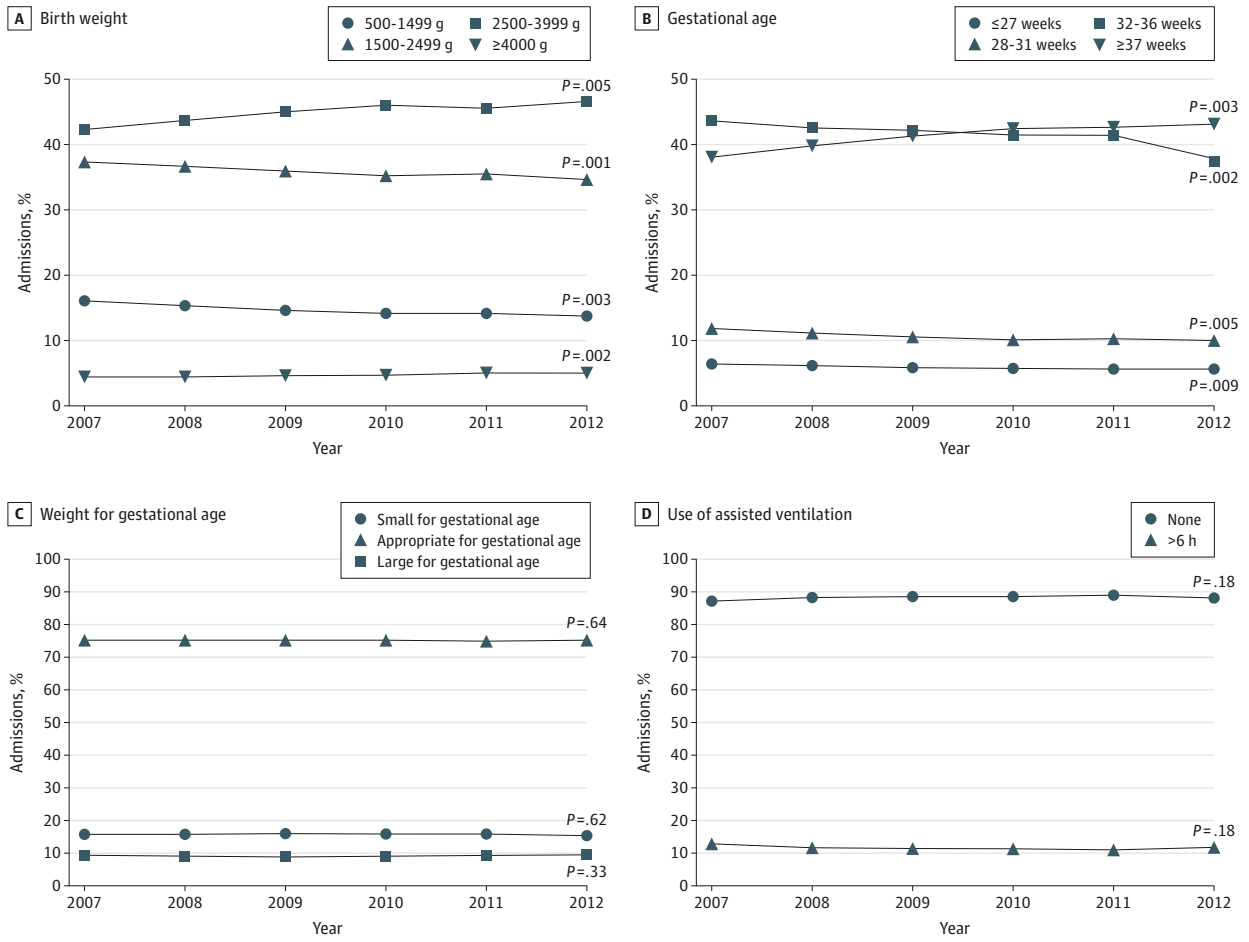
[c] $P < .001$.

[d] $P = .89$.

[e] $P = .005$.

by birth weight and gestational age were all statistically significant (birth weight: 500-1499 g, $P = .003$; 1500-2499 g, $P = .001$; 2500-3999 g, $P = .005$; and ≥4000 g, $P = .002$; gestational age: ≤27 weeks, $P = .009$; 28-31 weeks, $P = .005$; 32-36 weeks, $P = .002$; and ≥37 weeks, $P = .003$). In contrast, no significant trend was seen in the proportion of newborns admit-

Figure 2. Trends in the Composition of Level III and IV NICU Admissions by Newborn Risk Factors




A, Proportion of admissions by birth weight. B, Proportion of admissions by gestational age. C, Proportion of admissions by weight for gestational age. D, Proportion of admissions by use of assisted ventilation.

ted to NICUs who were small (*P* = .62), appropriate (*P* = .64), or large for gestational age (*P* = .33) or in the proportion of newborns receiving assisted ventilation for more than 6 hours (*P* = .18).

## Discussion

Using population-based data, our study demonstrates that NICU admission rates increased steadily from 2007 to 2012. After adjustment for infant and maternal characteristics likely to influence a newborn's chance for NICU admission, rates still showed a relative increase of 23% during the 6 years of the study. If these findings are applied to the total US birth cohort of almost 4 million, they indicate that, compared with 2007, approximately 58 000 additional NICU admissions occurred in 2012 alone, 38 000 of which were for normal-birth-weight infants.

How might one interpret these findings? On the one hand, neonatal intensive care is effective and has, without question, saved the lives of many newborns. On the other, it is very expensive and exposes families and newborns to additional stress and iatrogenic risks.[22-24] The increased admission rates for very low-birth-weight infants from 80% to nearly 85% support the former, more optimistic, interpretation since these infants are likely to benefit from neonatal intensive care and experience better outcomes when born in hospitals with a level III NICU.[25] Alternatively, the increase in adjusted admission rates for the entire birth cohort and, more specifically, for normal-birth-weight infants might be a cause for concern if less critically ill newborns are increasingly exposed to intensive and costly care. To our knowledge, this aspect of newborn services is understudied.

We cannot definitively state from our data whether the lower admission rates in 2007 or the higher rates seen more recently are closer to the "correct" rate. Previous studies, however, place our findings in context and may offer some clues as to their interpretation. Beginning in the 1970s, regionalized systems of perinatal care were developed with the goal of ensuring that premature and low-birth-weight infants deliver at regional level III NICUs, while healthy and less sick infants are cared for at level I and level II nurseries.[8] In the en-

suing 4 decades, growth in the neonatology workforce and bed capacity has been robust but poorly related to regional perinatal needs.[26-29] A cross-sectional analysis using linked birth-death certificate data from 1995 showed that higher regional neonatologist and NICU bed supply was associated with limited or no survival benefit.[30] Other work has suggested that this growth in NICUs contributed toward the deregionalization of perinatal care, with increasing numbers of high-risk births occurring in low-volume and low-level community NICUs.[29,31] Rather than improving outcomes through increased access, deregionalization appears to be associated with increased mortality for very low-birth-weight infants.[25,29,32]

Our findings that newborns admitted to NICUs are increasingly likely to be at term and of normal or high birth weight, combined with rising admission rates, raises the question of whether deregionalization may have also affected the care received by larger newborns. Initially developed to care for very premature and low-birth-weight infants, NICUs are now caring for a growing population of newborns that are larger and less ill. It may be that the development of transitional care areas within level III NICUs has led to more low- to moderate-risk newborns being admitted for short periods of observation only. Although they would be exposed to fewer interventions and invasive procedures than other NICU infants, this level of care may still be unnecessary, with the potential for negative effects. Spending unnecessary time in a NICU can contribute to family distress related to altered parental roles, higher costs, and the increased medicalization of a generally healthy birth.[33-35] This finding raises important questions about potential overuse and how to appropriately use this resource in a way that is efficient and effective.

Our study has several limitations. First, given our data source, we were unable to study patterns for level II nursery admissions. It could be that these increased admission rates represent substitutions for level II admissions rather than true increases among newborns previously cared for in normal newborn nurseries or that they reflect growth in so-called level II+ NICUs, which can provide mechanical ventilation, as had been observed in California 20 years ago.[36] Second, we cannot be certain that NICU admissions are recorded accurately in all instances. However, a 2011 report from the March of Dimes using registry data found gestational age–specific level III NICU admission rates similar to those seen in our birth certificate data.[37] Third, there exists the potential for inaccurate recording of maternal and newborn characteristics in our data; however, previous studies validating birth certificate data have found that they perform well for the variables included in our analysis.[17,38,39] Similarly, not all potentially important risk factors are recorded in birth certificates. Such factors may include payer (not available for all years) or maternal health status and complications of labor and delivery (owing to inaccurate reporting).[39] For example, in noting the increasing birth weights seen in the NICU cohort, it may be that trends in maternal obesity and gestational diabetes are contributing factors.[40] However, no consistent trend was seen in the proportion of NICU infants who were large for gestational age; furthermore, sensitivity analysis excluding these infants from our regression model failed to meaningfully alter our findings (eTable 2 in the Supplement). A final limitation of our study is that it was unable to measure outcomes beyond the NICU admission itself, such as neonatal mortality and long-term morbidity, costs of care, or complications.

Even with these limitations, it is likely that our results identify a true signal—that NICU admission rates increased during the study period independent of patient characteristics. This study should be viewed as a first step toward examining how neonatal intensive care is provided to the full spectrum of US newborns. Further efforts are needed to investigate the potential causes and consequences of these trends using additional data on patients (eg, registry data to better classify severity of illness), health systems (eg, supply of NICU beds), and outcomes (eg, claims data to determine costs and length of stay).

## Conclusions

Newborns in the United States are increasingly likely to be admitted to a NICU, and these units are increasingly caring for normal-birth-weight and term infants. The implications of these trends are not clear, but our findings raise questions about how this high-intensity resource is being used.


### ARTICLE INFORMATION

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*Acquisition, analysis, or interpretation of data:* Both authors.
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*Statistical analysis:* Harrison.
*Obtained funding:* Goodman.
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**Correction:** This article was corrected on August 13, 2015, to fix a text error in the Abstract.


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