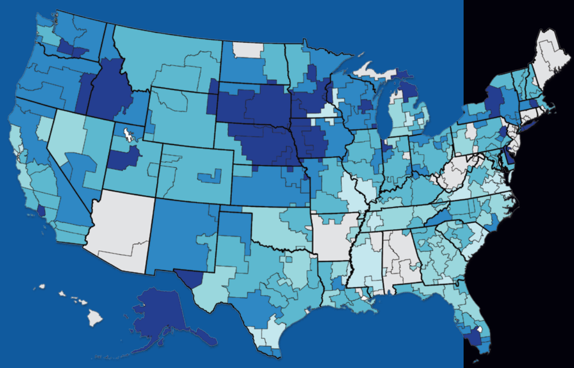

The Dartmouth Atlas of Neonatal Intensive Care

A Report of the Dartmouth Atlas Project

THE Dartmouth INSTITUTE
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A Report of the Dartmouth Atlas Project

Fall 2019

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Unus pro omnibus, omnes pro uno

Table of Contents

1. Introduction

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List of Abbreviations and Acronyms

CMS Centers for Medicare and Medicaid Services
CPQCC California Perinatal Quality Care Collaborative
CDC Centers for Disease Control
GA Gestational Age
LOS Length of Stay
LPT Late Preterm
MRI Magnetic Resonance Imaging
NICU Neonatal Intensive Care Unit
NICR Neonatal Intensive Care Region
NNN Norwegian Neonatal Network
SCD Special Care Days
TNP Texas Neonatal Intensive Care Project
VON Vermont Oxford Network
VLBW Very Low Birth Weight

Almost four million births occur in the United States each year. Ensuring the health and wellbeing of these infants is essential to the country's vitality and to future generations. Given that the quality of medical and surgical care is of central importance to a newborn's early chances, it might be expected that neonatal health care and outcomes are measured routinely. With some notable exceptions, this is not true. Overall, we know far less about health care for newborns than for any other patient group.

This Dartmouth Atlas report provides a comprehensive description of population-based patterns of newborn care across regions and hospitals for four large U.S. newborn populations: the U.S. total birth cohort, the Medicaid-insured newborns of Texas, and newborns insured by Anthem Blue Cross Blue Shield commercial and Medicaid plans. Population-based analyses start with an entire newborn population, not selected by health status or place of care. From this study population, medical care utilization of both mildly and very ill newborns is measured across all hospitals, regardless of whether care was provided in a neonatal intensive care unit. Similar analyses are also included from a groundbreaking report[1] of Norwegian newborns, who share a high degree of socioeconomic and racial/ethnic similarity and receive care in a tightly organized national health service that offers services equitably to all.

Population-based Newborn Studies

This Dartmouth Atlas report uses several types of population-based data to measure and understand newborn care. In this approach, an entire newborn population is identified (i.e., the U.S. birth cohort or Anthem-insured newborns) and care is measured from birth forward.

Population-based studies have a number of distinct strengths and weaknesses. A primary weakness compared to member-based collaboratives (e.g., the Vermont-Oxford Network or the California Perinatal Quality Care Collaborative (CPQCC)) is that the datasets generally rely on information collected for vital records (birth and death certificates) and billing purposes (insurance claims). Some relevant clinical data is not included, and the data are available only one to two years after the care was provided. Interpretation of the findings, of course, is limited to the particular population included in the cohort.

Population-based studies also have some notable strengths. The analyses include the experience of all newborns in the birth cohort regardless of health status, the hospital where they received care, or whether they were admitted to a NICU. This is particularly important for less severely ill newborns (e.g., late preterm newborns) where the majority are not admitted to a NICU. Inclusion in the dataset is not dependent on the willingness of the hospital to participate. Newborns can be followed both at the hospital of birth and at any other hospitals to which they are transferred. Most importantly, newborn care and outcomes can be measured after they are discharged home.

The cost and possible overuse of NICU care are growing concerns as the number of NICU beds expands. Population-based studies are often a better choice than member-based collaboratives to examine these issues which are important, but may impact hospitals' revenue or reputations, particularly when coupled with public reporting. It should, however, be noted that some of the best documented efforts to remedy overuse in newborn care, such as the reduction of needless antibiotic use, have been done under the auspices of the VON and the CPQCC.

The Vermont-Oxford Network

Established as a not-for-profit research collaborative of neonatal intensive care units (NICUs) in 1988, the Vermont Oxford Network (VON) includes over 1,200 hospitals worldwide committed to improving NICU care through quality improvement efforts, education, and research. Individual centers voluntarily submit clinical data including patient characteristics, interventions, and outcomes, primarily during the NICU stay. Originally, VON collected data on very low birth weight newborns (401-1,500 grams or 22-29 weeks gestation) admitted to a member unit. Today, over half of VON members report data on all NICU admissions. Some members also report health and developmental data for extremely low birth weight infants at 18 to 24 months. VON data collection uses standardized definitions with numerous quality controls.

VON members receive reports of risk-adjusted performance measures for their own unit compared to anonymous peer NICUs. The VON also offers opportunities to participate in quality improvement collaboratives at the local, regional, or health system levels.

Why examine several groups of newborns? Each of the cohorts is associated with different types of information. While none has complete information on both utilization of care and outcomes, together they provide a consistent set of findings: the care of newborns varies widely across regions and hospitals, even after adjusting for differences in health status. These findings raise troubling questions about whether newborns are receiving the care that they need and that their families want.

Table 1.1. Study periods, number of live births, and number of regions included for each study population

	Years	Total live births	Number of regions
Section 2			
U.S. birth cohort	2013	3,940,764	246
Anthem BCBS	2010-2014	1,205,091	246
Commercial plans		698,865	
Medicaid plans		506,226	
Section 3			
Texas Medicaid	2010-2014	1,133,441	21
Section 4			
Norway	2009-2014	368,068	15

Note: The number of newborns and regions used for specific analyses may be lower.

Neonatal Intensive Care

This report focuses particularly on neonatal intensive care, one of the most effective and expensive modalities of pediatric care. Since its origin in the 1960s, neonatal intensive care has developed into a mature and widely available clinical service while undergoing robust growth in the number of neonatal intensive care unit (NICU) beds and clinicians across the United States.[2] Neonatal intensive care has greatly reduced newborn mortality and morbidity caused by prematurity, congenital anomalies, and other neonatal illnesses,[3,4] but many aspects of quality, outcomes, and efficiency of care remain incompletely documented and poorly understood.[5-12] As NICUs expand, analysis of the care provided has become more urgent. For very sick newborns, the benefits of NICUs clearly outweigh any risks. But those with less severe illnesses have less to gain from intensive care yet are still exposed to the possible adverse effects of a hospital setting designed primarily for critical care. Many NICUs are relatively bright and noisy, while newborn sleep patterns and neurodevelopment depend on quiet and dim lights, particularly at night. Despite the best efforts of doctors and nurses, interactions between the newborn and mother are often affected, impairing maternal-newborn bonding and breastfeeding, and potentially leading to disruptions in newborn development and the risk of depression for mothers.[13-15] Hospital-acquired infections and antibiotic use are also more likely, as are more frequent blood and imaging tests.[16-18] Neonatologists are increasingly concerned about balancing these potential harms of NICU environments against possible benefits for late preterm and mildly ill newborns. Identifying overuse could reveal opportunities to decrease adverse effects, reduce unnecessary spending, allow for earlier discharge home, and improve outcomes for newborns and their families.

Concerns about the varying effectiveness of NICU care for different cohorts of newborns, including those at low risk for complications, are joined by questions about high expenditures. The care of extremely premature newborns is understandably expensive. Clinicians, economists, and ethicists have debated for three decades about the balance between costs and outcomes for these newborns' care.[19,20] Much less effort has been directed at measuring payments for low-risk newborns and understanding why expenditures for all newborns differ so much across hospitals.[21]

NICUs do not practice in isolation but are part of a wider system of reproductive health and perinatal care. Good birth outcomes are dependent on monitoring maternal and fetal risk (e.g., diabetes, hypertension, obesity, twins) during pregnancy and, when appropriate, referral to tertiary centers, including regional perinatal health centers staffed with maternal-fetal medicine physicians and other specialized clinicians.[22] The care required to improve outcomes of high-risk pregnancies can range from monitoring the mother's and fetus' wellbeing to delivering in a tertiary center that can provide the highest level of care necessary for the mother and newborn. Just as levels of care have been defined for pregnant women, hospital newborn units are generally classified as Level I (well newborn nursery), Level II (special care nursery), Level III (neonatal intensive care unit), and Level IV (regional neonatal intensive care unit), reflecting their capabilities for providing medical and surgical care.[23] Ideally, pregnant women and newborns receive care in the most appropriate setting, aided by systems of maternal and newborn transport.

This concept of regionalization[24] has been stressed by two trends: the expansion of NICUs and the high financial margins for obstetrical and NICU services. While the growth and dissemination of NICUs from academic tertiary centers to hospitals in community settings affords better access to specialized care closer to home, it is not a guarantee that newborns receive care in the most appropriate unit level. Table 1.2 shows the expansion of NICU beds and neonatologists in recent decades. In many cities, there are multiple NICUs within the same area, leading to competition and, in some instances, relatively low patient volumes. This is a particular concern for very premature infants, as newborn mortality is lower in high-volume Level III or IV units.[25] The second and related trend is the commercialization of maternal and NICU care. Not all very premature newborns are born in higher-level NICU hospitals, and some have suggested that the loss of revenue by the sending hospital acts as a disincentive to transfer pregnant women.[26] On the newborn side, most NICUs are "high-margin" services.[27,28] This is a strong incentive for further building and expansion of NICUs and for keeping beds full, potentially leading to overuse of services, especially in lower-risk newborns. Finally, when premature newborns are stable and growing, there are missed opportunities to transfer back to a hospital closer to home. The lack of insurance reimbursement for "back transfers" of newborns is an important barrier to family-centered care for many families.[29]

Table 1.2. Change in the supply of NICU beds and neonatologists, 1995 to 2013

	Intensive NICU beds per 1,000 live births		
	1995	2013	Percent change
All live births	3.4	5.7	69%
≥ 2,500 grams	0.08	0.13	66%
< 2,500 grams	46.0	72.6	58%
< 1,500 grams	280.6	466.0	66%

	Live births per neonatologist			
	1981	1996	2013	Percent change 1996-2013
All live births	7,201	1,687	965	-43%
≥ 2,500 grams	6,712	1,565	888	-43%
< 2,500 grams	490	123	77	-37%
< 1,500	83	23	14	-40%

Sources: AMA Masterfile, AHA Survey, U.S. Vital Records.

The number of NICU beds increased almost 70% per newborn during the 18-year period from 1995 to 2013. As the number of neonatologists increased from 1981 to 2013, the number of neonatologists for each newborn fell dramatically.

The Opportunity to Achieve the Triple Aim with the Guidance of Population-Based Newborn Analysis

The Triple Aim—better care, better health, and lower costs—provides a useful framework for understanding opportunities to improve newborn care.[30-32] Better care can be understood as both high technical quality and better patient and family experiences. Higher quality is associated with better health: higher survival, fewer adverse events, and improved long-term outcomes. Providing the right care at the right place at the right time limits waste and lowers costs.[33,34] Joined with better outcomes, efficient use of medical services is the basis of high-value care.

How does analysis of population-based health care data help achieve these aims? Descriptions and investigation of regional and hospital variation provide rich information about the delivery of newborn care, particularly neonatal intensive care, at different hospitals by different providers; geographic analysis can reveal the practice styles of hospitals and physician groups within each region. Information about specific NICUs can be obtained using measurement at the hospital level (although the hospitals are not identified), the most important locus for care improvement. In turn, these findings can raise questions about the reasonableness of current practice patterns, stimulating provider engagement as well as public discussion. The measures can also show what is attainable in terms of quality and efficiency and can offer benchmarks to guide clinical improvement and policy development. The findings often generate ideas regarding both the causes and effects of the variations, and, in turn, the data can then be used to test hypotheses as to the best ways to deliver care. Finally, the measurement set can support public reporting of performance measures, which accelerates the pace of improvement.[35]

Good care can be expensive, but using health care resources efficiently is also an important aim.[33] In a California study, very low birth weight (VLBW) newborns represented less than 1% of all births but accounted for 36% of total newborn hospital payments.[36] While the sickest newborns (e.g., VLBW) have the highest payments, most NICU admissions are for mildly ill infants, meaning that a significant proportion of overall spending is for a less severely ill newborn population.[5] Understanding variation in practice patterns and outcomes across both high- and low-risk newborns helps clinicians, health systems, and other partners and policymakers identify opportunities for both better care and higher value.

Newborn Study Populations in this Report

Very low birth weight newborns

Very low birth weight (VLBW) newborns, defined as those with a birth weight less than 1,500 grams (about 3 pounds 5 ounces), are commonly premature (< 37 weeks gestation), but this group also includes older infants that are born small for gestational age. These smallest and, typically, most premature newborns are at the greatest risk for complications and need the highest level of care in a NICU. Immediate respiratory support is required at birth, usually with a ventilator. They are cared for in an isolette to maintain their body temperature. Cardiopulmonary monitoring is also essential, as apnea (pauses in breathing) and bradycardia (drops in the heart rate) are common. Nutritional needs cannot be met through bottle or breastfeeding, and VLBW newborns initially require intravenous fluids and nutrition with slow advancement of oral feedings to avoid serious, and sometimes fatal, bowel complications. Finally, as these newborns grow, vision and development must be assessed; these services may not be available at lower level NICUs.

Level III/IV NICUs, with neonatal nurses, neonatologists, and other sub-specialty physicians, provide the highly specialized care necessary for VLBW newborns. These units also have readily available specialized equipment and support services such as pharmacy, radiology, and respiratory therapy. This combination of specialized clinicians and services improves outcomes for these tiny patients, as shown in a recent research paper demonstrating improved outcomes in VLBW newborns delivered in hospitals with Level III/IV NICUs.[1]

1. Lasswell S, Barfield WD, Rochat R, Blackmon L. Perinatal regionalization for very low birth weight and very preterm infants: a meta-analysis. *JAMA*. 2010;304[9]:992–1000.

Late preterm newborns

The typical length of human gestation is 40 weeks, with those born before the 37th week considered premature. Although much is known about infants born very or extremely premature, those born just a few weeks early, designated as late preterm (34-36 weeks gestation), are not well studied. This group of patients is at lower risk of major complications but frequently has important medical needs.

The developing fetus gains skills required for transition to extra-uterine life in the third trimester. These skills include the ability to regulate their temperature, to safely feed by mouth, and to breathe without assistance. Like all developmental milestones, these are achieved at varying times within a range of normal development. Therefore, an infant born in this late preterm window may have all or none of the skills needed for a safe transition to the extra-uterine environment.

This uncertainty at the time of birth leads to the need for flexibility in the care of these newborns. Some may need intensive monitoring and respiratory support, while others will be able to breathe, feed, and stay warm without any assistance. Provision of respiratory support generally requires a Level III/IV NICU, but support for feeding and temperature regulation can be provided in less specialized units such as a Level II NICU. The wide variation in normal development and transition, and therefore medical need, for late preterm infants often creates uncertainty regarding the best location and level of care required.

Other newborn groups

VLBW and late preterm newborns are two distinct newborn groups, one with high risk of mortality and morbidity, the other with low risk. This report also uses other groupings of risk that depend on the topic of interest and the availability of data. The national studies using Vital Records information identify differing newborn risk by multiple categories of birth weight and gestational age. The Norwegian studies use populations defined by gestational age. The analysis of Anthem-insured newborns includes a group termed “low risk,” which is defined as those newborns with an absence of serious medical diagnoses and surgical procedures.

A Framework for Interpreting Variation in Health Care

Measuring variation in health care is motivated primarily by an interest in understanding the causes and consequences of differences in the performance of health care providers and systems. Health care is expected to vary to the extent that populations differ in their needs and preferences for health care. *Unwarranted variation* is the variation that cannot be explained by population needs or preferences, but rather is due to differences in health system performance.

Over the past two decades, a classification system for unwarranted variation was developed by Wennberg and colleagues,[37] with variation in health care utilization categorized into three types: effective care, preference-sensitive care, and supply-sensitive care. Variation in health care capacity, such as hospital beds and physicians, is a fourth category.

Variation in effective care

Variation in effective care reflects differences in technical quality, i.e., in care that has been shown to be beneficial with few tradeoffs. High technical quality of medical services is identified as care with good scientific evidence of improved health outcomes. The Agency for Healthcare Research and Quality (AHRQ) describes quality measures as follows:

“Quality measurements typically focus on structures or processes of care that have a demonstrated relationship to positive health outcomes and are under the control of the health care system… Health care quality measurement for children is the process of using a scientifically sound tool to assess the extent to which children are receiving quality health care in any of the IOM quality domains.”[38]

The “right rate” of effective care is usually known for a given population. Immunization for Hepatitis B is one perinatal example where the ideal rate should approach 100%. The rate of late sepsis (blood stream infection) or meningitis in very low birth weight newborns is another example; a lower rate is obviously better. Technical quality measures are limited in neonatal care,[8] and some measures require clinical data that are not widely available.

Variation in preference-sensitive care

Preference-sensitive care refers to medical care for which the choice of treatment should reflect an informed patient or family decision, weighing the balance of possible benefits and harms for the different care options. For this type of medical care, there is no single “right rate” for every population or area. The right rate would reflect the decisions of fully informed patients and families, reached through a process of shared decision-making. It would be expected that care choices would differ across families and, in turn, across regions. The result would be variation warranted by patient and family preferences.

The original analyses that led to this concept were studies of adult men facing treatment choices for benign prostatic hyperplasia,[39] a decidedly non-perinatal problem. Most of the research in decision quality and shared decision-making has been for adult conditions, ranging from lower back pain to early stage breast cancer in women. Decision aids[40] have been developed to assist patients and clinicians in choosing care that is consistent with the patient's values. The introduction of decision aids usually—but not always—reduces utilization rates. Even when the overall rate remains unchanged, decision aids improve outcomes by ensuring that the right care is (or is not) provided to the right patient.

A list of available decision aids and their sources can be found at the Ottawa Hospital Research Institute website.[41] These differ greatly in quality, and only a few are available for pediatric illness. Decision aids for newborn care are limited to those discussing breastfeeding, circumcision, and the care of extremely premature newborns.

Variation in supply-sensitive care

Supply-sensitive care refers to medical services for which utilization rates are sensitive to the local availability of health care resources, such as hospital or intensive care beds, imaging units (e.g., MRI scanners), and physicians. While in some instances, effective care may be constrained by the lack of resources, this category is principally concerned with the many types of medical care for which there is weak theory and little evidence that more services are generally better. In such situations, regions with a greater supply of health care resources tend to have higher utilization rates—but not necessarily improved outcomes. Generally, the "right rate" is the lowest rate consistent with favorable outcomes. While this is a category of variation that has been studied extensively for adult patients, little research has been conducted in children's health care.[42]

Variation in health care capacity

Studies have shown striking population-based variation in pediatric and NICU health care capacity such as hospital beds, intensive care unit beds, and other specialized resources. Several studies have shown marked variation in the per capita (e.g., per child or newborn) number of general pediatricians and neonatologists.[43,44]

Pediatric capacity is generally not located where needs are greater. Chang et al showed a lack of association between general pediatrician supply and indicators of child health needs across states.[45] Mayer observed a very high degree of variation across Dartmouth Atlas hospital referral regions for different pediatric subspecialists,[46] and Goodman et al found little relationship between the supply of neonatologists and regional differences in perinatal risk.[44] The irrational distribution of pediatric capacity has important implications for the health care system and the health of children and families.

A Preview...

The report begins with two studies of the U.S. total birth cohort and then examines regional and hospital variation in NICU admissions, number of special care days, and imaging in different newborn populations. The magnitude of variation is strikingly high and is not explained by differences in newborn health status. The concluding section discusses the implications of these findings for families, health systems, and government and private payers.

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2. National Studies of Newborn Medical Care

Photo: iStock.com/pekkak

Perinatal health (e.g., low birth weight, neonatal mortality rate) and its antenatal determinants, such as poverty and intendedness of pregnancy,[1] are routinely measured across the populations of states and counties in the United States through the Vital Records system and other perinatal surveys. Unfortunately, the U.S. and most other countries lack systematic population-based measures of newborn care. Health care statistics of this type are widely available for the majority of the Medicare population (i.e., the aged) through annual research datasets that have been available to researchers for more than 25 years. The resulting studies have accelerated the pace of achieving quality standards and have stimulated numerous new care and financing models. The data have also enabled public reporting of both quality and patient experience metrics for Medicare beneficiaries, initially by Dartmouth researchers and now routinely by numerous public entities, including the Centers for Medicare and Medicaid Services (CMS). Evaluating the medical care and outcomes of newborns lags far behind these initiatives because there is no comparable national medical claims dataset for the under-65 population. Nevertheless, in recent years, a few investigators have made progress in national population-based studies of newborns that have the potential to provide invaluable information for improving the quality and value of perinatal services.

This section reports on studies conducted at Dartmouth that provide a national perspective on newborn care over time and across regions. Trends in the proportion of newborns admitted to neonatal intensive care units (NICUs) are presented first, followed by an examination of the supply of NICU beds across neonatal intensive care regions (NICRs), the chances of newborn NICU admissions, and the association between the two. Both of these analyses draw from the entire U.S. birth cohort as reported in the national natality file from the National Center for Health Statistics of the Centers for Disease Control (CDC). This file has very accurate information about maternal and newborn characteristics useful for accurate estimation of newborn health risk. From this, newborns can be grouped into categories of risk based on attributes such as birth weight or gestational age, and measures of their care can be further adjusted for other factors.

In the second half of the section, the utilization experience of Anthem Blue Cross Blue Shield-insured newborns is reported across regions for those enrolled in commercial and Medicaid managed care plans. Anthem market penetration across regions is not uniformly high enough to report newborn measures for the entire country, but a large majority of NICRs are included. The strength of the Anthem database is that it includes utilization information (e.g., number of special care days and imaging procedures) not found in the national natality file, and it allows for a comparison of two different insurance groups. A relative weakness is that it has far less information related to maternal and newborn health risk. These analyses are limited to two groups that can be reliably identified in claims: very low birth weight newborns (< 1,500 grams) and those at low risk for complications (newborns with an absence of serious diagnoses).

All U.S. Newborns

Trends in Neonatal Intensive Care Unit Admissions[2]

The expansion of neonatal intensive care units (NICUs) and beds in recent decades has been associated with changes in the newborn population receiving NICU care. In its early years of development, NICU care was in short supply, and admission was primarily limited to critically ill premature newborns. Many newborns who might have benefitted from the medical and nursing care of a specialized unit were not cared for in hospitals with NICUs. As the number of units increased and regional perinatal networks were developed, this unintended rationing declined, but simultaneously resulted in higher use of NICUs for less ill newborns. By 2007, only 16.1% of U.S. Level III/IV NICU admissions were for very low birth weight (VLBW) newborns (Figure 2.1). Just five years later (2012), this percentage had fallen to 13.8%, while the proportion admitted that were normal birth weight newborns (2,500-3,999 grams) rose from 42.2% to 46.6%. This trend has continued. By 2017, the percentage of NICU admissions that were for VLBW newborns had further decreased to 12.7%, and the percentage for normal birthweight had increased to 48.0%. The expansion of neonatal intensive care—and the resulting hospital competition for newborns—seems to have led to the loss of regionalized systems of perinatal care, and is not only associated with increasing use of NICUs for larger newborns, but may also be linked to more VLBW newborns (all of whom should be cared for in a Level III/IV NICU) receiving care in lower level units.[3]

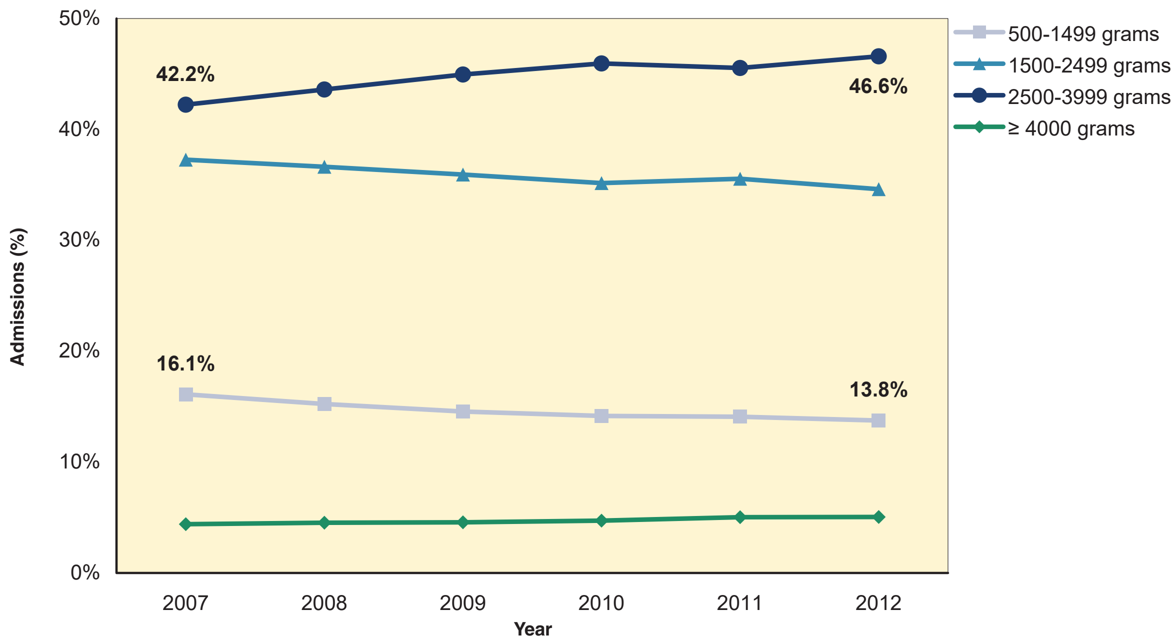


Figure 2.1. Trends in the Composition of Level III and IV NICU Admissions by Birth Weight (2007 to 2012)

Figure 2.2 shows the distribution of NICU-admitted newborns by birth weight. The blue line is the percent of newborns admitted to Level III/IV units. The chance of a NICU admission is highest for newborns 1,000-1,499 grams—85.6%—and then falls steeply to 3.4% for newborns 3,500-3,999 grams. The chance of a NICU admission is also higher for very large newborns. The green line is the cumulative percentage: the product of the risk of admission and the number of newborns. Small newborns have a very high risk of admission, but they are far fewer in number than larger newborns. This means that larger newborns dominate NICU admissions because of their high numbers, even though the admission risk for each newborn is low.

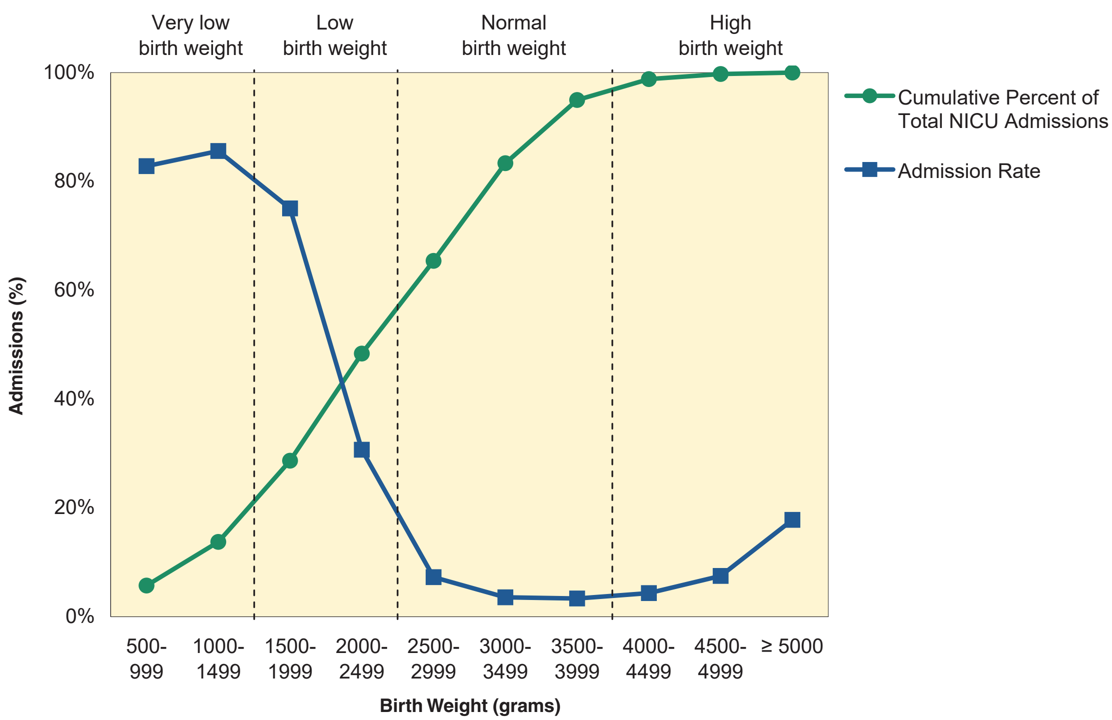


Figure 2.2. Level III and IV NICU Admissions by Birth Weight (2012)

This shift in the composition of NICU admissions to a greater proportion of higher weight and gestational age newborns has outpaced our knowledge about the effectiveness and value of the care they receive. Relatively little is known about care processes and outcomes for newborns greater than 1,500 grams, including whether the newborns being admitted are best cared for in a NICU environment—or whether there are newborns being cared for in Level II units who would do better if admitted to Level III/IV NICUs. At the same time, approximately 15% of newborns less than 1,500 grams are not admitted to a Level III/IV NICU despite evidence showing improved outcomes and reduced mortality when they are cared for in higher level units.[4-6]

Neonatal Intensive Care Regions

Throughout the Atlas, analyses of newborn care are presented by regions that represent relatively self-contained markets for neonatal intensive care. In this section, national neonatal intensive care regions (NICRs; n=246) are used, which were initially defined in the late 1990s using Vital Records data8 to reflect travel patterns of mothers of low birth weight newborns, and continue to be valid regional markets for neonatal intensive care.[7,9] They are also reasonable markets for Anthem-insured newborns except where there is low Anthem market penetration. For the Texas Medicaid analyses, we defined regions (n=21) using recent Medicaid utilization data. Norway defined their own regions of neonatal care. Similar to the U.S. regions, there is limited border crossing from Norwegian region of birth or maternal residence to hospital of intensive care. Further information on the definition of regions in the U.S. and Norway can be found at http://www.dartmouthatlas.org/.

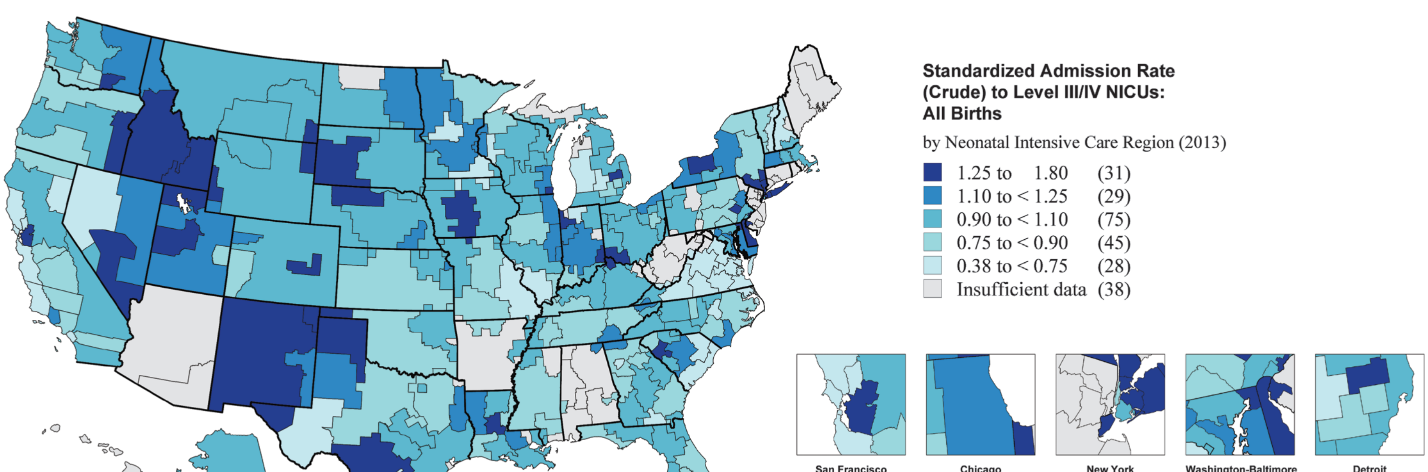
Regional Variation in Level III/IV NICU Admission Rates[7]

For all newborns, the admission rate to NICUs varies markedly (Map 2.1). (Note that data are missing for the few states that had not yet adopted the revised CDC birth certificate that includes a field for NICU admission.) Admission rates are depicted as the ratio of the region's rate to the overall rate for all reporting regions. Some variation is expected and warranted, given that perinatal risk factors, such as birth weight and socioeconomic status, also vary by states and regions.

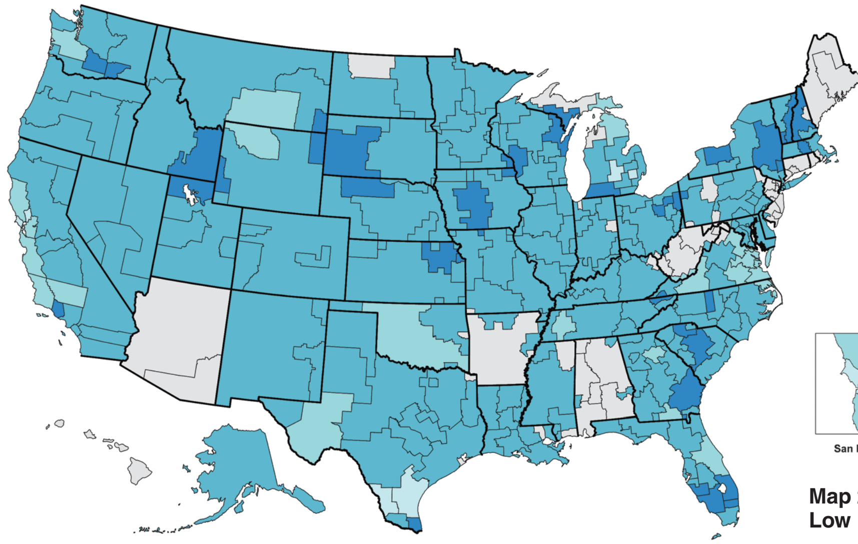
The data shown in Maps 2.2-2.4 partially control for regional differences in the health status of newborns by restricting to three birth weight categories: very low birth weight (VLBW) (500-1,499 grams), moderately low birth weight (1,500-2,499 grams), and normal birth weight (≥ 2,500 grams). A quick glance shows relatively little variation in NICU admissions for the sickest newborns (i.e., VLBW); almost all of them were admitted to NICUs regardless of the region (Map 2.2). The coefficient of variation was 10.

For moderately low birth weight newborns (1,500-2,499 grams), high variation in NICU admissions was observed. Regions with low admission rates included Laredo, Texas (15.4%), Lansing, Michigan (16.4%), Richmond, Virginia (19.4%), Corpus Christi, Texas (20.7%), and Valdosta, Georgia (20.9%). Admission rates were more than three times higher than the lowest regions in Lincoln, Nebraska (60.9%), Stony Brook, New York (56.9%), Boise, Idaho (55.5%), Minneapolis, Minnesota (55.3%), and Rapid City, South Dakota (55.3%) (Map 2.3). The coefficient of variation was 20.

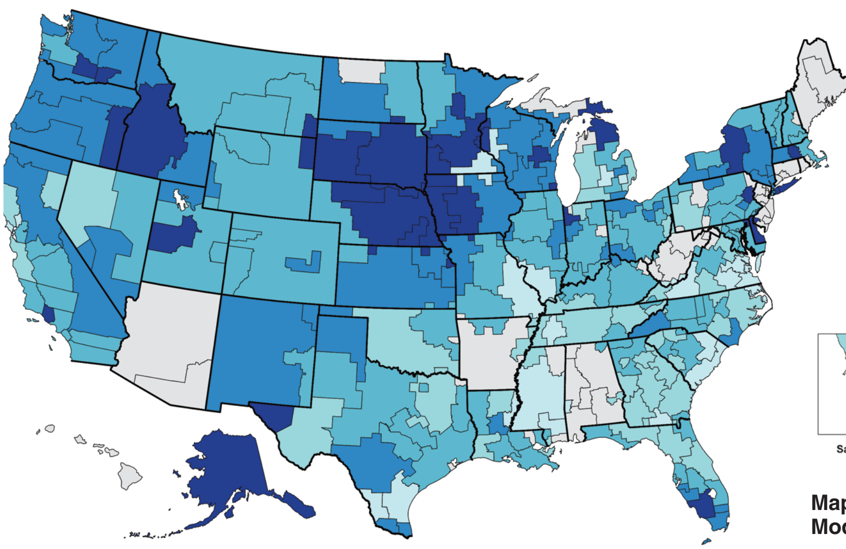
The highest variation in regional NICU admission rates was seen in the normal birth weight (≥ 2,500 grams) newborns. Regions with low admission rates included Richmond, Virginia (1.6%), Laredo, Texas (1.7%), Valdosta, Georgia (1.7%), Roanoke, Virginia (1.8%), and Corpus Christi, Texas (1.8%). In the regions with the highest rates, including Newark, Delaware (9.2%), Alexandria, Louisiana (9.0%), El Paso, Texas (8.9%), Stony Brook, New York (8.3%), and Staten Island, New York (8.1%), admissions to NICUs were more than five times higher. The coefficient of variation was 34.



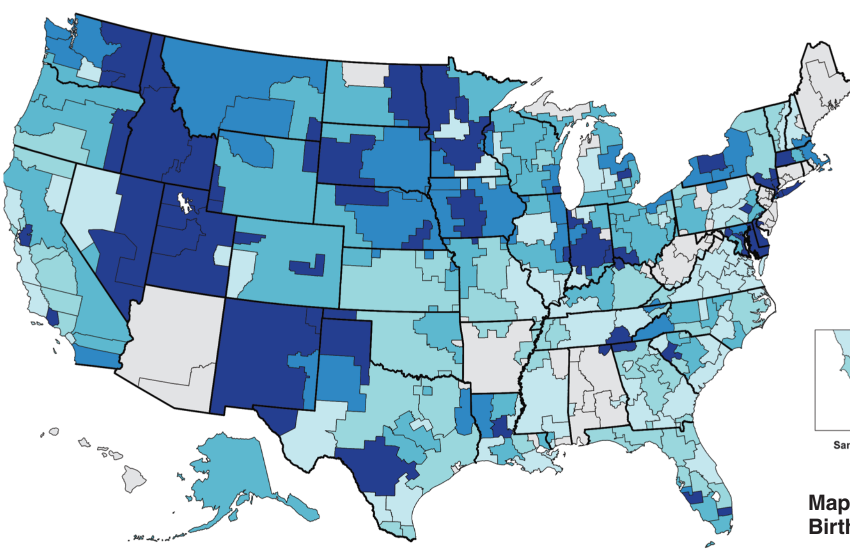
Map 2.1. Admission Rates to Level III/IV NICUs among All Newborns by NICR (2013)

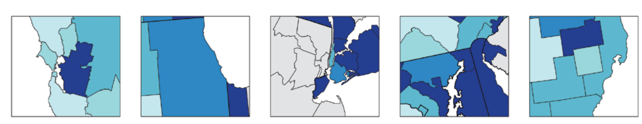


Map 2.2. Admission Rates to Level III/IV NICUs among Very Low Birth Weight Newborns by NICR (2013)



Map 2.3. Admission Rates to Level III/IV NICUs among Moderately Low Birth Weight Newborns by NICR (2013)





Map 2.4. Admission Rates to Level III/IV NICUs among Normal Birth Weight Newborns by NICR (2013)

Is Neonatal Intensive Care Bed Supply Associated with Newborn Medical Needs?[7]

The regional supply of NICU beds and neonatologists is known to vary widely. In the late 1990s, Dartmouth researchers demonstrated that there was virtually no association between regional supply and a number of measures of perinatal risk.[10] In other words, regions with a high proportion of premature newborns, or other factors related to newborn illness, were not the regions with a higher number of NICU beds or neonatologists per newborn.

Fifteen years later (2013), the alignment between NICU bed supply in relation to need had not improved. As seen in Figures 2.3-2.5, the supply of NICU beds per newborn was not associated with the regional percent of low birth weight births (< 2,500 grams) (Figure 2.3), maternal education level (Figure 2.4), or the rate of cesarean sections (Figure 2.5).

It is very troubling that such an important and expensive health care resource is not found in greater supply in the places where it is most needed by newborns. It raises two important questions: How are the extra beds used? And is greater supply of NICU resources linked to better outcomes for newborns?

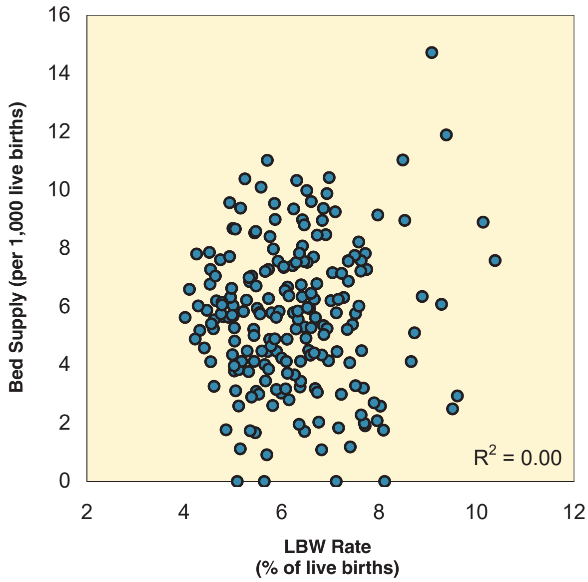


Figure 2.3. Relationship Between Low Birth Weight Births and NICU Bed Supply by NICR (2013)

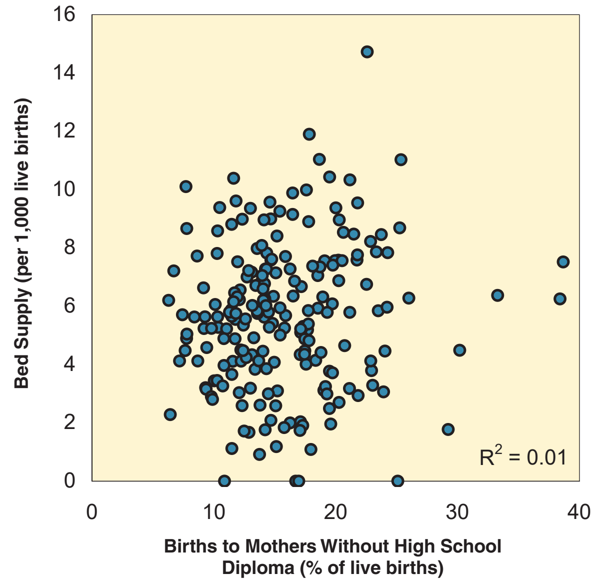


Figure 2.4. Relationship Between Maternal Education Level and NICU Bed Supply by NICR (2013)

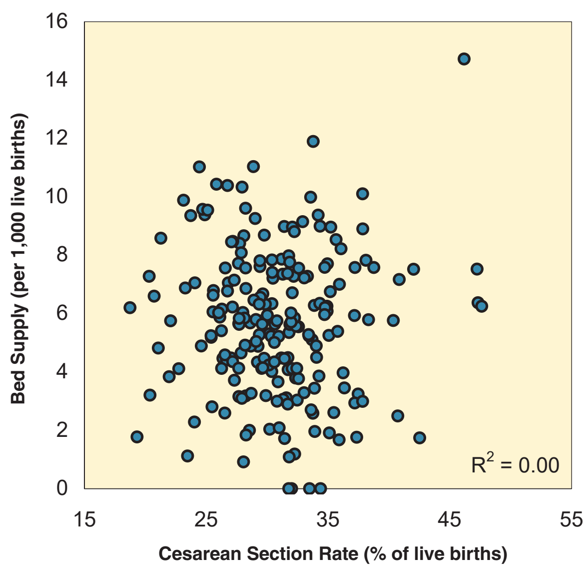


Figure 2.5. Relationship Between Cesarean Section Rate and NICU Bed Supply by NICR (2013)

The figures show the correlation between several newborn risk factors and the regional bed supply among the 208 neonatal intensive care regions with sufficient data to report. There was no relationship between the supply of beds and measures of newborn risk.

Does Higher NICU Bed Supply Lead to More NICU Admissions?[7]

More regional NICU beds are sometimes associated with higher NICU admission rates, but not always. As seen in Figure 2.6, within categories of bed supply (very low, low, medium, high, and very high), the differences in NICU admission rates among VLBW newborns were not statistically significant (linear test of trend p=0.94). This is good news; most of these very ill newborns were admitted to Level III/IV units whether the bed supply was relatively low or high. In contrast, bed supply was more strongly associated with admission rates in the larger and lower risk newborn groups. Figure 2.7 shows the association in the moderately low birth weight newborn group (p=0.08) and in those of normal birth weight (p=0.04). Other investigators have also observed the effect of NICU supply on utilization.[3,11]

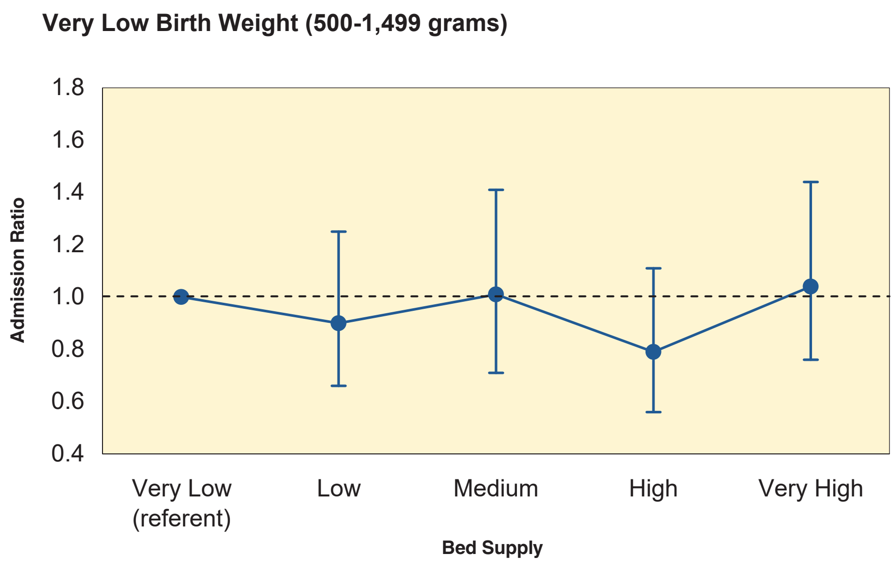
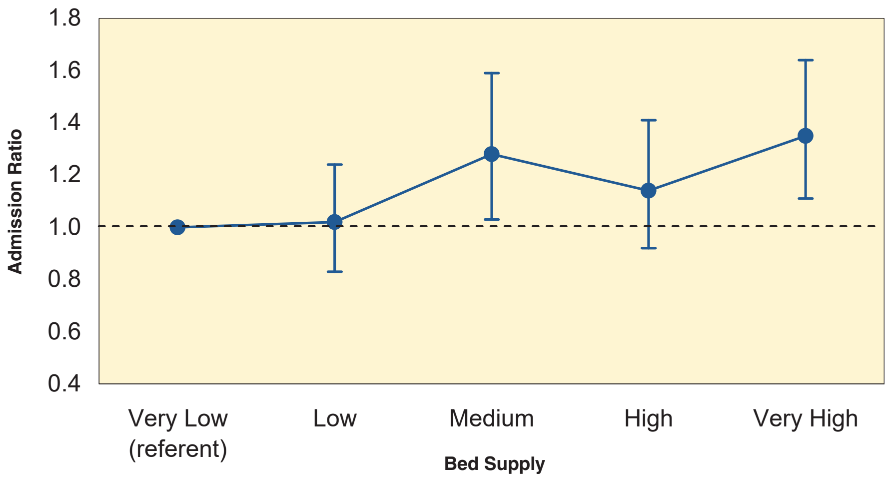


Figure 2.6. Association Between Bed Supply and Likelihood of Admission to a Level III/IV NICU among Very Low Birth Weight Newborns (2013)

Moderately Low Birth Weight (1,500-2,499 grams)



Normal Birth Weight (≥ 2,500 grams)

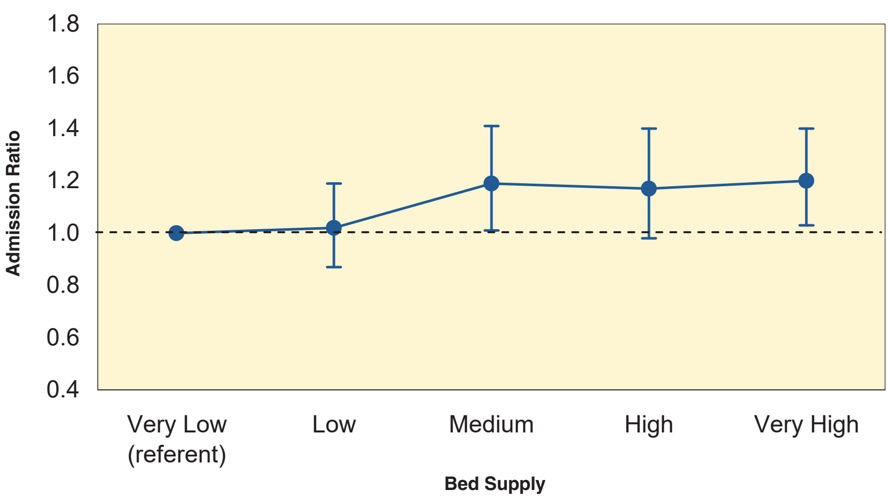


Figure 2.7. Association Between Bed Supply and Likelihood of Admission to a Level III/IV NICU among Moderately Low and Normal Birth Weight Newborns (2013)

Is Greater Supply of NICU Resources Associated with Better Newborn Outcomes?

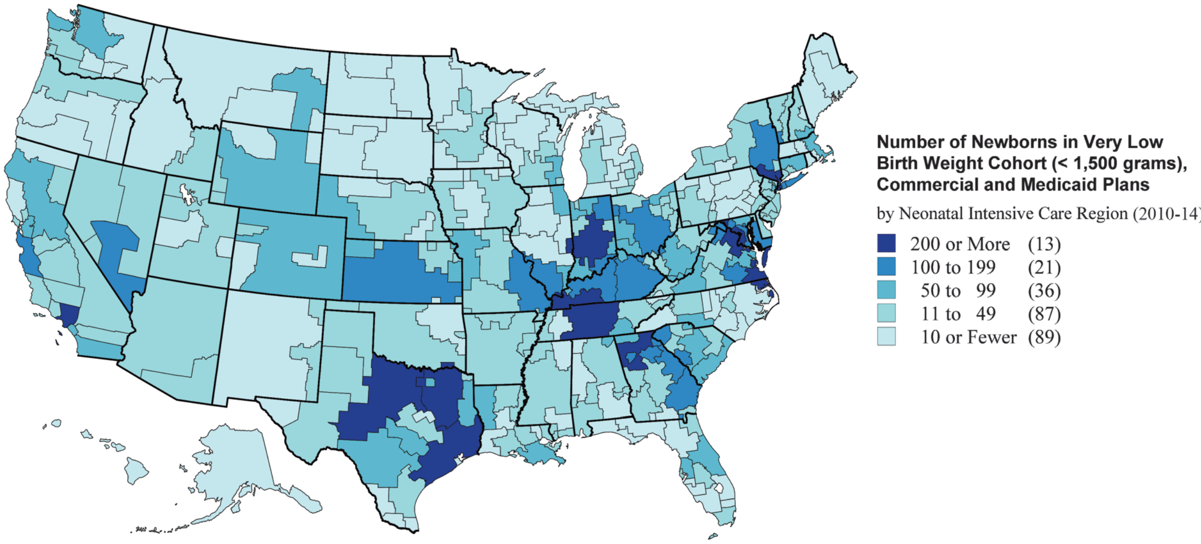
The value of a higher supply of NICU beds and neonatologists is an important question given their maldistribution. The single national study that measured the association between NICU supply and outcomes was conducted almost twenty years ago.[12] It found that very low supply of neonatologists was associated with higher neonatal mortality, but there was no further relationship between mortality and low, moderately high, or very high neonatologist supply. In other words, very low supply was worse, but any supply higher than very low was not better. The regional supply of NICU beds was not associated with neonatal mortality at all. More recent studies that examine current associations of NICU resources with mortality and with other newborn outcomes are needed.

Anthem-Insured Newborns

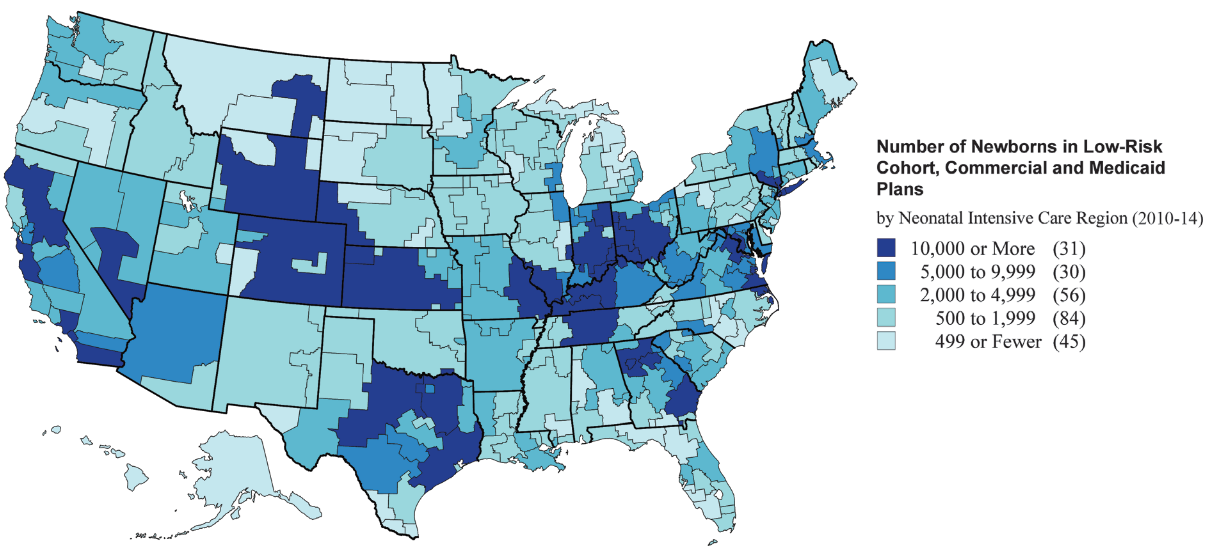
Anthem is one of the largest health insurers in the nation, serving members through numerous plan types. In this Atlas, we report on the utilization of newborns insured by Anthem, either through state Medicaid plans or in commercial plans. The latter includes members in national accounts, local groups, federal employee programs, and individuals. Anthem's market penetration differs widely across states and regions. This is reflected in the number of Anthem-insured newborns by region, as seen in Maps 2.5 and 2.6.

The overall Anthem newborn cohort (2010-14) was 1.2 million. This section presents analyses for two specific newborn populations for the period 2010-14: 1) Very low birth weight newborns (VLBW; < 1,500 grams; n=12,086), who are typically premature and almost always require neonatal intensive care; and 2) Low-risk newborns (n=1,110,517), defined as singleton newborns without significant prematurity, a serious diagnosis, or receiving a major surgical procedure during the newborn hospital episode. For example, newborns less than 35 weeks gestational age, weighing less than 1,500 grams, and with major congenital anomalies were excluded from the low-risk group. Utilization measures were not reported for regions with fewer than 50 very low birth weight or fewer than 1,000 low-risk newborns. (See the complete list of exclusions at http://www.dartmouthatlas.org/.) Hyperbilirubinemia and tachypnea (rapid breathing) were not excluded, but kernicterus (an unusual and severe form of elevated bilirubin) and respiratory failure were excluded.

Conducting analyses within these categories controls for many of the regional differences in newborn risk. The measures were also adjusted for socioeconomic status, as indicated by whether the newborn's insurance plan was Medicaid or commercial. This combination of restriction to specific newborn risk groups, socioeconomic adjustment, and calculating measures at a regional level greatly reduces any systematic differences in health status in the reported measures. Many of the measures presented in this section are examined in more detail for Texas in section 3.



Map 2.5. Number of Very Low Birth Weight Newborns in Anthem commercial and Medicaid plans (2010-14)



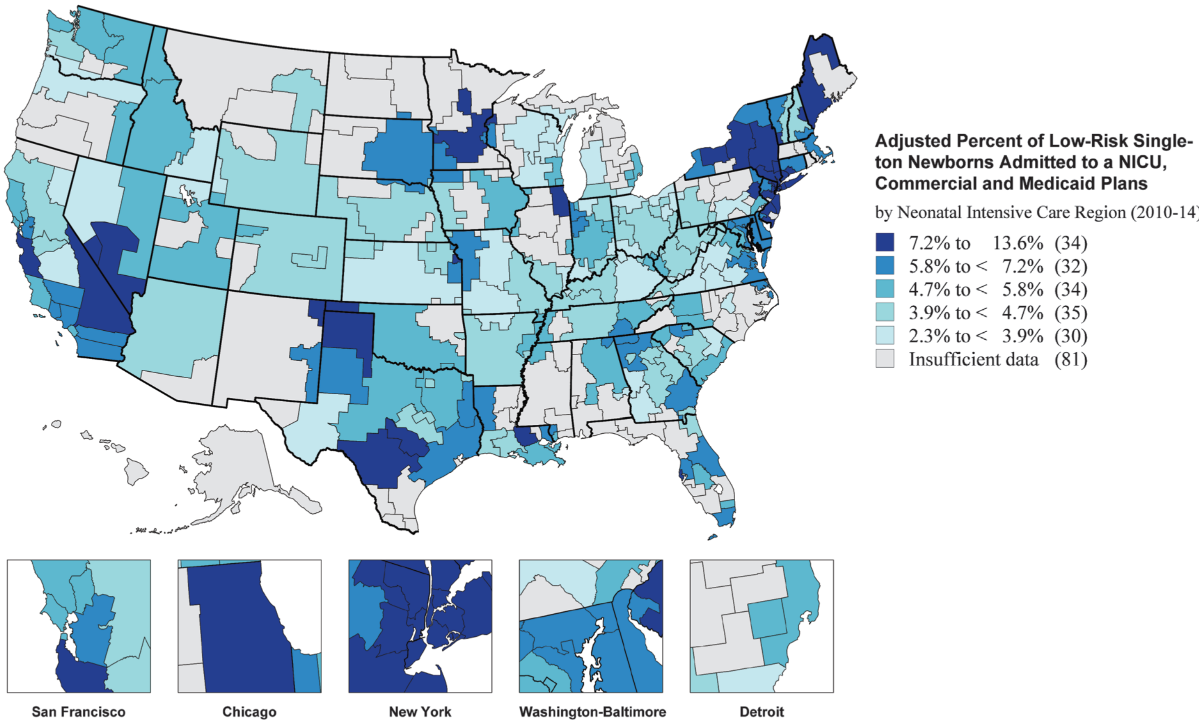
Map 2.6. Number of Low-Risk Newborns in Anthem commercial and Medicaid plans (2010-14)

Neonatal Intensive Care Unit Admission Rates

Very low birth weight newborns (VLBW) have high medical needs and almost all are admitted to NICUs regardless of region of residence. Overall, 96.8% of Anthem-insured VLBW newborns were admitted to a NICU, and this proportion was similar for both Medicaid-insured (98.0%) and commercially-insured (95.7%) newborns (Table 2.1). These percentages are higher than those reported in the U.S. natality file (see previous section), but the admission definition used for Anthem newborns was not limited to Level III/IV NICUs and included Level II nurseries (alternatively called intermediate or special care nurseries). There was little variation across regions (coefficient of variation=3), reflecting the strong professional consensus on the need for intensive care for most VLBW newborns.

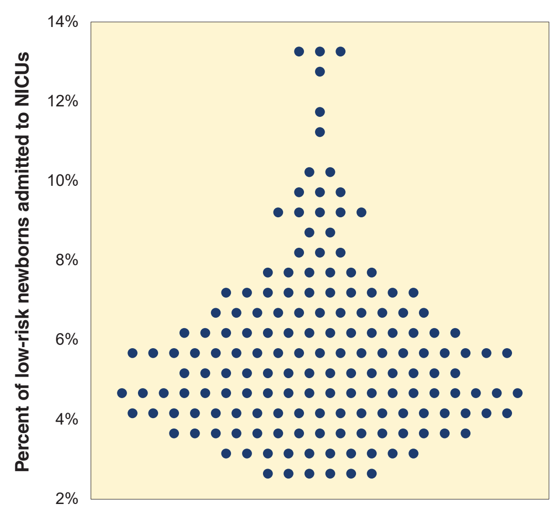
Table 2.1. Variation in Utilization Rates by Cohort Across NICRs, Overall and by Plan Type (2010-14)

	Number of Newborns	Percent of Newborns Admitted to NICU	Number of Special Care Days		Number of Chest Films		Number of Abdominal Films		Number of Head Ultrasounds per Newborn	Percent of Newborns Having Head MRI
			per Newborn	per 100 Newborns	per Newborn	per 100 Newborns	per Newborn	per 100 Newborns		
Very Low Birth Weight										
Overall	12,086	96.8%	59.9		8.7		4.9		2.1	9.2%
Medicaid-insured	5,928	98.0%	60.5		8.5		4.9		2.0	9.8%
Commercially-insured	6,158	95.7%	59.3		9.0		4.9		2.2	8.7%
Low-Risk										
Overall	1,110,517	6.2%		61.2		4.7		1.5		
Medicaid-insured	464,707	6.2%		62.4		3.7		1.4		
Commercially-insured	645,810	6.1%		60.4		5.5		1.5		



Map 2.7. Adjusted Percent of Low-Risk Singleton Newborns Admitted to a NICU by Neonatal Intensive Care Region (2010-14)

In contrast to VLBW newborns, only 6.2% of newborns in the low-risk group were admitted to NICUs. This is a much larger group of newborns, so the absolute number of admissions was over five times greater (VLBW, 11,704; low-risk, 68,547 NICU admissions in 2010-14). The adjusted rates varied markedly across larger regions (defined for this section as those having more than 50 very low birth weight or 1,000 low-risk newborns), from less than 3% in Neenah, Wisconsin (2.4%), Canton, Ohio (2.7%), Columbia, Missouri (2.8%), and Toledo, Ohio (2.8%) to more than 12% in Staten Island (13.5%), Stony Brook (13.3%), Manhasset (13.1%), and Flushing (12.6%), all regions in metropolitan New York City (Map 2.7). The coefficient of variation was 38 across all regions (Figure 2.8). Given the increasing number of opioid-exposed newborns in the U.S., we examined the association, but found no relationship, between newborns diagnosed with opioid-related illness and regional NICU admission rates.



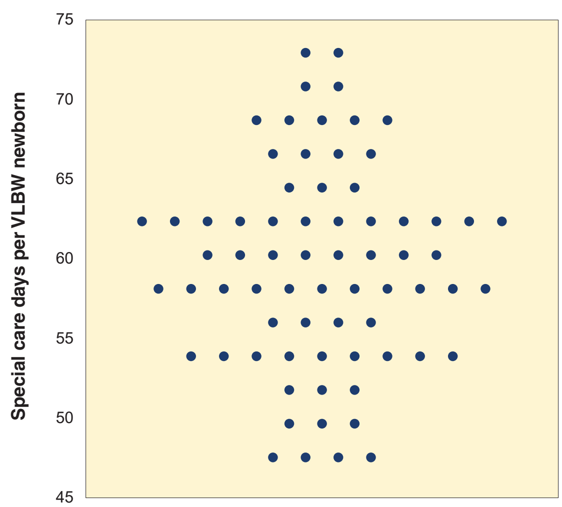
Overall rate	6.2%
Extremal ratio	5.66
Coefficient of variation	38

Figure 2.8. Adjusted Percent of Low-Risk Singleton Newborns Admitted to a NICU by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted percent of low-risk Anthem-insured newborns admitted to a NICU. Each dot represents one of the 165 NICRs with sufficient data to report.

Special Care Days

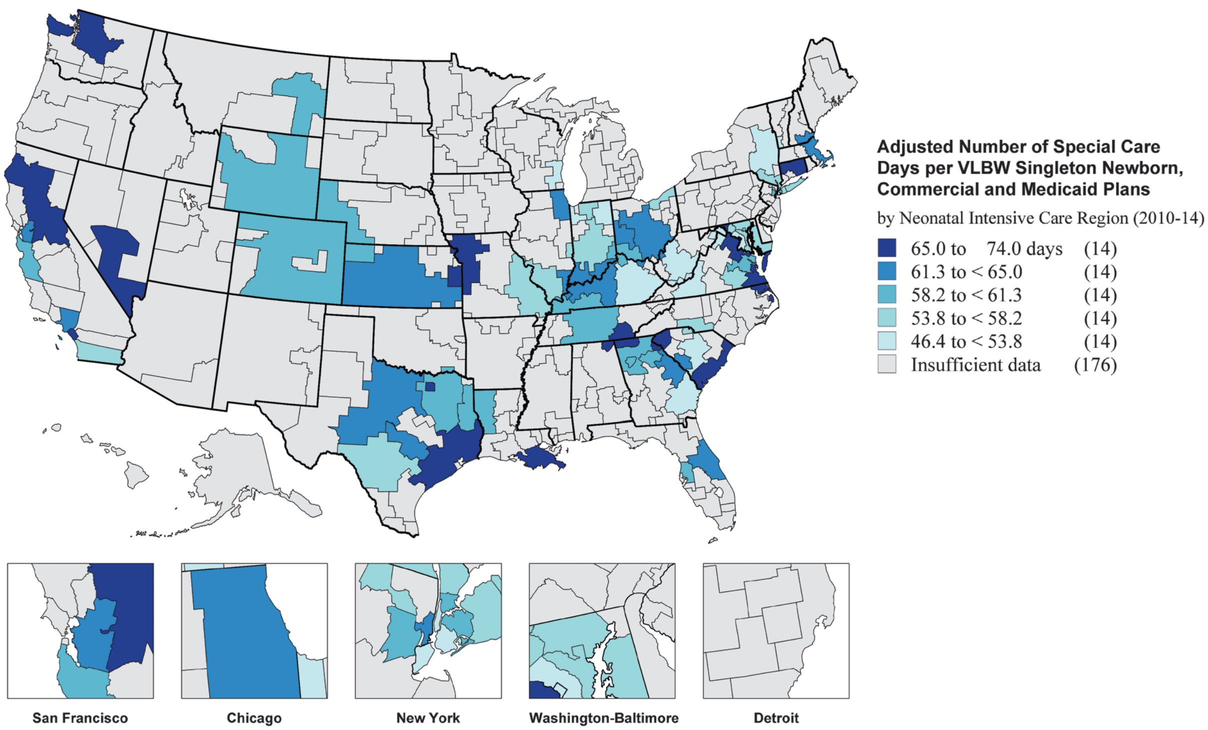
Although the percent of very low birth weight newborns admitted to NICUs varied little, there was moderately high variation in the adjusted number of special care days per VLBW newborn across NICRs. Overall, VLBW newborns received 59.9 days of special care. Across larger regions with more than 50 VLBW newborns, the number of special care days differed by more than 20 days. Regions with relatively few days per newborn included Lexington, Kentucky and Albany, New York, both with about 46 days, and Winchester, Virginia and Milwaukee, Wisconsin, with 47 days. Newborns in Las Vegas, Nevada (74.0 days), Sacramento, California (73.3), Seattle, Washington (71.3), and Kansas City, Missouri (70.7) all spent between 70 and 75 days receiving special care (Map 2.8). The coefficient of variation was 11 (Figure 2.9).



Overall rate	59.9
Extremal ratio	1.59
Coefficient of variation	11

Figure 2.9. Adjusted Number of Special Care Days among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of special care days per Anthem-insured VLBW newborn. Each dot represents one of the 70 NICRs with sufficient data to report.



Map 2.8. Adjusted Number of Special Care Days among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The number of special care days was similar for Medicaid (60.5 days) and commercially-insured (59.3 days) newborns (Table 2.1). Across the regions with sufficient data to report for both insurance types, there was no association in the number of special care days received by Medicaid and commercially-insured VLBW newborns (Figure 2.10).

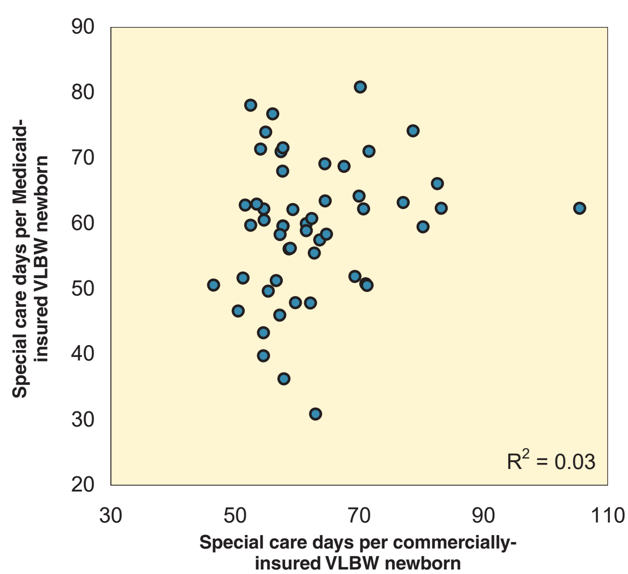


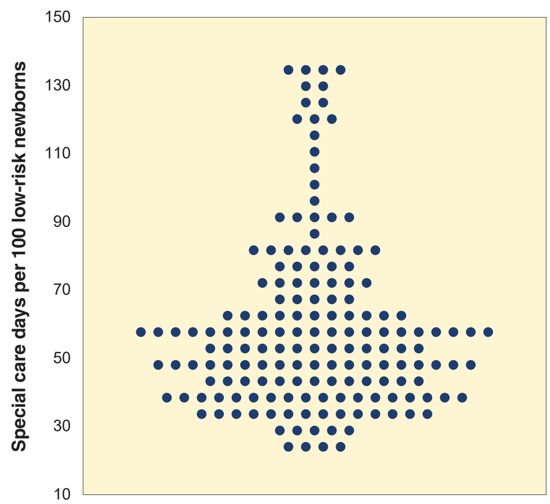
Figure 2.10. Relationship Between Special Care Days per VLBW Newborn Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between special care day rates for VLBW newborns in Anthem commercial and Medicaid plans among the 52 neonatal intensive care regions with sufficient data to report for both measures. There was no relationship between the number of special care days per newborn based on insurance type.

Low-risk newborns received only 61.2 days of special care per 100 (i.e., less than one per newborn) overall, but due to the far greater number of these patients, all together this group spent nearly as many days in special care (679,969 days) during the six-year study period as the VLBW newborns (723,624 days). The high proportion of NICU days for low-risk newborns indicates the importance of research into this understudied perinatal population.

Regional variation in the number of special care days per 100 low-risk newborns was high, with a coefficient of variation of 43 (Figure 2.11). Large regions with low adjusted rates of special care days included Toledo, Ohio (22 days per 100 newborns), Canton, Ohio (22), Madison, Wisconsin (23), and Columbia, Missouri (25). NICRs with high rates included four regions in New York state: Syracuse (137 days), Valhalla (136), Albany (134), and Stony Brook (133) (Map 2.9).

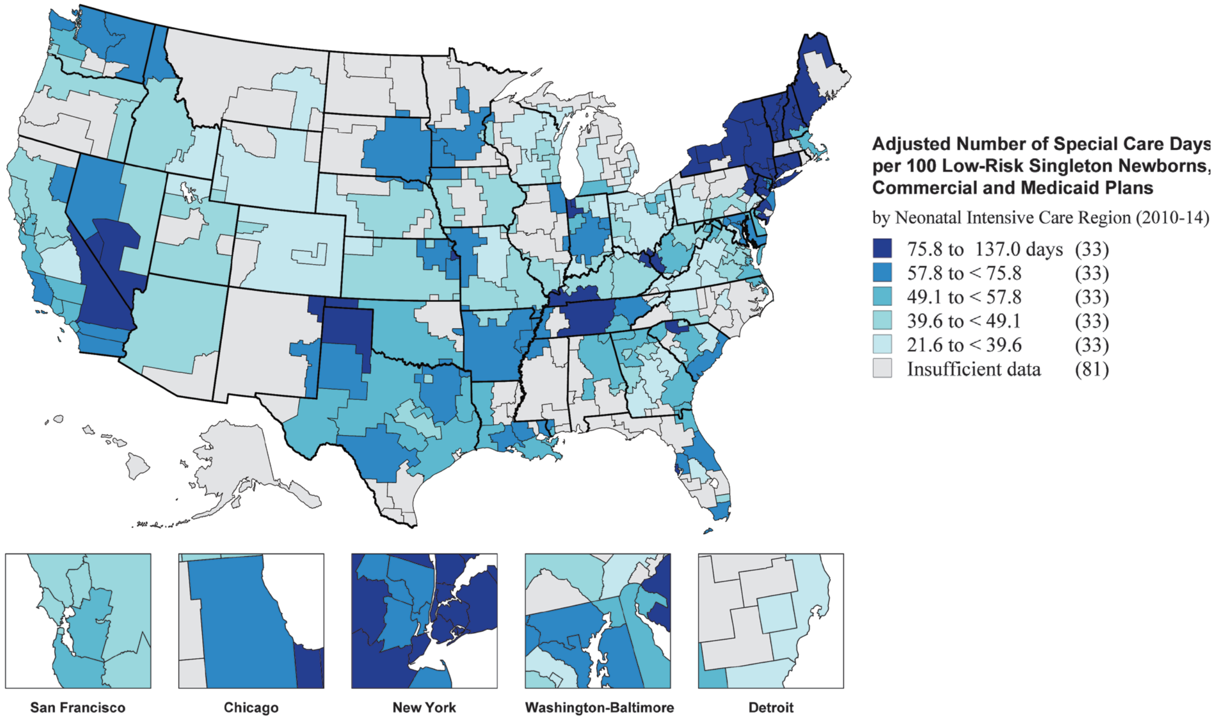
There was no association between special care day rates among the Medicaid and commercially-insured low-risk newborns across NICRs (Figure 2.12). Similarly, regions with higher numbers of special care days for VLBW newborns were not generally the same regions with higher rates for those with low risk (Figure 2.13).



Overall rate	61.2
Extremal ratio	6.34
Coefficient of variation	43

Figure 2.11. Adjusted Number of Special Care Days among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of special care days per 100 Anthem-insured low-risk newborns. Each dot represents one of the 165 NICRs in the U.S. with sufficient data to report.



Map 2.9. Adjusted Number of Special Care Days among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)

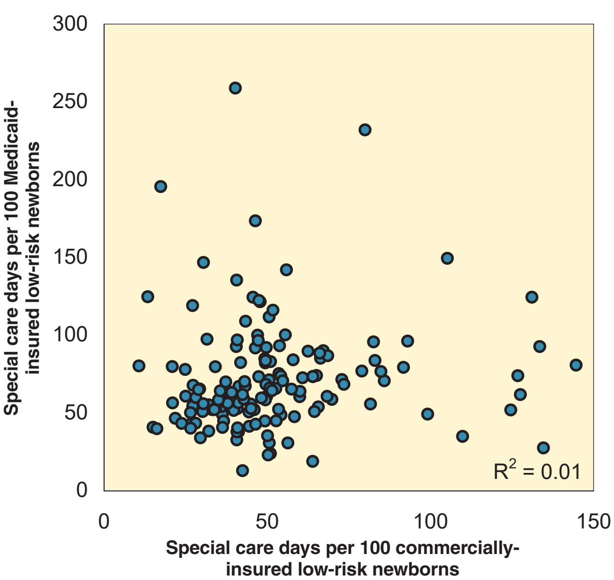


Figure 2.12. Relationship Between Special Care Days per 100 Low-Risk Newborns Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between special care day rates for low-risk newborns in Anthem commercial and Medicaid plans among the 152 neonatal intensive care regions with sufficient data to report for both measures. There was no relationship between the number of special care days per 100 newborns based on insurance type.

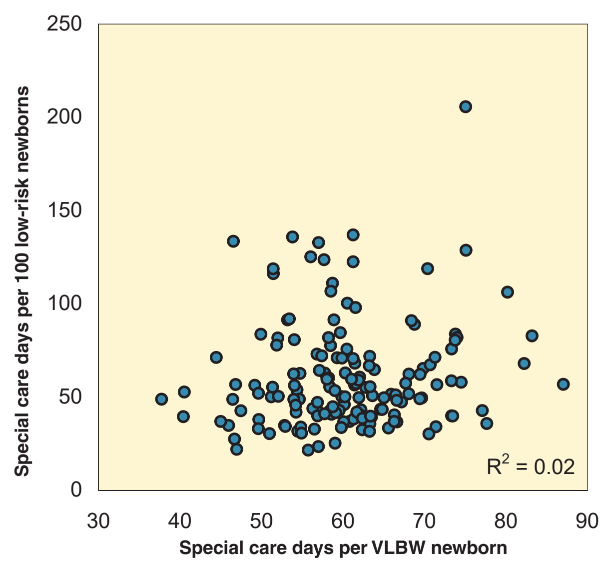


Figure 2.13. Relationship Between Special Care Days among VLBW and Low-Risk Newborns Insured by Anthem Commercial and Medicaid (2010-14)

The figure shows the correlation between special care day rates for VLBW and low-risk newborns among the neonatal intensive care regions with sufficient data to report for both measures. There was no relationship between the rates of special care days based on birth weight.

Head MRIs in VLBW Newborns

The use of magnetic resonance imaging (MRI) has expanded over the last decade, becoming a readily available resource. MRI of the brain is a non-invasive high-resolution imaging technique that does not expose patients to radiation, in contrast to imaging such as computed tomography (CT) scans. These qualities make it ideal for the still-developing premature infant. MRI can be used to assess a wide range of brain abnormalities and injuries.

Very low birth weight (VLBW) infants have premature brains that grow and develop in the NICU as they near term-equivalent age. Even in the best of NICU settings, the growing premature infant is subjected to various stresses that reflect an environment that cannot mimic the human womb; they are therefore at risk of delayed growth and development, as well as complications.

Although head ultrasound in this population is the standard assessment method for detecting IVH, routine use of MRIs has grown in the term-corrected VLBW infant. This practice has been controversial. Although there is little evidence that obtaining an MRI improves outcomes, some suggest that the findings may provide prognostic insight and allow for insurance coverage of therapeutic interventions such as physical, occupational, or speech therapy. The uncertainty of patient benefit leaves the decision to obtain an MRI in term-equivalent infants at the discretion of the clinician and family, but without clear evidence-based guidance.

Imaging

Head MRIs and Head Ultrasounds

Very low birth weight newborns are at high risk for intraventricular hemorrhages in the brain. Both head ultrasounds and MRIs are used to identify affected infants, and each has diagnostic value (see sidebars), but there is not a consensus with regard to when one or the other imaging procedure should be used. The images are also subject to differences in interpretation; and for many findings, there are no additional therapeutic measures beyond what all VLBW newborns should receive (i.e., careful medical and developmental follow-up and services).

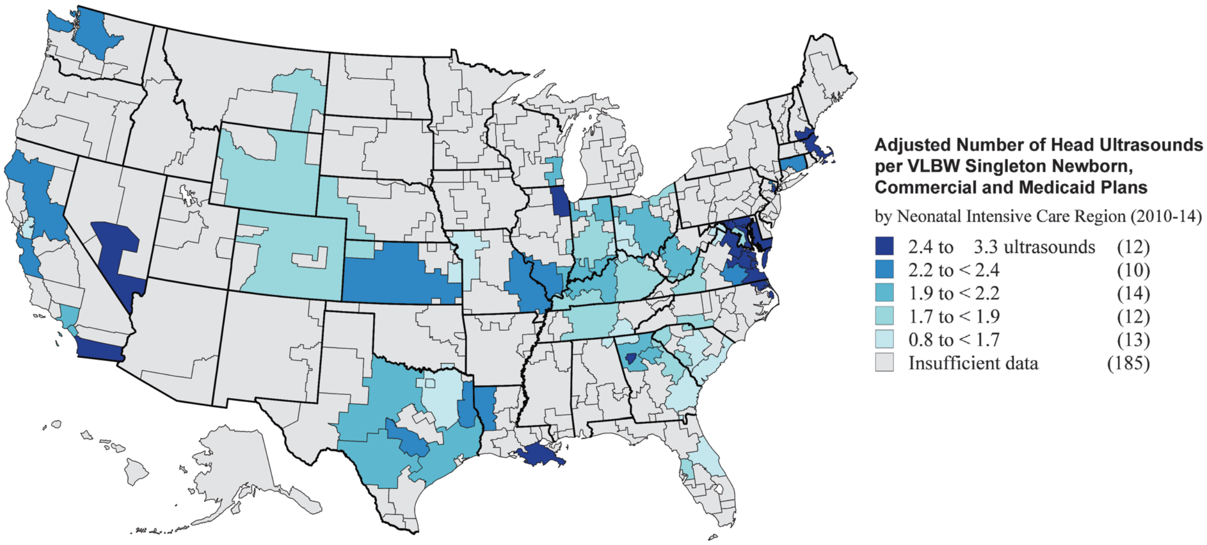
The sound waves used to image the brain in head ultrasounds have been studied extensively over many years and appear to be safe. The use of head MRIs in VLBW newborns is a more recent practice, and there is substantial uncertainty regarding whether it provides value compared to an ultrasound. Head MRIs are also expensive. The American Academy of Pediatrics Section on Perinatal Pediatrics, in conjunction with the Choosing Wisely initiative, named routine MRI at term-equivalent age (or at discharge) for preterm infants as one of five things physicians and patients should question.[12]

Table 2.2. Adjusted Percent of Very Low Birth Weight Singleton Newborns with At Least One Head MRI by Neonatal Intensive Care Region (2010-14)

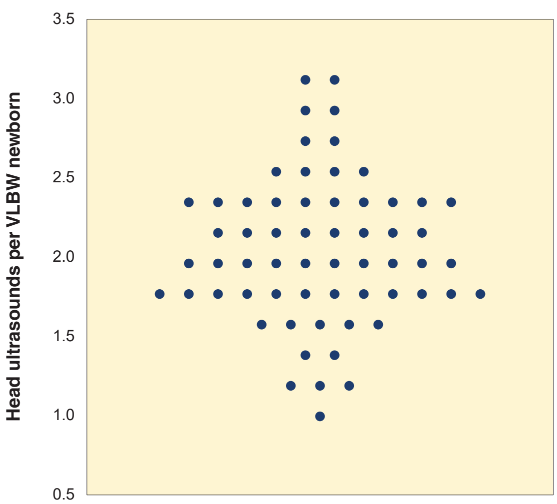
NICR	Number of VLBW Newborns	Adjusted Percent of VLBW Newborns Having a Head MRI
Houston, TX	491	20.6%
Los Angeles, CA	304	9.0%
Indianapolis, IN	510	6.8%
Nashville, TN	472	4.6%
Brooklyn, NY	312	4.6%
Dallas, TX	450	4.5%
Norfolk, VA	297	4.3%
Atlanta, GA	431	2.7%
Overall	**12,086**	**9.2%**

Table 2.2 presents the percent of Anthem-insured VLBW newborns having head MRIs in eight very large regions. (In most regions, the number of events was low and the percentage was statistically imprecise.) These data provide a limited view of head MRI use in the U.S. but show a striking degree of variation. The adjusted rate in Houston, Texas (20.6%) was almost eight times higher than in Atlanta, Georgia (2.7%). Los Angeles, California also had a relatively high rate of 9.0%. Norfolk, Virginia (4.3%) and Dallas, Texas (4.5%) had rates about half that of Los Angeles. Texas regional rates will be explored further in section 3.

The number of head ultrasounds per VLBW newborn was 2.1 overall (Medicaid 2.0; commercial 2.2), but the rate varied greatly across regions (coefficient of variation=23) (Figure 2.14). Large NICRs with low numbers of head ultrasounds per VLBW newborn included Chattanooga, Tennessee (0.90 per newborn), Charleston, South Carolina (1.14), Columbia, South Carolina (1.25), and Winchester, Virginia (1.41). Regions with high rates included Baltimore, Maryland (3.21), North Baltimore, Maryland (3.08), Falls Church, Virginia (2.90), and Las Vegas, Nevada (2.86) (Map 2.10).



Map 2.10. Adjusted Number of Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)



Overall rate	2.1
Extremal ratio	3.58
Coefficient of variation	23

Figure 2.14. Adjusted Number of Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of head ultrasounds per VLBW Anthem-insured newborn. Each dot represents one of the 61 NICRs with sufficient data to report.

Head Ultrasounds

Premature infants are at risk for multiple complications, including intraventricular hemorrhage (IVH). This bleeding into the fluid spaces of the brain occurs spontaneously, and the risk factors, other than prematurity, are unknown. Approximately a quarter of very low birth weight (< 1,500 grams) newborns develop IVH, with the most severe form leading to long-term consequences including developmental delay and cerebral palsy.

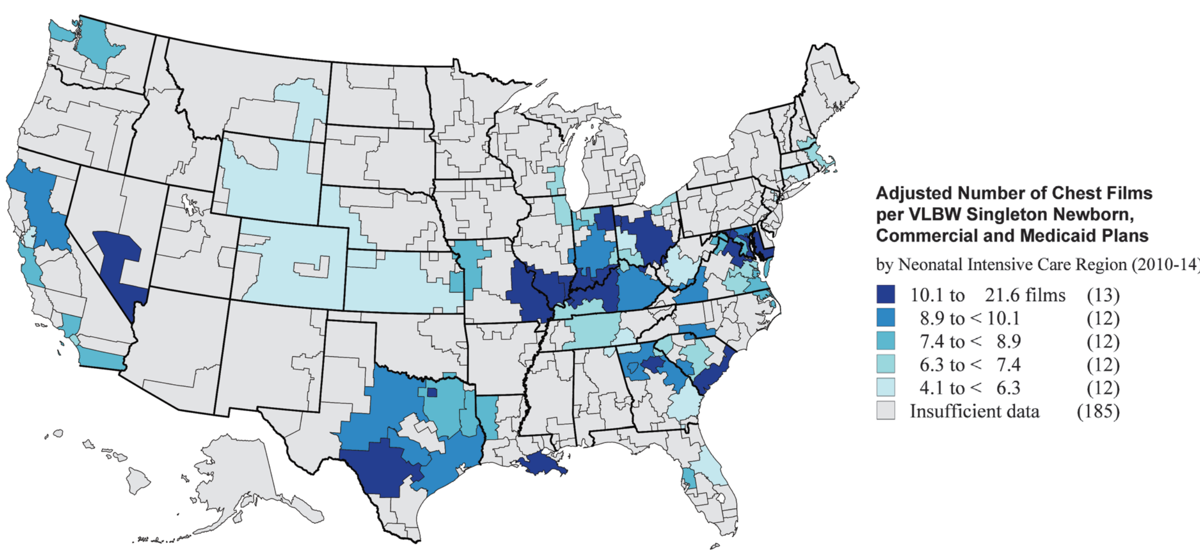
Detecting IVH is important for planning a newborn's care in the NICU and after discharge. The safest method is head ultrasound, which involves placing an ultrasound probe on the fontanelle, also known as the soft spot, of the head to obtain pictures of the brain. This test is quick, painless, and involves no radiation, making it ideal for infants. Routine head ultrasound to detect IVH in VLBW infants is considered a standard of care.

For newborns with birth weights greater than 1,500 grams (non-VLBW), head ultrasound has limited ability to detect other brain pathology. Generally, the need for brain imaging is indicated by physical examination. Therefore, routine use of head ultrasound in the absence of clinical signs or symptoms is not recommended for non-VLBW newborns.

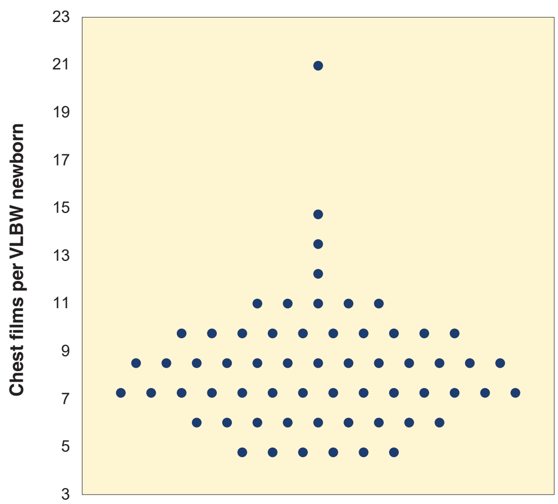
Chest Films

Chest films are commonly used to diagnose pulmonary disease, including respiratory distress syndrome, which is particularly common in preterm infants. These imaging procedures are inexpensive but expose newborns to small and often repeated doses of radiation. On average, VLBW newborns received 8.7 chest films during their newborn inpatient stay, with 8.5 films for Medicaid and 9.0 for commercially-insured newborns. There was high variation across NICRs, with a coefficient of variation of 33 (Figure 2.15). Across regions with more than 50 VLBW newborns, the number of chest films differed by more than 17 films per newborn. Large regions with relatively low numbers of chest films included Oakland, California (4.1 per newborn), Hartford, Connecticut (4.9), Savannah, Georgia (5.2), and Newark, New Jersey (5.2). Regions with relatively high chest film rates included Las Vegas, Nevada (21.6), Falls Church, Virginia (14.2), Plano, Texas (13.2), and Baltimore, Maryland (12.6) (Map 2.11).

There was a weak association between the number of chest films in Medicaid and in commercially-insured newborns among NICRs with sufficient data to report for both insurance types (Figure 2.16). Generally, many regions providing high numbers of chest films to the Medicaid population were not the same as those providing more for the commercially insured.



Map 2.11. Adjusted Number of Chest Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)



Overall rate	8.7
Extremal ratio	5.21
Coefficient of variation	33

Figure 2.15. Adjusted Number of Chest Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of chest films per Anthem-insured VLBW newborn. Each dot represents one of the 61 NICRs with sufficient data to report.

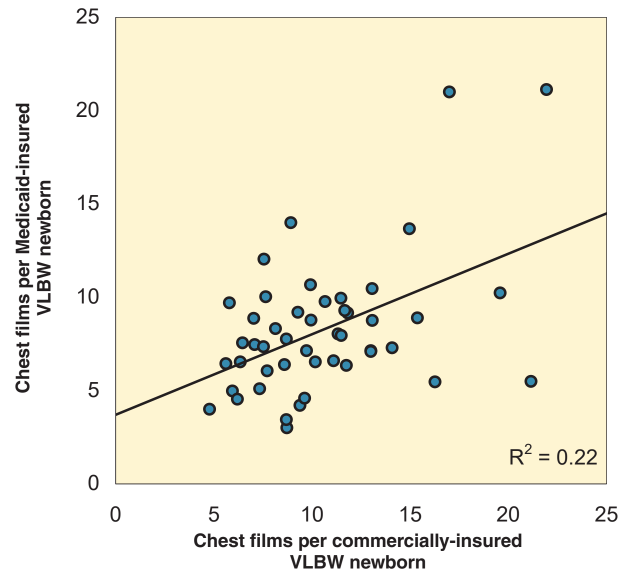
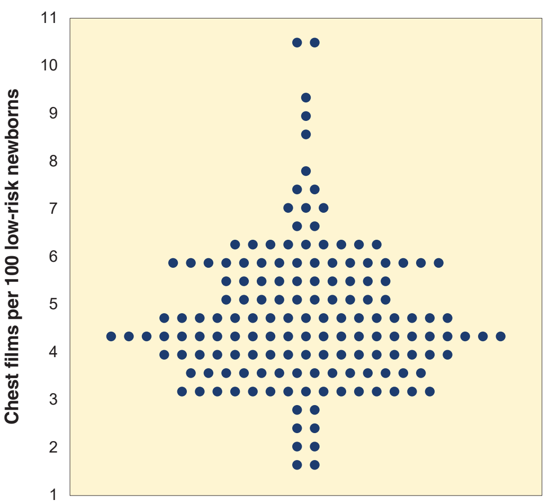


Figure 2.16. Relationship Between Numbers of Chest Films per VLBW Newborn Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between chest film rates for VLBW newborns in Anthem commercial and Medicaid plans among the 47 neonatal intensive care regions with sufficient data to report for both measures. There was a weak relationship between the number of chest films per newborn based on insurance type.

On average, low-risk newborns received about 4.7 chest films per 100 newborns, with 3.7 films per 100 for Medicaid and 5.5 per 100 for commercially-insured newborns. There was high variation across NICRs, with a coefficient of variation of 31 (Figure 2.17). Across regions with more than 1,000 low-risk newborns, the number of chest films differed by more than 9 films per 100 newborns. Large regions with relatively low chest film rates included Burlington, Vermont (1.4 per 100 newborns), Florence, South Carolina (1.7), Tacoma, Washington (2.2), and Madison, Wisconsin (2.2). Regions with relatively high chest film rates included Waco, Texas (10.7 per 100), Lubbock, Texas (10.4), Portland, Maine (9.2), and St. Petersburg, Florida (9.1) (Map 2.12). There was no association between the number of chest films in Medicaid and in commercially-insured newborns (Figure 2.18).



Overall rate	4.7
Extremal ratio	7.38
Coefficient of variation	31

Figure 2.17. Adjusted Number of Chest Films among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of chest films per 100 Anthem-insured low-risk newborns. Each dot represents one of the 152 NICRs with sufficient data to report.

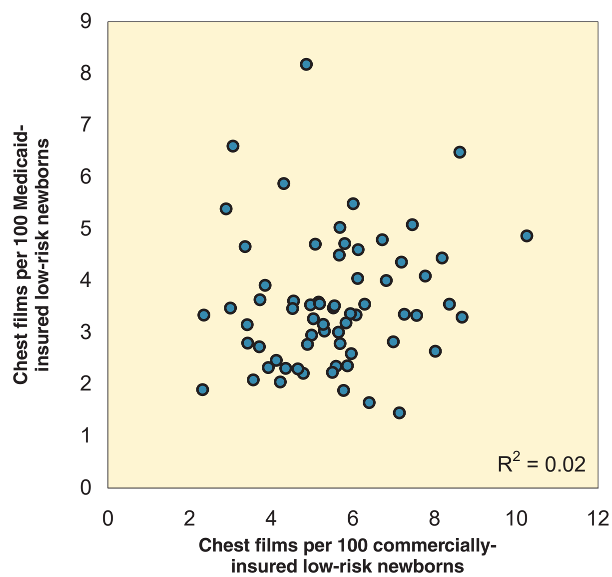
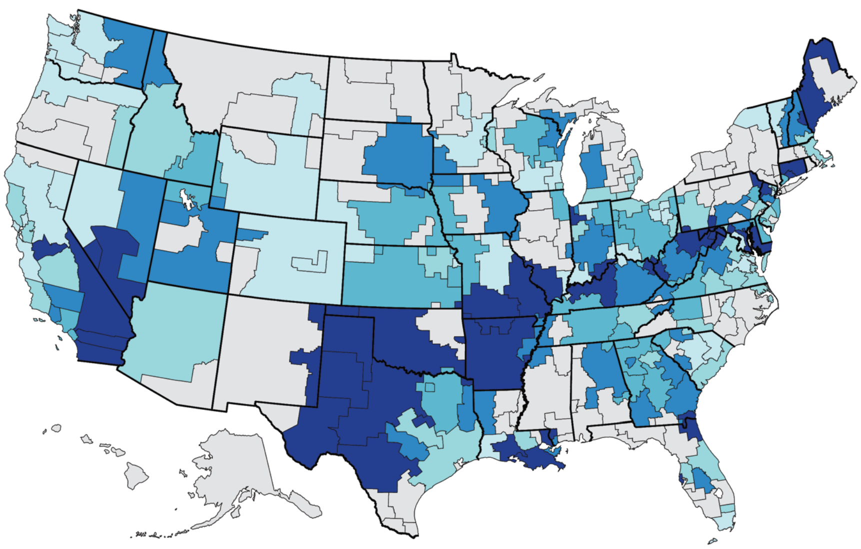


Figure 2.18. Relationship Between Numbers of Chest Films per 100 Low-Risk Newborns Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between chest film rates for low-risk newborns in Anthem commercial and Medicaid plans among the 66 neonatal intensive care regions with sufficient data to report for both measures. There was no relationship between the number of chest films per 100 newborns based on insurance type.



Map 2.12. Adjusted Number of Chest Films among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)

There was a weak association between the number of chest films in VLBW and in low-risk newborns (Figure 2.19). Often, the regions providing high numbers of chest films to the high-risk newborns (VLBW) were not the same as those providing more for the low-risk group.

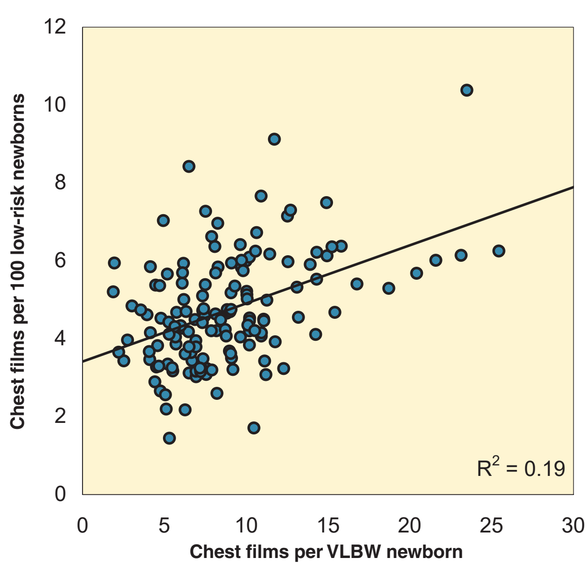
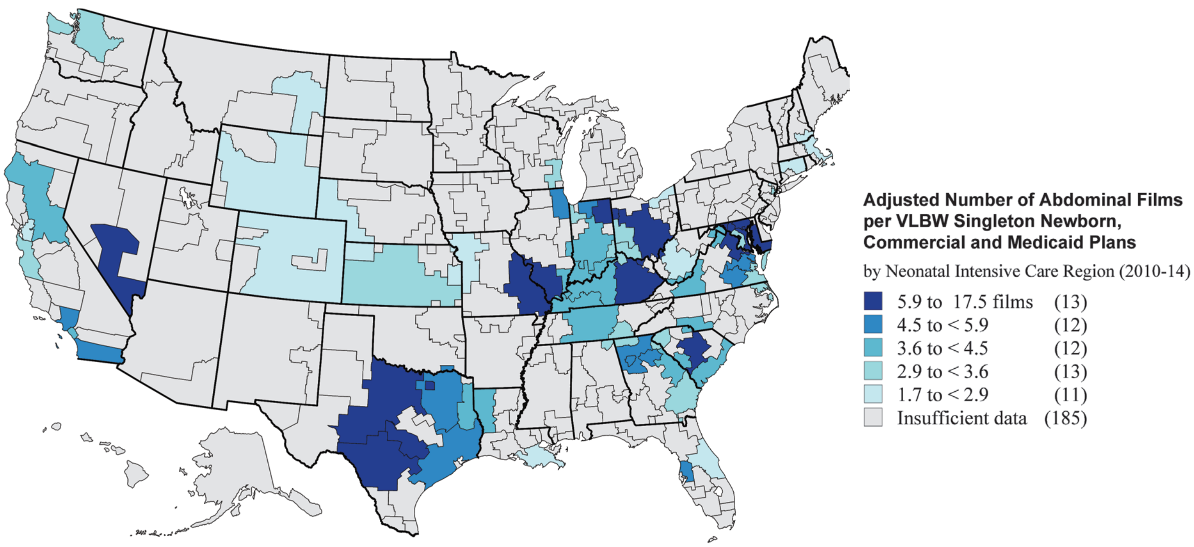


Figure 2.19. Relationship Between Chest Film Rates among VLBW and Low-Risk Newborns Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

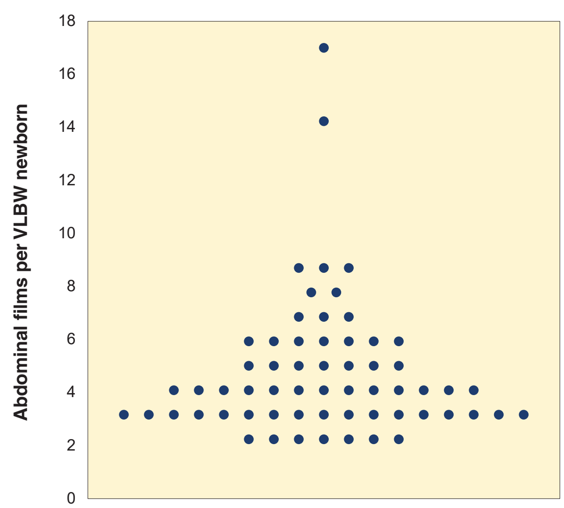
The figure shows the correlation between chest film rates for VLBW and low-risk newborns among the neonatal intensive care regions with sufficient data to report for both measures. There was a weak relationship between chest film rates based on birth weight.

Abdominal Films

Abdominal films are used to detect a wide range of gastrointestinal anomalies and diseases, including necrotizing enterocolitis, a serious disorder of unknown cause with varying incidence across NICUs. Variation in the number of abdominal films per VLBW newborn was extremely high across NICRs. Rates varied by a factor of almost ten, with a coefficient of variation of 57 (Figure 2.20). Among the regions with at least 50 VLBW newborns, the number of abdominal films per newborn was relatively low in Charleston, West Virginia (1.8 films per newborn), Cleveland, Ohio (1.9), Oakland, California (2.0), Hartford, Connecticut (2.3), and Orlando, Florida (2.5). The number of abdominal films per VLBW newborn in Las Vegas, Nevada (17.5 per newborn) was more than eight times higher than the rate in Charleston (1.8). Abdominal film rates were also relatively high in Falls Church, Virginia (14.3), San Antonio, Texas (9.1), Fort Wayne, Indiana (8.9), and St. Louis, Missouri (8.7) (Map 2.13).



Map 2.13. Adjusted Number of Abdominal Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

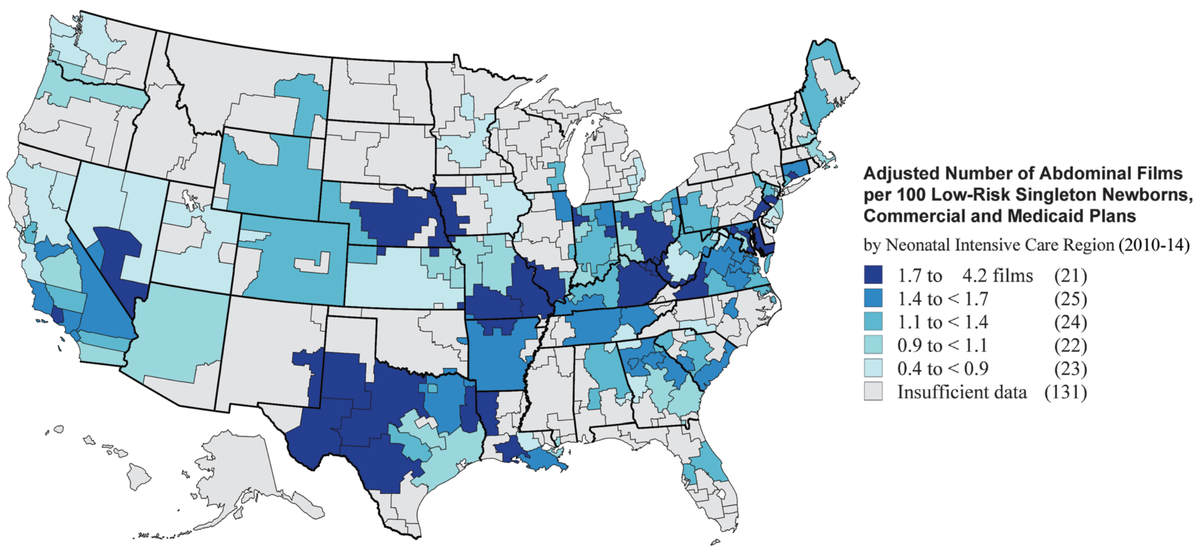


Overall rate	4.9
Extremal ratio	9.82
Coefficient of variation	57

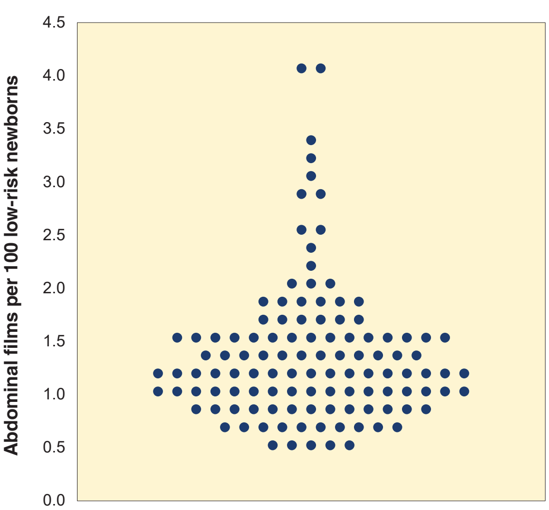
Figure 2.20. Adjusted Number of Abdominal Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of abdominal films per Anthem-insured VLBW newborn. Each dot represents one of the 61 NICRs with sufficient data to report.

Variation in abdominal film rates was similarly high among the low-risk newborn group; rates varied nearly tenfold across NICRs, with a coefficient of variation of 49 (Figure 2.21). Among the larger regions with at least 1,000 low-risk newborns, rates were relatively low in Jersey City, New Jersey (0.44 films per 100 newborns), Kansas City, Kansas (0.52), San Francisco, California (0.52), and Tacoma, Washington (0.54). Rates of abdominal films per 100 newborns were much higher in Lubbock, Texas (4.2 per 100), Las Vegas, Nevada (4.0), Springfield, Missouri (3.5), and Fort Worth, Texas (3.2) (Map 2.14).



Map 2.14. Adjusted Number of Abdominal Films among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)



Overall rate	1.5
Extremal ratio	9.47
Coefficient of variation	49

Figure 2.21. Adjusted Number of Abdominal Films among Low-Risk Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The figure shows the distribution in rates for the adjusted number of abdominal films per 100 Anthem-insured low-risk newborns. Each dot represents one of the 115 NICRs with sufficient data to report.

It should also be noted that sometimes a diagnostic film is taken that includes both the chest and abdomen. These “babygrams” do not have a separate procedure code and are billed as either a chest or abdominal film. This raises the question as to whether differences in billing practices for babygrams would result in regions with high chest film rates having low rates for abdominal films (i.e., a negative association). This was not the case, as seen in Figures 2.22 and 2.23. There was a relatively high positive association between the use of both types of films for VLBW newborns and a moderately positive association for low-risk newborns.

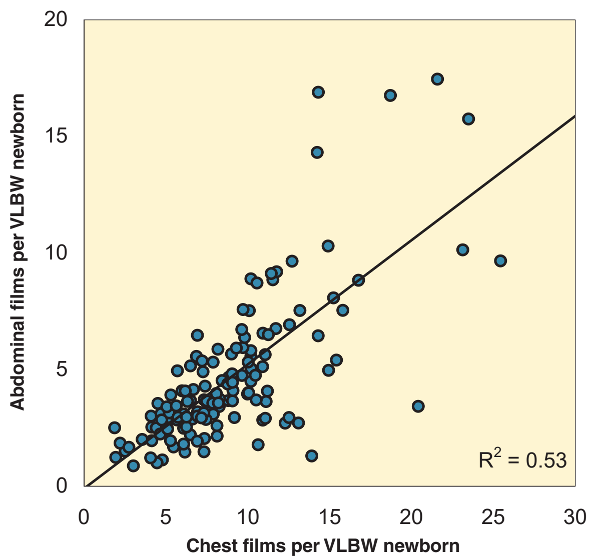


Figure 2.22. Relationship Between Adjusted Rates of Chest and Abdominal Films among Very Low Birth Weight Singleton Newborns Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between chest and abdominal film rates for VLBW newborns among the neonatal intensive care regions with sufficient data to report for both measures. There was a relatively strong relationship between the two imaging rates for VLBW newborns.

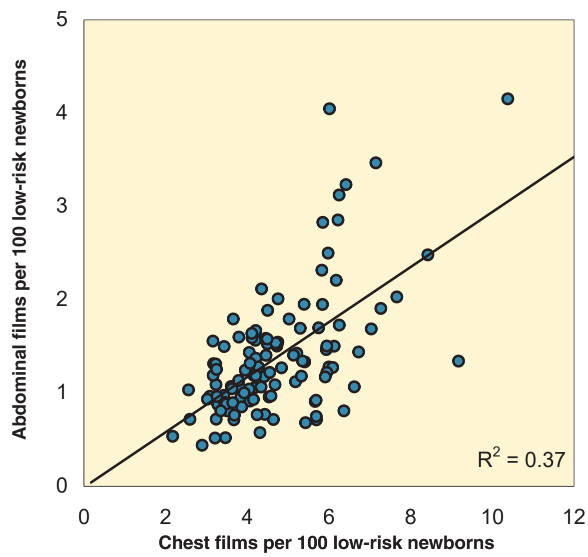


Figure 2.23. Relationship Between Adjusted Rates of Chest and Abdominal Films among Low-Risk Singleton Newborns Insured by Anthem Commercial and Medicaid Plans among NICRs (2010-14)

The figure shows the correlation between chest and abdominal film rates for low-risk newborns among the neonatal intensive care regions with sufficient data to report for both measures. There was a moderate relationship between the two imaging rates for low-risk newborns.

Summing Up

The national data from Vital Records and Anthem provide a sweeping view of the changing landscape of newborn and neonatal intensive care. NICUs continue to provide important and substantial services to the smallest and most critically ill newborns, but more than half of NICU admissions and close to half of special care days are now for lower-risk newborns. The regional supply of neonatologists and NICU beds has grown, but these resources are located with little regard for where the needs of newborns are greatest. Against this background, there was marked variation in all newborn medical services save one: the NICU admission rates for VLBW newborns varied little, reflecting high need, high NICU availability, and a strong professional consensus of benefit. But for the other services provided to VLBW newborns—special care days and imaging services—there were large differences in utilization across regions, reflecting the greater degree of clinical uncertainty regarding these aspects of care and illustrating a component of unwarranted variation (variation that is not due to patient need or preference). These services also varied for low-risk newborns, as did the chances of an admission to a NICU. While far fewer low-risk newborns received these special services, the large size of this population underscores the importance of monitoring care and outcomes across the total birth cohort.

The Atlas now turns its attention to two specific newborn populations: Texas Medicaid-insured newborns and Norwegian newborns. The quality of data available for these two populations is particularly high, and the results confirm and expand on the findings presented in this section.

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3. Texas Medicaid-Insured Newborns

Photo: iStock.com/andresr

Texas is one of the largest and most diverse states in the nation, with a population of 29 million and almost 10% of all U.S. births. In 2017, among the 383,050 newborns, 47% were Hispanic and 13% were Black. Compared to 9.9% in the U.S. overall,10.6% of Texan newborns were born preterm (< 37 weeks gestation), while the percent of very low birth weight births (< 1,500 grams) was 1.4%, the same proportion as the U.S. The percent of late preterm (34-36 weeks gestation) births in Texas (7.7%) was somewhat higher than the U.S. average (7.2%). One important measure of perinatal outcomes, the infant mortality rate (deaths occurring during the first year of life), was slightly lower in Texas (5.8%) than in the U.S. overall (5.9%).[1,2]

Texan children and their families face above-average economic challenges, with 21% of children living in poverty compared to 18% in the U.S. overall. The uninsured rate in Texas is the highest of any state at 17.3% (8.7% in the U.S.), reflecting in part the state's decision not to expand Medicaid under the Affordable Care Act. Eight percent of children under age five lack health insurance, which is the second highest state rate and twice the rate of the nation as a whole.[3]

Newborn care in Texas is provided in over 200 hospitals, ranging from critical access hospitals with fewer than 25 beds to one of the largest children's hospitals in the world, Texas Children's Hospital in Houston. Over the past two decades, the number of Texas NICUs and NICU beds has expanded robustly, increasing the availability of services but also drawing the attention of the state legislature. An unpublished Texas Health and Human Services Commission study reported that, between 1998 and 2009, NICU beds in Texas increased by 84%, while births grew by only 18%. In a related 2011 *Texas Tribune* article, one legislator commented, "We don't want to reduce services, but we need to combat inefficient, unnecessary use."[4] Although there have been no legislative or regulatory actions related to NICU expansion, the state completed a rigorous designation program of neonatal facility levels in 2018. In January 2019, there were 82 facilities designated as Level I "well nurseries," 75 as Level II "special care nurseries," 56 as Level III "intensive care units," and 20 as Level IV "advanced intensive care units."[5]

Eighty-five (56%) of the Level II-IV units participate in the Vermont-Oxford Network's quality and outcomes measurement and clinical improvement activities (see section 1 for more information about the Vermont-Oxford Network).

The Texas Neonatal Intensive Care Unit Project (TNP)

In 2015, the Texas Health and Human Services Commission asked The Dartmouth Institute and the University of Texas School of Public Health to conduct a study of neonatal intensive care in Texas Medicaid-insured newborns in collaboration with the University of Florida Institute for Child Health Policy. The objectives of the project, known as the Texas Neonatal Intensive Care Unit Project (TNP), were to measure regional and hospital variation in NICU admissions, variation in the types and quantity of care and costs, and to partner with the Commission in developing an ongoing surveillance system of newborn services. This section of the Atlas is adapted from the project's final report, released in November of 2018.[6]

Table 3.1. The Number of Level II-IV NICUs in Each Region (2014)

NICU Region (1)	Total NICUs (II,II,IV)	NICU Level (2)		
		II	III	IV
Abilene	2	1	1	0
Amarillo	3	1	2	0
Austin	12	7	5	1
Beaumont	3	0	3	0
Brownsville	3	0	3	0
College Station	3	1	2	0
Corpus Christi	5	1	2	2
Dallas	26	9	14	3
Denton	5	1	4	0
El Paso	5	0	5	0
Fort Worth	16	4	12	0
Houston	32	15	14	3
Laredo	2	0	1	1
Longview	2	0	2	0
Lubbock	3	0	1	2
McAllen	4	0	4	0
Odessa	3	1	2	0
San Antonio	12	6	4	2
Temple	3	1	1	1
Tyler	2	1	1	0
Victoria	2	0	2	0
Total	**148**	**49**	**85**	**15**

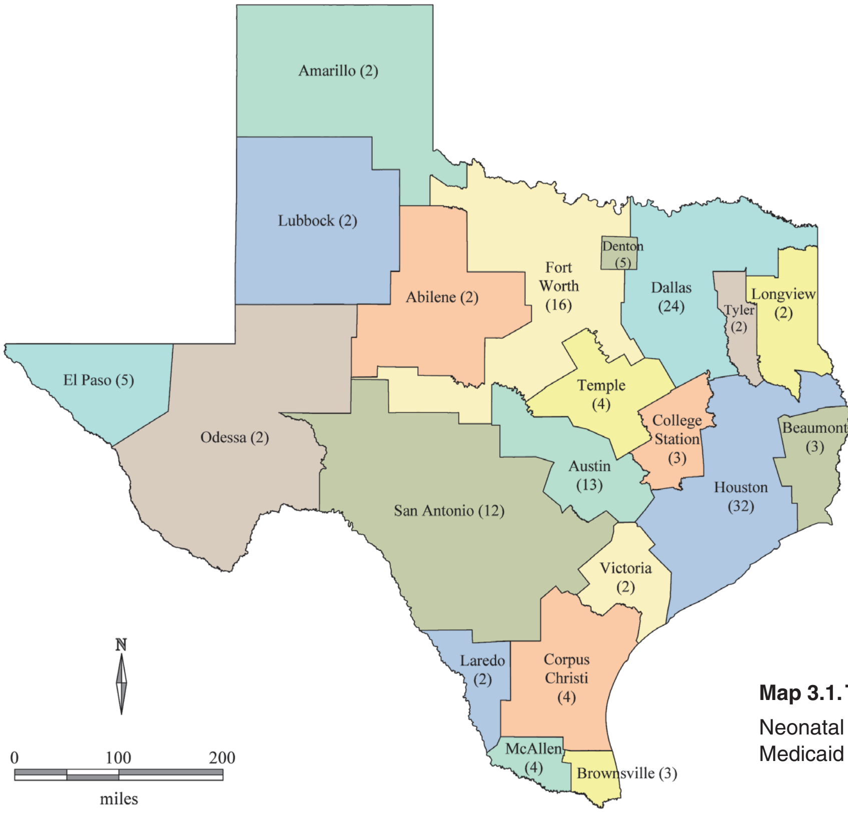
Notes: (1) Created based on the following criteria: a) > 500 infants in 3 years, b) A Level III or IV NICU, c) ≥ 60% localization index, d) At least 2 NICU facilities, e) Contiguity for counties with very low numbers. (2) NICU levels are from the 2014 Texas Annual Hospital Survey.

The numbers in the table are based on hospital NICU self-designations prior to the implementation of a state-regulated designation system in 2018.

In order to make fair comparisons across regions and hospitals, the analyses presented in this report are adjusted for the numerous indicators of newborn risk and health status available in the TNP database.[6]

The TNP is the world's largest population-based study of newborn care, with rich information about maternal and newborn characteristics and health care utilization extending from maternal prenatal care through the first year of life. This report presents the care of two subgroups of the overall Medicaid birth cohort born during the years 2010-14 (n=1.13 million). The first is those singleton infants with birth weights of 400-1,499 grams (very low birth weight (VLBW): n=12,826). Most of these newborns are significantly premature, and all require complex medical care, usually in a Level III or IV NICU. The second newborn group—singleton late preterm newborns (LPT) (34-36 weeks gestation: n=78,013)—is, on average, at low risk for serious complications. Not all require neonatal intensive care, but most need longer hospital stays than a term newborn (see section 1 for more information about VLBW and LPT newborns).

Two perspectives are used to present variation in newborn utilization rates. As with the national newborn studies, the project defined Texas Medicaid neonatal intensive care regions (NICRs) (Map 3.1) that represent relatively discrete geographic markets for NICU care (n=21). While measures at the regional level indicate a troubling degree of variation in the clinical care of newborns, differences in practice style among hospitals and their clinicians are "averaged out" within the regional rates. Therefore, rates are also presented for the 50 hospitals caring for the highest number of very low birth weight and late preterm newborns. These hospitals are not named. The full magnitude of the different approaches to newborn care, particularly neonatal intensive care, is revealed in these hospital-specific analyses.



Map 3.1. Texas Medicaid Neonatal Intensive Care Regions

Neonatal intensive care regions (NICRs) were defined using Texas Medicaid utilization data for 2011-13.

Overall Findings

Striking variation was observed in the care of Medicaid-insured newborns across regions and hospitals, with and without adjustment for differences in health risk. This variation in rates of NICU services and imaging occurred in both the high- and low-risk cohorts (i.e., VLBW and LPT). The overall Medicaid program payment for newborn care in 2014 was $1.1 billion, with newborns requiring special care (i.e., elevated care in either a NICU or a maternal-newborn care unit) accounting for 85% of the total. Most (85%) of the payments were for facility charges (i.e., hospitals), with the balance accounted for by professional services, primarily physician bills.

Preliminary analyses failed to find either benefit or harm in differences in NICU length of stay. If confirmed for other aspects of care, there are opportunities to reduce the intensity of care and payments and to increase the value of newborn care in the Texas Medicaid program.

Care of High-Risk Newborns: Very Low Birth Weight Newborns (< 1,500 grams)

Neonatal Intensive Care Unit Admission Rates

Almost all VLBW newborns received NICU care, and there was little variation in NICU admission rates across regions and hospitals. The low variation in rates of admission to a NICU reflects its very high value in caring for this high-risk group of newborns. In contrast, the duration of hospital care, the intensity of services, and the use of imaging varied widely.

Special Care Days

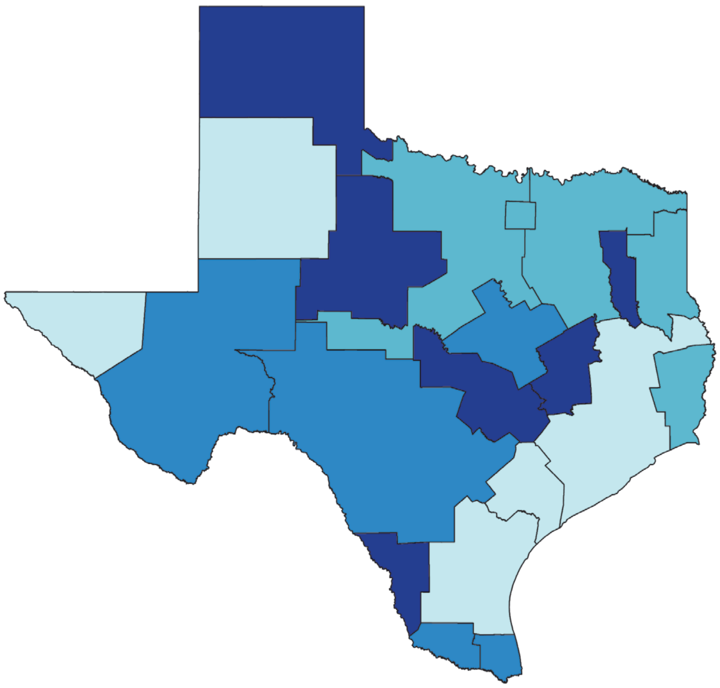
Number of Special Care Days per Newborn

VLBW newborns require a long duration of medical care before they are ready to go home. On average, each VLBW newborn in the Texas Medicaid program received

Table 3.2. Adjusted Number of Special Care Days among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Special Care Days (Any)	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	58	45	2,699	60.1	57.9	62.4	62.9	60.4	65.5
Amarillo	221	179	11,727	65.6	64.5	66.8	63.8	62.3	65.3
Austin	749	672	48,081	71.6	70.9	72.2	69.5	68.3	70.7
Beaumont	170	149	8,026	53.9	52.7	55.1	53.3	51.9	54.7
Brownsville	331	285	16,879	59.1	58.2	60.0	58.3	58.3	58.3
College Station	87	78	4,750	60.9	59.1	62.6	61.4	59.5	63.4
Corpus Christi	338	310	16,883	54.4	53.6	55.3	51.5	50.4	52.6
Dallas	2,159	1,925	106,828	55.5	55.2	55.8	54.8	53.9	55.7
Denton	141	127	6,842	53.8	52.5	55.1	53.1	51.6	54.6
El Paso	492	447	23,390	52.4	51.7	53.1	48.1	47.2	49.1
Fort Worth	1,320	1,124	62,223	55.4	54.9	55.8	53.7	52.8	54.6
Houston	3,470	3,083	171,966	55.8	55.5	56.0	52.7	51.8	53.5
Laredo	170	150	10,703	71.5	70.2	72.9	67.5	65.9	69.2
Longview	275	248	14,201	57.3	56.3	58.2	57.7	56.4	59.0
Lubbock	266	246	13,247	53.9	53.0	54.9	52.8	51.7	54.1
McAllen	609	540	31,843	58.9	58.3	59.6	57.9	56.8	59.0
Odessa	243	222	14,969	67.4	66.3	68.5	60.9	59.6	62.2
San Antonio	1,309	1,182	75,226	63.7	63.2	64.1	61.2	60.2	62.3
Temple	246	210	13,561	64.6	63.5	65.7	59.7	58.4	61.1
Tyler	108	92	5,626	61.0	59.4	62.6	61.5	59.6	63.4
Victoria	64	55	2,716	49.1	47.2	50.9	50.2	48.2	52.3
Texas	**12,826**	**11,323**	**659,687**	**58.3**					
Extremal Ratio		**1.44**							
Interquartile Ratio		**1.16**							
Coefficient of Variation		**10**							

(1) Adjusted for mortality in the first 27 days of life



Adjusted Rate of Special Care Days (Intensive or Intermediate) per VLBW Singleton Newborn with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

61.3 to 69.5 days	(6)
57.8 to < 61.3	(5)
52.9 to < 57.8	(5)
48.1 to < 52.9	(5)

Map 3.2. Adjusted Number of Special Care Days among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

58.3 days of special care. The number of special care days (SCDs) varied across NICRs, and this variation was not appreciably lower after adjusting for differences in newborn risk. Crude (unadjusted) rates ranged from 49.1 days per newborn in Victoria to 71.6 days per newborn in Austin. NICRs with low adjusted rates included El Paso (48.1 days per newborn), Victoria (50.2 days), Corpus Christi (51.5 days), and Houston (52.7 days). The four highest adjusted rates were observed in Austin (69.5 days per newborn), Laredo (67.5 days), Amarillo (63.8 days), and Abilene (62.9 days) (Map 3.2). The extremal ratio (the highest rate divided by the lowest rate) was 1.44 and the coefficient of variation (the standard deviation divided by the mean) was 10 (Table 3.2).

The variation in the number of SCDs per VLBW newborn was greater across hospitals than regions. Crude rates varied more than twofold, from 40.0 days per newborn at the hospital with the lowest rate to 90.8 days at the hospital with the highest rate. Even after adjusting for differences in risk, adjusted rates varied by a factor of 1.9, from fewer than 45 days at the three lowest-rate hospitals (40.5, 43.4, and 44.0 days) to more than 70 at the three highest-rate hospitals (77.8, 76.3, and 72.4 days) (Figure 3.1).

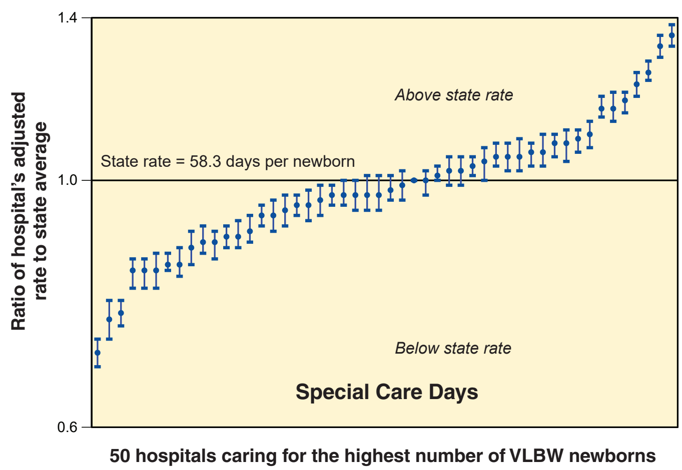


Figure 3.1. Standardized Adjusted Rate and 95% Confidence Interval for Special Care Days among Very Low Birth Weight Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted SCD rate per newborn to the state average for the 50 hospitals caring for the highest number of VLBW newborns in Texas. The dot represents the hospital's day rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval. The shorter the line, the more precise the estimate.

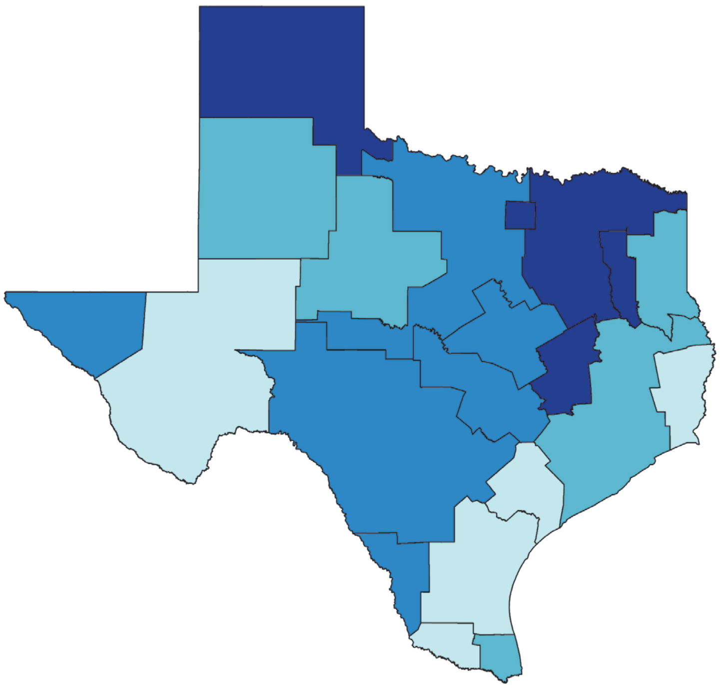
Percent of Special Care Days Billed as Intensive Days

Both hospitals and physicians classify each day of newborn care as routine, intermediate, or intensive for Medicaid reimbursement using billing codes (note that the exact terminology used in billing codes for care intensity may differ). Higher levels of care are usually associated with higher reimbursements from Medicaid. Almost 86% of all SCDs for VLBW newborns were billed as intensive days during 2010-14, with the remainder billed as intermediate. The range in the percent of SCDs billed as intensive across regions in terms of crude percentages was 51.7% in Corpus Christi to 95.6% in Denton. For adjusted rates, the regions with low percentages were Corpus Christi (51.9%), Victoria (67.5%), Odessa (71.4%), and Beaumont (71.8%). The four highest adjusted percentages were observed in Denton (96.2%), College Station (95.8%), Tyler (94.4%), and Dallas (93.3%) (Map 3.3). The extremal ratio was 1.85 and the coefficient of variation was 13 (Table 3.3).

Table 3.3. Adjusted Percent of Special Care Days Billed as Intensive among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns with Special Care Days	Special Care Days	Intensive Special Care Days	Crude Percent	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Percent	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	57	2,699	2,252	83.4	80.0	86.9	85.5	81.7	89.5
Amarillo	212	11,727	10,763	91.8	90.0	93.5	92.9	90.5	95.4
Austin	738	48,081	43,287	90.0	89.2	90.9	90.3	88.5	92.2
Beaumont	168	8,026	5,674	70.7	68.9	72.5	71.8	69.5	74.1
Brownsville	320	16,879	14,059	83.3	81.9	84.7	84.0	82.0	86.2
College Station	83	4,750	4,455	93.8	91.0	96.5	95.8	92.6	99.2
Corpus Christi	325	16,883	8,735	51.7	50.7	52.8	51.9	50.5	53.4
Dallas	2,095	106,828	98,938	92.6	92.0	93.2	93.3	91.5	95.2
Denton	136	6,842	6,542	95.6	93.3	97.9	96.2	93.3	99.2
El Paso	482	23,390	21,673	92.7	91.4	93.9	92.8	90.7	94.9
Fort Worth	1,266	62,223	56,448	90.7	90.0	91.5	90.9	89.1	92.7
Houston	3,380	171,966	139,543	81.1	80.7	81.6	81.2	79.6	82.8
Laredo	166	10,703	9,727	90.9	89.1	92.7	91.8	89.4	94.4
Longview	264	14,201	12,520	88.2	86.6	89.7	89.3	87.1	91.6
Lubbock	261	13,247	11,230	84.8	83.2	86.3	85.7	85.7	85.7
McAllen	596	31,843	23,705	74.4	73.5	75.4	75.3	73.7	77.0
Odessa	241	14,969	10,870	72.6	71.3	74.0	71.4	69.6	73.4
San Antonio	1,283	75,226	67,855	90.2	89.5	90.9	90.4	88.6	92.2
Temple	229	13,561	12,580	92.8	91.1	94.4	91.8	89.5	94.1
Tyler	104	5,626	5,216	92.7	90.2	95.2	94.4	91.4	97.6
Victoria	63	2,716	1,771	65.2	62.2	68.2	67.5	64.2	70.9
Texas	**12,469**	**662,386**	**567,843**	**85.7**					

Extremal Ratio	**1.85**
Interquartile Ratio	**1.14**
Coefficient of Variation	**13**



Adjusted Percent of Special Care Days Billed as Intensive among VLBW Singleton Newborns with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 92.9% to 96.3% (5)
- 90.3% to < 92.9% (6)
- 81.0% to < 90.3% (5)
- 51.9% to < 81.0% (5)

Map 3.3. Adjusted Percent of Special Care Days Billed as Intensive among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

Among the 50 hospitals caring for the highest number of VLBW newborns, both crude and adjusted percentages of SCDs billed as intensive varied by a factor of more than 2.5. Crude rates ranged from 37.2% at the lowest-rate hospital to 98.6% at the highest. Similarly, adjusted rates varied from about 40% of SCDs at the two hospitals with the lowest rates (38.1% and 41.9%) to more than 98% at five hospitals (Figure 3.2).

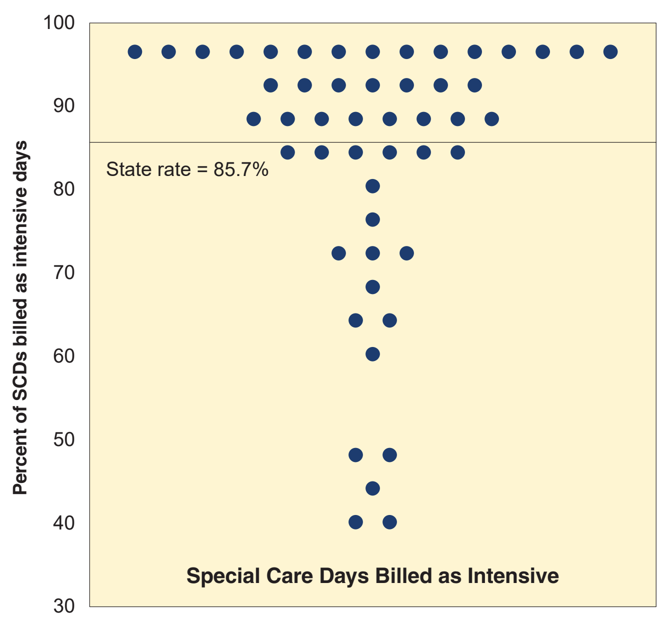


Figure 3.2. Adjusted Percent of Special Care Days Billed as Intensive among Very Low Birth Weight Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the distribution in rates for the adjusted percent of SCDs billed as intensive days. Each blue dot represents one of the 50 hospitals caring for the highest number of VLBW newborns in Texas.

Imaging

Given the illness acuity of VLBW newborns, high rates of diagnostic imaging are expected. Overall, among VLBW newborns insured by Medicaid in Texas, imaging rates were 17 per newborn for chest films, 9 per newborn for abdominal films, and 2.5 per newborn for head ultrasounds. Twenty percent of all VLBW newborns had a head MRI prior to discharge. Compared to rates of SCDs, regional variation in adjusted diagnostic imaging rates was much higher.

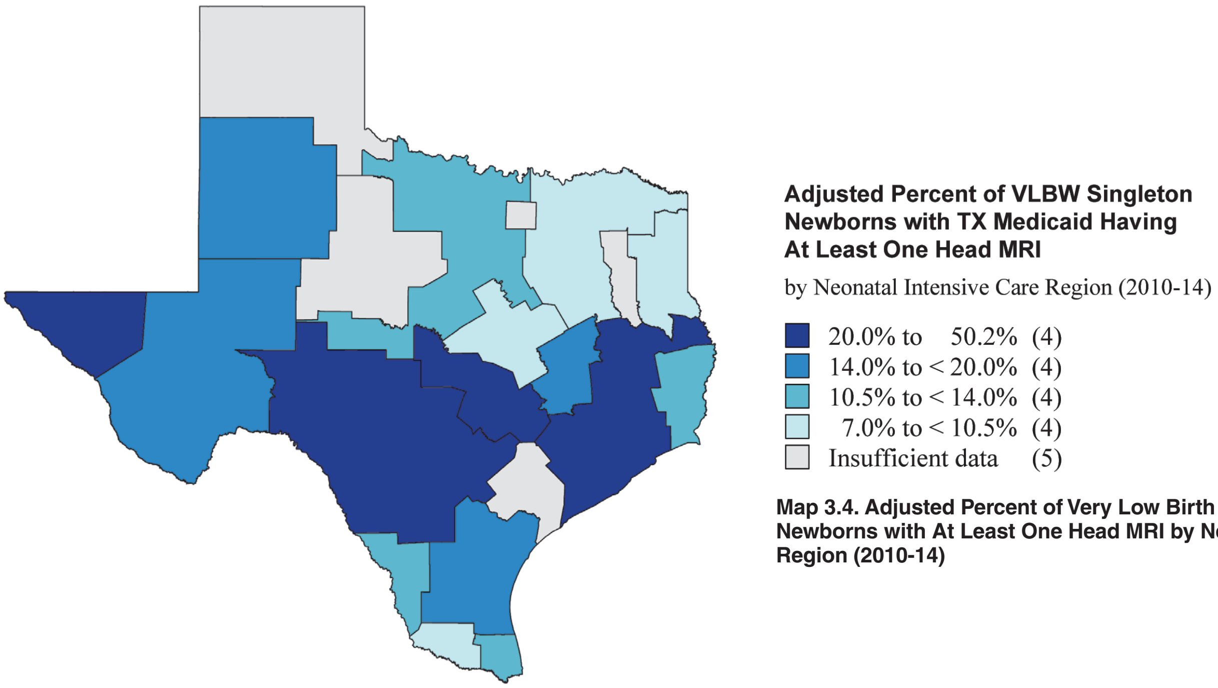
Head MRIs

Head MRIs are used to detect brain injuries or congenital anomalies (see section 2 for more information about head MRIs). Overall, 19.5% of VLBW newborns insured by Texas Medicaid received a head MRI, but this rate varied more than sevenfold across regions. There was relatively little difference between the crude and adjusted

Table 3.4. Adjusted Percent of Very Low Birth Weight Singleton Newborns with At Least One Head MRI by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number of Newborns with Head MRI	Crude Percent	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Percent	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	58	----	----	----	----	----	----	----	----
Amarillo	221	----	----	----	----	----	----	----	----
Austin	749	672	253	37.7	33.0	42.3	43.3	32.4	58.0
Beaumont	170	149	16	10.7	5.5	16.0	12.6	7.2	21.9
Brownsville	331	285	27	9.5	5.9	13.0	11.0	6.9	17.4
College Station	87	78	12	15.4	6.7	24.1	18.3	9.8	34.2
Corpus Christi	338	310	55	17.7	13.0	22.4	19.5	19.5	19.5
Dallas	2,159	1,925	167	8.7	7.4	10.0	10.2	7.5	13.8
Denton	141	----	----	----	----	----	----	----	----
El Paso	492	447	208	46.6	40.3	52.9	50.2	37.3	67.6
Fort Worth	1,320	1,124	112	10.0	8.1	11.8	11.4	8.3	15.7
Houston	3,470	3,083	785	25.5	23.7	27.2	28.3	21.5	37.2
Laredo	170	150	18	12.0	6.5	17.6	13.2	7.8	22.5
Longview	275	248	18	7.3	3.9	10.6	8.6	5.1	14.7
Lubbock	266	246	33	13.4	8.9	18.0	15.6	10.2	24.1
McAllen	609	540	33	6.1	4.0	8.2	7.1	4.6	10.9
Odessa	243	222	36	16.2	10.9	21.5	17.2	11.3	26.2
San Antonio	1,309	1,182	404	34.2	30.9	37.5	38.9	29.4	51.6
Temple	246	210	17	8.1	4.2	11.9	8.7	5.1	15.0
Tyler	108	----	----	----	----	----	----	----	----
Victoria	64	----	----	----	----	----	----	----	----
Texas	**12,826**	**10,870**	**2,194**	**19.5**					
Extremal Ratio		**7.10**							
Interquartile Ratio		**2.01**							
Coefficient of Variation		**68**							

(1) Adjusted for mortality in the first 27 days of life



Map 3.4. Adjusted Percent of Very Low Birth Weight Singleton Newborns with At Least One Head MRI by Neonatal Intensive Care Region (2010-14)

rates. The four regions with the lowest adjusted rates were McAllen (7.1%), Longview (8.6%), Temple (8.7%), and Dallas (10.2%). The percent of VLBW newborns having a head MRI was more than seven times higher in El Paso (50.2%) than in McAllen (7.1%). Other regions with high adjusted rates included Austin (43.3%), San Antonio (38.9%), and Houston (28.3%) (Map 3.4). The extremal ratio was 7.1 and the coefficient of variation was 68 (Table 3.4).

The variation across hospitals in head MRI rates for VLBW newborns was even more striking than the variation among regions. At the two hospitals with the lowest adjusted rates, less than 5% (4.5% and 4.7%) of VLBW newborns had a head MRI. This rate was about 13 times higher at the highest-rate hospital (58.7%). Two other hospitals had head MRI rates greater than 50% (55.0% and 51.4%) (Figure 3.3).

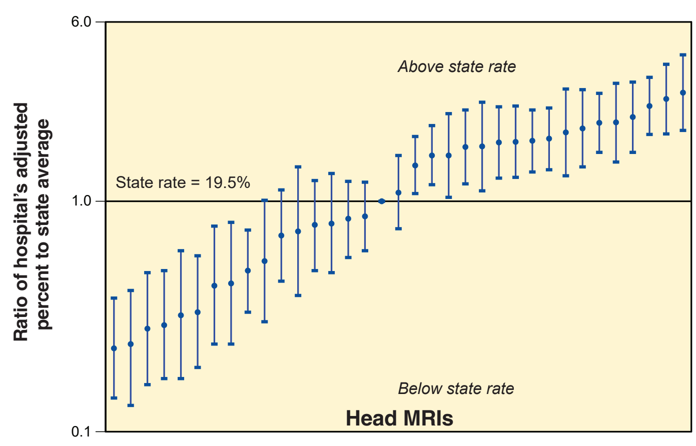


Figure 3.3. Standardized Adjusted Percent and 95% Confidence Interval for Very Low Birth Weight Singleton Newborns with At Least One Head MRI by Hospital (n=35) (2010-14)

The figure shows the ratio to the state average of the adjusted percent of newborns receiving a head MRI for the 35 hospitals with sufficient data to allow reporting among the 50 hospitals caring for the highest number of VLBW newborns in Texas. The dot represents the hospital's percentage standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

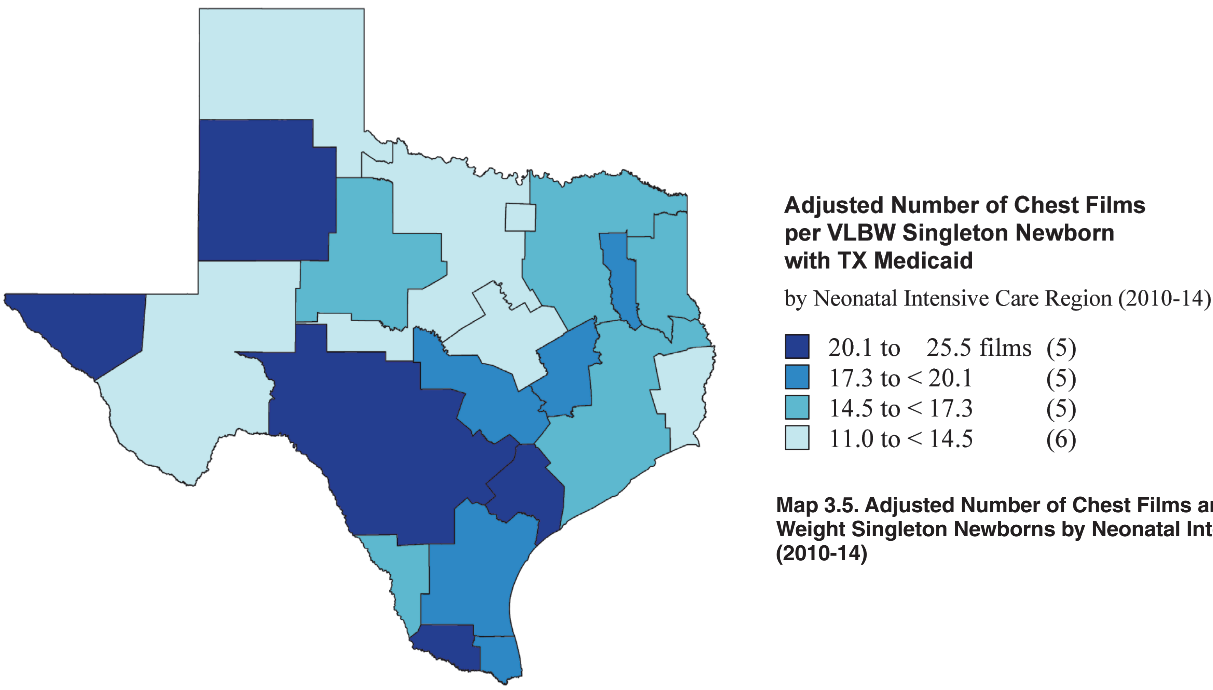
Chest Films

Chest films are necessary to assess respiratory symptoms in VLBW newborns, but the number of chest films received by newborns varied more than twofold across NICRs. On average, each VLBW newborn received 17 chest films, but the crude number per newborn ranged from 10.3 in Denton to 25.8 in San Antonio. After adjusting for differences in newborn risk, the four NICRs with the lowest number of chest films were Amarillo (11.0 per newborn), Denton (11.2), Temple (11.3), and Beaumont (12.1). Rates of chest imaging were about twice as high in McAllen (25.4 per newborn), San Antonio (25.4), Victoria (23.9), and Lubbock (23.2) (Map 3.5). The extremal ratio was 2.31 and the coefficient of variation was 26 (Table 3.5).

Table 3.5. Adjusted Number of Chest Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number of Chest Films	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	58	45	569	12.7	11.6	13.7	16.4	15.1	17.8
Amarillo	221	179	1,912	10.7	10.2	11.2	11.0	10.5	11.5
Austin	749	672	11,939	17.8	17.5	18.1	18.1	17.8	18.5
Beaumont	170	149	1,578	10.6	10.1	11.1	12.1	11.5	12.7
Brownsville	331	285	4,723	16.5	16.1	17.0	18.2	17.6	18.8
College Station	87	78	1,127	14.4	13.6	15.3	17.8	16.8	18.9
Corpus Christi	338	310	5,413	17.5	17.0	17.9	17.5	17.0	18.0
Dallas	2,159	1,925	32,360	16.8	16.6	17.0	17.0	17.0	17.0
Denton	141	127	1,312	10.3	9.8	10.9	11.2	10.6	11.8
El Paso	492	447	9,982	22.4	21.9	22.8	20.1	19.7	20.6
Fort Worth	1,320	1,124	14,018	12.5	12.3	12.7	12.9	12.6	13.1
Houston	3,470	3,083	45,387	14.7	14.6	14.9	14.6	14.4	14.8
Laredo	170	150	2,386	15.9	15.3	16.6	16.1	15.5	16.8
Longview	275	248	3,557	14.3	13.9	14.8	16.3	15.8	16.9
Lubbock	266	246	5,242	21.3	20.8	21.9	23.2	22.5	23.9
McAllen	609	540	12,581	23.3	22.9	23.7	25.4	24.9	26.0
Odessa	243	222	3,680	16.6	16.0	17.1	14.5	14.0	15.0
San Antonio	1,309	1,182	30,487	25.8	25.5	26.1	25.4	25.0	25.8
Temple	246	210	2,572	12.2	11.8	12.7	11.3	10.9	11.8
Tyler	108	92	1,458	15.8	15.0	16.6	18.8	17.9	19.8
Victoria	64	55	1,067	19.3	18.1	20.4	23.9	22.5	25.4
Texas	**12,826**	**11,368**	**193,350**	**17.0**					
Extremal Ratio		**2.31**							
Interquartile Ratio		**1.30**							
Coefficient of Variation		**26**							

(1) Adjusted for mortality in the first 27 days of life



Map 3.5. Adjusted Number of Chest Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

Both crude and adjusted rates of chest films per newborn varied nearly tenfold among the 50 hospitals caring for the highest number of VLBW newborns in Texas Medicaid. At the three hospitals with the lowest adjusted rates, VLBW newborns had about 6 chest films (5.5, 5.7, and 6.2 per newborn). The rate was nearly 10 times higher—53.5 chest films per newborn—at the hospital with the highest adjusted rate. Three additional hospitals had rates close to 30 chest films per newborn (30.9, 28.2, and 28.0) (Figure 3.4).

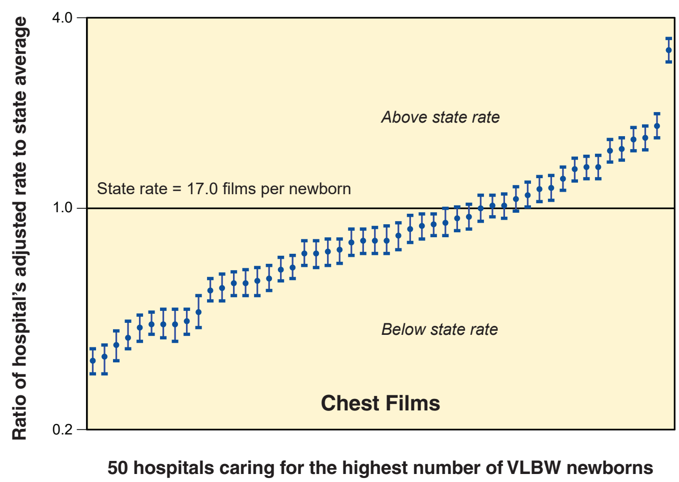


Figure 3.4. Standardized Adjusted Rate and 95% Confidence Interval for Chest Films among Very Low Birth Weight Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted rate of chest films per newborn to the state average for the 50 hospitals caring for the highest number of VLBW newborns in Texas. The dot represents the hospital's rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

Abdominal Films

Abdominal films are common in very ill newborns to monitor central lines (i.e., umbilical) and acute diseases of the digestive tract. On average, each VLBW newborn insured by Texas Medicaid received 9 abdominal films, but this rate varied more than fourfold across regions. The crude number per newborn ranged from 4.2 in Longview to 21.4 in San Antonio. After adjusting for newborn risk, the four NICRs with the lowest rates were Longview (4.4 abdominal films per newborn), Beaumont (4.6), El Paso (4.9), and Houston (6.1). NICRs with high adjusted rates included San Antonio (18.9 abdominal films per newborn), Lubbock (11.8), Brownsville (11.6), and Victoria (11.2) (Map 3.6). The extremal ratio was 4.26 and the coefficient of variation was 40 (Table 3.6).

The variation in the number of abdominal films per newborn was striking among the 50 hospitals caring for the highest number of VLBW newborns, driven by the adjusted rate at the highest hospital—68.3 abdominal films per newborn—which was more than 30 times higher than the rate at the lowest hospital (2.0). Even discounting these extremes, rates still varied more than fivefold, from fewer than 5 per newborn at seven other hospitals to more than 25 per newborn at three additional hospitals (Figure 3.5).

Relationship Between Chest and Abdominal Films

There was a moderately strong relationship between rates of chest and abdominal films per newborn among the 50 hospitals caring for the highest number of VLBW newborns in Texas (Figure 3.6), indicating that, where providers had a higher probability of ordering chest films, they were also more likely to order abdominal films.

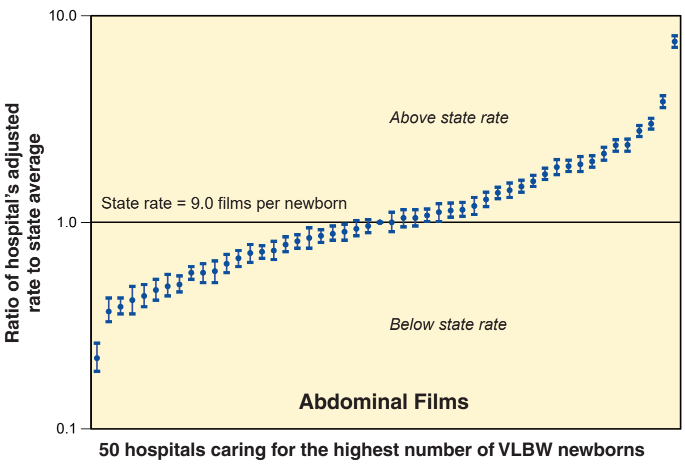


Figure 3.5. Standardized Adjusted Rate and 95% Confidence Interval for Abdominal Films among Very Low Birth Weight Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted rate of abdominal films per newborn to the state average for the 50 hospitals caring for the highest number of VLBW newborns in Texas. The dot represents the hospital's rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

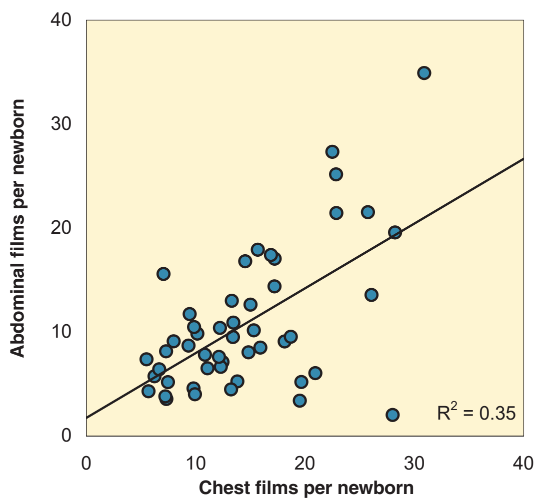
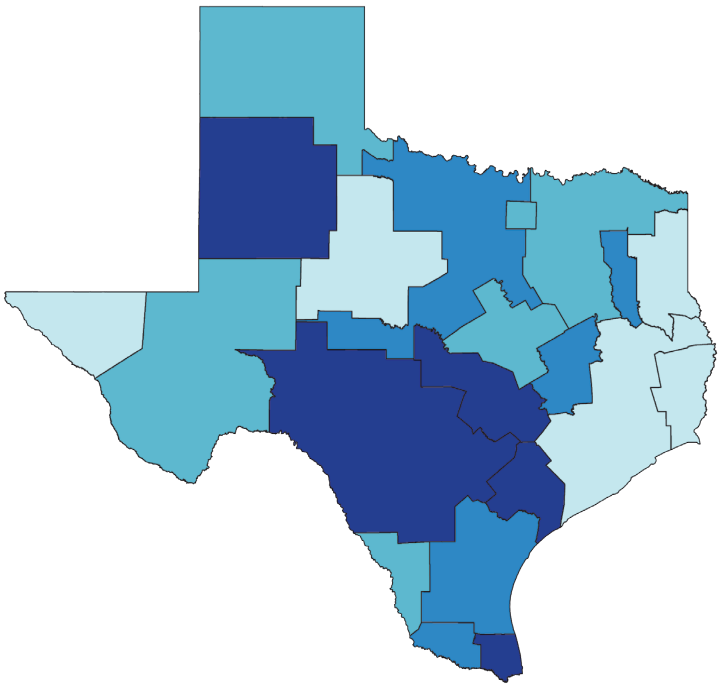


Figure 3.6. Relationship Between Adjusted Rates of Chest and Abdominal Films among Very Low Birth Weight Singleton Newborns by Hospital (n=49) (2010-14)

The figure shows the correlation between rates of chest and abdominal films per newborn for the 49 hospitals with sufficient data to allow reporting among the 50 hospitals caring for the highest number of VLBW newborns in Texas. One hospital with extremely high rates for both measures (53.5 chest films and 68.3 abdominal films per newborn) was excluded to avoid distorting the figure.



Adjusted Number of Abdominal Films per VLBW Singleton Newborn with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 9.2 to 19.0 films (5)
- 7.3 to < 9.2 (5)
- 6.4 to < 7.3 (6)
- 4.4 to < 6.4 (5)

Map 3.6. Adjusted Number of Abdominal Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

Table 3.6. Adjusted Number of Abdominal Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number of Abdominal Films	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	58	45	243	5.4	4.7	6.1	6.2	5.5	7.1
Amarillo	221	179	1,215	6.8	6.4	7.2	6.5	6.0	6.9
Austin	749	672	6,616	9.8	9.6	10.1	9.4	9.0	9.8
Beaumont	170	149	666	4.5	4.1	4.8	4.6	4.3	5.0
Brownsville	331	285	3,292	11.5	11.1	11.9	11.6	11.1	12.2
College Station	87	78	598	7.7	7.0	8.3	8.4	7.7	9.2
Corpus Christi	338	310	3,012	9.7	9.4	10.1	9.0	9.0	9.0
Dallas	2,159	1,925	14,840	7.7	7.6	7.8	7.3	7.0	7.6
Denton	141	127	894	7.0	6.6	7.5	7.0	6.5	7.5
El Paso	492	447	2,550	5.7	5.5	5.9	4.9	4.6	5.1
Fort Worth	1,320	1,124	9,285	8.3	8.1	8.4	7.7	7.4	8.0
Houston	3,470	3,083	20,413	6.6	6.5	6.7	6.1	5.9	6.4
Laredo	170	150	1,049	7.0	6.6	7.4	6.6	6.1	7.1
Longview	275	248	1,053	4.2	4.0	4.5	4.4	4.1	4.8
Lubbock	266	246	2,930	11.9	11.5	12.4	11.8	11.3	12.5
McAllen	609	540	4,139	7.7	7.4	7.9	7.7	7.3	8.0
Odessa	243	222	1,730	7.8	7.4	8.2	6.5	6.1	6.9
San Antonio	1,309	1,182	25,236	21.4	21.1	21.6	18.9	18.2	19.7
Temple	246	210	1,726	8.2	7.8	8.6	7.2	6.8	7.6
Tyler	108	92	733	8.0	7.4	8.5	8.5	7.9	9.2
Victoria	64	55	559	10.1	9.3	10.9	11.2	10.2	12.2
Texas	**12,826**	**11,368**	**102,779**	**9.0**					

Extremal Ratio	**4.26**
Interquartile Ratio	**1.40**
Coefficient of Variation	**40**

(1) Adjusted for mortality in the first 27 days of life

Head Ultrasounds

Head ultrasounds are most commonly used in VLBW infants to diagnose intraventricular hemorrhage (see section 2 for more information about head ultrasounds). Overall, each VLBW newborn in Texas Medicaid received 2.5 head ultrasounds. Across NICRs, the unadjusted rate varied more than twofold, from 1.5 per newborn in El Paso to 3.8 in Odessa. Adjusting for differences in patient health risk had only a small effect on rates. NICRs with low adjusted rates included El Paso (1.4 per newborn), Amarillo (1.6), College Station (1.7), and Fort Worth (1.8). The NICRs with the highest adjusted rates were Odessa (3.4 per newborn), San Antonio (3.4), McAllen (3.3), and Corpus Christi (3.2) (Map 3.7). The extremal ratio was 2.50 and the coefficient of variation was 25 (Table 3.7).

Rates of head ultrasound—both crude and adjusted—varied about fivefold across the 50 hospitals caring for the highest number of VLBW newborns in Texas Medicaid. The adjusted head ultrasound rate was 0.9 per newborn at the lowest hospital, and there were fewer than 1.5 head ultrasounds per newborn at three additional hospitals. By contrast, the rate was 4.6 head ultrasounds per newborn at the highest hospital, and 4.4 per newborn at two other hospitals (Figure 3.7).

Relationship Between Head MRIs and Head Ultrasounds

Both head MRIs and ultrasounds can identify intraventricular hemorrhages. At hospitals that have high use of one imaging technique, one might expect to observe lower utilization of the other. Instead, there was no association across hospitals in the use of head MRIs and ultrasounds (Figure 3.8).

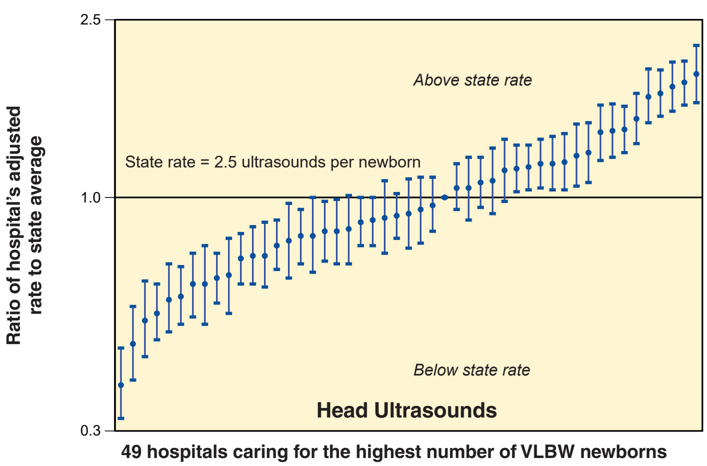


Figure 3.7. Standardized Adjusted Rate and 95% Confidence Interval for Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Hospital (n=49) (2010-14)

The figure shows the ratio of the adjusted head ultrasound rate per newborn to the state average for the 49 hospitals with sufficient data to allow reporting among the 50 hospitals with the highest number of VLBW newborns in Texas. The dot represents the hospital's rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

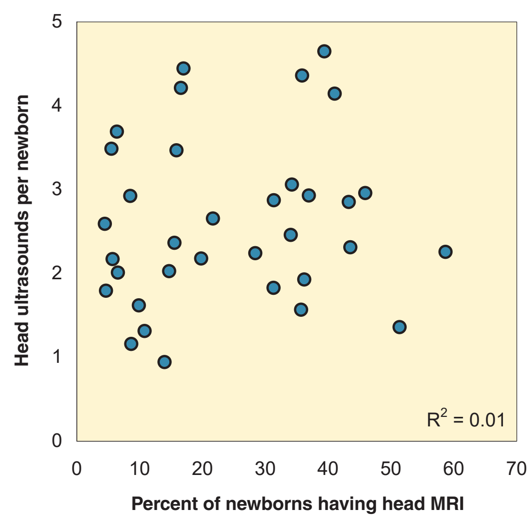
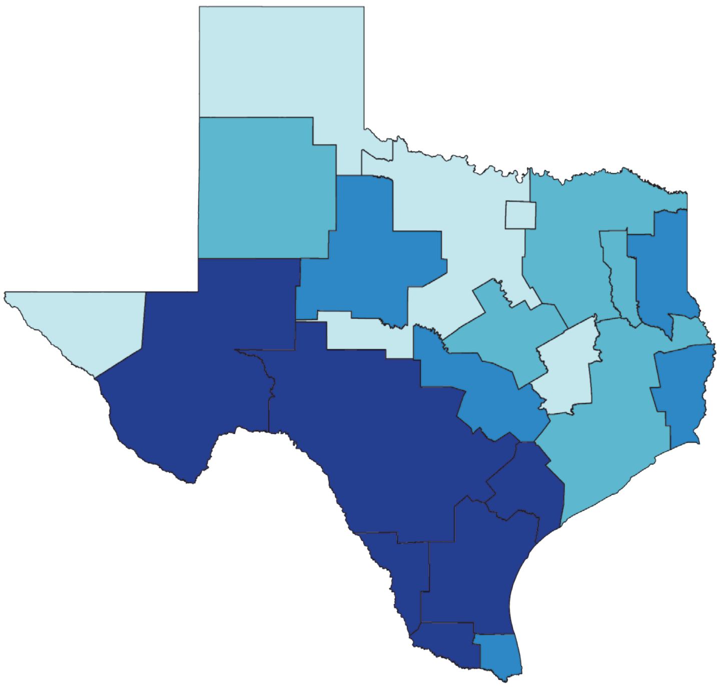


Figure 3.8. Relationship Between Adjusted Rates of Head MRI and Head Ultrasound among Very Low Birth Weight Singleton Newborns by Hospital (n=34) (2010-14)

The figure shows the correlation between the percent of VLBW newborns having a head MRI and the number of head ultrasounds per newborn at 34 hospitals with sufficient data to allow reporting among the 50 hospitals caring for the highest number of VLBW newborns in Texas.



Adjusted Number of Head Ultrasounds per VLBW Singleton Newborn with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 3.00 to 3.39 ultrasounds (6)
- 2.40 to < 3.00 (5)
- 1.97 to < 2.40 (5)
- 1.35 to < 1.97 (5)

Map 3.7. Adjusted Number of Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

Table 3.7. Adjusted Number of Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number f Head Ultrasounds	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	58	45	118	2.6	2.2	3.1	2.8	2.3	3.4
Amarillo	221	179	288	1.6	1.4	1.8	1.6	1.4	1.8
Austin	749	672	1,714	2.6	2.4	2.7	2.5	2.5	2.5
Beaumont	170	149	420	2.8	2.6	3.1	2.8	2.6	3.2
Brownsville	331	285	830	2.9	2.7	3.1	2.9	2.7	3.1
College Station	87	78	126	1.6	1.3	1.9	1.7	1.4	2.0
Corpus Christi	338	310	1,031	3.3	3.1	3.5	3.2	2.9	3.4
Dallas	2,159	1,925	4,499	2.3	2.3	2.4	2.3	2.2	2.4
Denton	141	127	249	2.0	1.7	2.2	2.0	1.7	2.2
El Paso	492	447	657	1.5	1.4	1.6	1.4	1.2	1.5
Fort Worth	1,320	1,124	2,073	1.8	1.8	1.9	1.8	1.7	1.9
Houston	3,470	3,083	7,088	2.3	2.2	2.4	2.2	2.1	2.3
Laredo	170	150	483	3.2	2.9	3.5	3.1	2.8	3.4
Longview	275	248	587	2.4	2.2	2.6	2.4	2.2	2.6
Lubbock	266	246	565	2.3	2.1	2.5	2.3	2.1	2.5
McAllen	609	540	1,784	3.3	3.1	3.5	3.3	3.1	3.5
Odessa	243	222	837	3.8	3.5	4.0	3.4	3.1	3.7
San Antonio	1,309	1,182	4,143	3.5	3.4	3.6	3.4	3.2	3.6
Temple	246	210	447	2.1	1.9	2.3	2.0	1.8	2.2
Tyler	108	92	209	2.3	2.0	2.6	2.3	2.0	2.7
Victoria	64	55	160	2.9	2.4	3.3	3.0	2.6	3.6
Texas	**12,826**	**11,368**	**28,308**	**2.5**					

Extremal Ratio	**2.50**
Interquartile Ratio	**1.54**
Coefficient of Variation	**25**

(1)Adjusted for mortality in the first 27 days of life

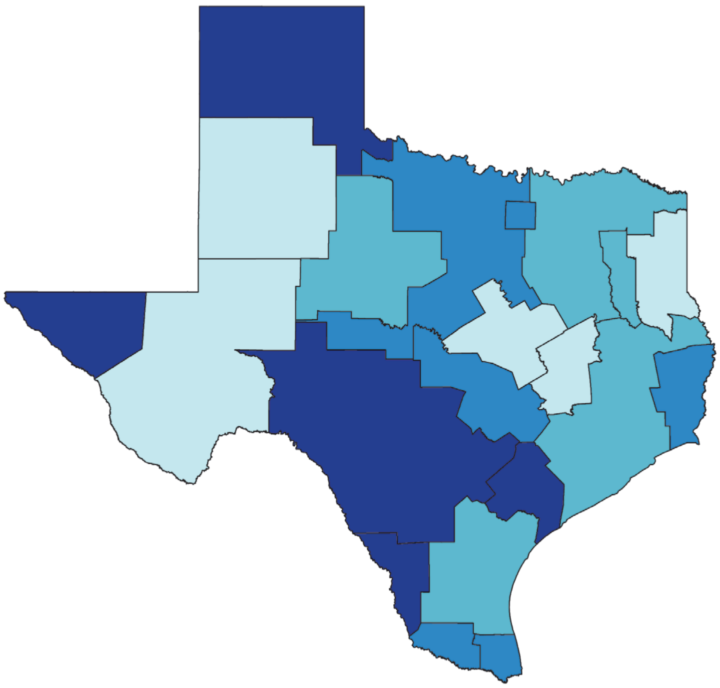
Care of Low-Risk Newborns: Late Preterm Newborns (gestational age 34-36 weeks)

Neonatal Intensive Care Unit Admission Rates

Late preterm (LPT) singleton newborns (34-36 weeks gestation) are generally at low risk for mortality, but some of these newborns need medical care for respiratory difficulties, feeding problems, or infections. These sicker newborns require medical services that can range from feeding assistance to mechanical ventilation. As NICU capacity has grown over the past couple of decades, this population—as well as other newborns with a birth weight of at least 1,500 grams—has experienced much higher utilization rates of neonatal intensive care services, leading some neonatologists to question possible overuse.[7,8]

Table 3.8. Adjusted Percent of Late Preterm Singleton Newborns Admitted to a NICU by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Number of Newborns with NICU Admission	Crude Percent	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Percent	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	632	230	36.4	31.7	41.1	32.1	27.8	37.1
Amarillo	1,133	592	52.3	48.0	56.5	41.8	37.8	46.3
Austin	4,087	1,684	41.2	39.2	43.2	34.9	32.3	37.8
Beaumont	1,175	540	46.0	42.1	49.8	37.9	34.1	42.1
Brownsville	2,608	984	37.7	35.4	40.1	37.4	37.4	37.4
College Station	626	197	31.5	27.1	35.9	29.0	24.9	33.8
Corpus Christi	2,294	892	38.9	36.3	41.4	34.7	31.7	38.0
Dallas	10,900	3,707	34.0	32.9	35.1	33.2	30.9	35.6
Denton	990	413	41.7	37.7	45.7	35.9	32.0	40.3
El Paso	3,550	1,651	46.5	44.3	48.8	46.0	42.5	49.8
Fort Worth	7,579	2,677	35.3	34.0	36.7	34.9	32.4	37.6
Houston	19,663	6,997	35.6	34.8	36.4	34.2	31.9	36.5
Laredo	1,323	484	36.6	33.3	39.8	40.0	35.9	44.6
Longview	2,314	678	29.3	27.1	31.5	29.5	26.8	32.6
Lubbock	1,725	524	30.4	27.8	33.0	24.9	22.4	27.7
McAllen	5,033	1,932	38.4	36.7	40.1	39.3	36.4	42.4
Odessa	1,763	455	25.8	23.4	28.2	28.7	25.6	32.0
San Antonio	8,134	3,670	45.1	43.7	46.6	41.5	38.7	44.5
Temple	1,254	381	30.4	27.3	33.4	30.1	26.8	33.9
Tyler	666	244	36.6	32.0	41.2	32.7	28.4	37.6
Victoria	564	282	50.0	44.2	55.8	44.2	38.7	50.4
Texas	**78,013**	**29,214**	**37.5**					
Extremal Ratio		**1.84**						
Interquartile Ratio		**1.22**						
Coefficient of Variation		**15**						



Adjusted Percent of LPT Singleton Newborns with TX Medicaid Admitted to a NICU

by Neonatal Intensive Care Region (2010-14)

- 39.3% to 46.0% (5)
- 34.7% to < 39.3% (6)
- 32.0% to < 34.7% (5)
- 24.9% to < 32.0% (5)

Map 3.8. Adjusted Percent of Late Preterm Singleton Newborns Admitted to a NICU by Neonatal Intensive Care Region (2010-14)

Unlike the high-risk VLBW newborns, less than half of LPT newborns are admitted to neonatal intensive care units. In Texas, 37.5% of these low-risk newborns were admitted to NICUs during the period from 2010 to 2014. Across NICRs, the unadjusted percent of LPT newborns admitted to a NICU ranged from 25.8% in Odessa to 52.3% in Amarillo. NICRs with low rates after adjustment for newborn health risk included Lubbock (24.9%), Odessa (28.7%), College Station (29.0%), and Longview (29.5%). Regions with high adjusted rates included El Paso (46.0%), Victoria (44.2%), Amarillo (41.8%), and San Antonio (41.5%) (Map 3.8). The extremal ratio was 1.84 and the coefficient of variation was 15 (Table 3.8).

The variation in NICU admission rates among the 50 hospitals caring for the highest number of LPT newborns in Texas was somewhat greater than across regions. Crude rates varied nearly threefold, from 24.6% of LPT newborns at the hospital with the lowest rate to 69.2% at the hospital with the highest rate. Adjusted rates varied almost twofold, from about 25% at the three hospitals with the lowest rates (24.9%, 25.0%, and 25.9%) to more than 45% at the three hospitals with the highest rates (48.0%, 46.5%, and 46.2%) (Figure 3.9).

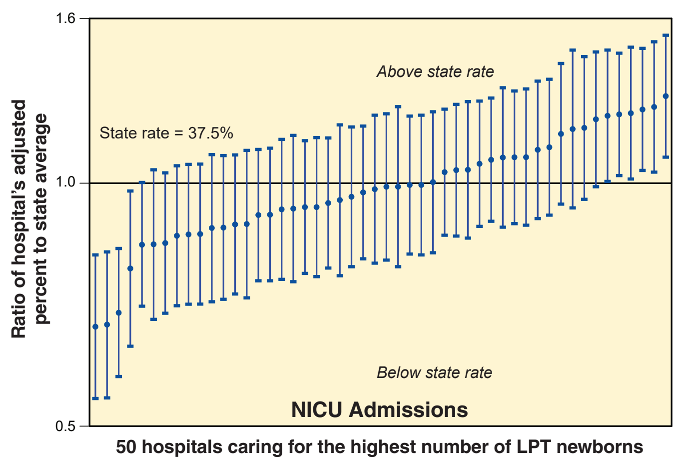


Figure 3.9. Standardized Adjusted Percent and 95% Confidence Interval for Late Preterm Singleton Newborns Admitted to a NICU by Hospital (n=50) (2010-14)

The figure shows the ratio to the state average of the adjusted percent of newborns admitted to NICUs for the 50 hospitals caring for the highest number of LPT newborns in Texas. The dot represents the hospital's percentage standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

Special Care Days

Number of Special Care Days per Newborn

On average, the number of special care days per LPT newborn in Texas was 4.6. The number of SCDs varied about twofold across NICRs for both unadjusted and adjusted rates. The unadjusted number of SCDs per LPT newborn ranged from 3.3 days in Denton to 7.1 in Amarillo. After adjusting for regional differences in newborn risk, low rates were observed in Denton (2.9 days per newborn), Corpus Christi (3.3), Victoria (3.5), and Beaumont (3.7). High rates were noted in Odessa (6.0 days per newborn), Amarillo (5.8), San Antonio (5.3), and Austin (5.0) (Map 3.9). The extremal ratio was 2.06 and the coefficient of variation was 18 (Table 3.9).

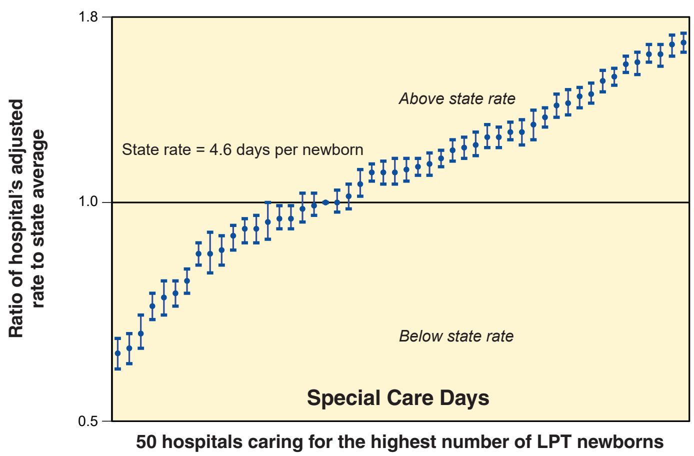


Figure 3.10. Standardized Adjusted Rate and 95% Confidence Interval for Special Care Days among Late Preterm Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted SCD rate per newborn to the state average for the 50 hospitals caring for the highest number of LPT newborns in Texas. The dot represents the hospital's day rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

Among the 50 hospitals caring for the highest number of LPT newborns in Texas, the crude rate of SCDs varied more than fivefold, from 2.0 days per newborn at the hospital with the lowest rate to 11.6 days at the hospital with the highest rate. Adjusting for differences in newborn risk reduced the variation somewhat, but rates still varied more than twofold. The adjusted SCD rate was about 3 days per LPT newborn at the three lowest hospitals (2.8, 2.8, and 3.0 days) compared to more than 7 days per newborn at the highest hospitals (7.5, 7.5, and 7.3 days) (Figure 3.10).

Are Hospitals with Higher SCD Rates Generally the Same for VLBW and LPT Newborns?

Figure 3.11 shows a moderately strong association in the adjusted number of SCDs per newborn between VLBW and LPT newborns across hospitals. This finding strongly suggests that system factors (i.e., differences in hospitals, not the patients cared for) are responsible for the variation in the number of SCDs per newborn. These factors might include differences in the relative availability of NICU beds, practice guidelines for discharge, and possible community constraints in supporting families caring for newborns after NICU discharge.

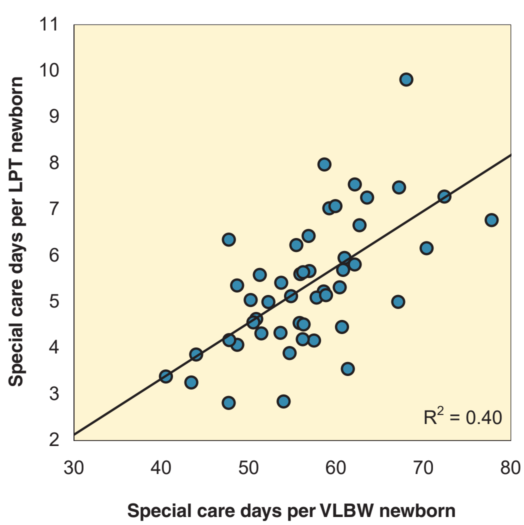
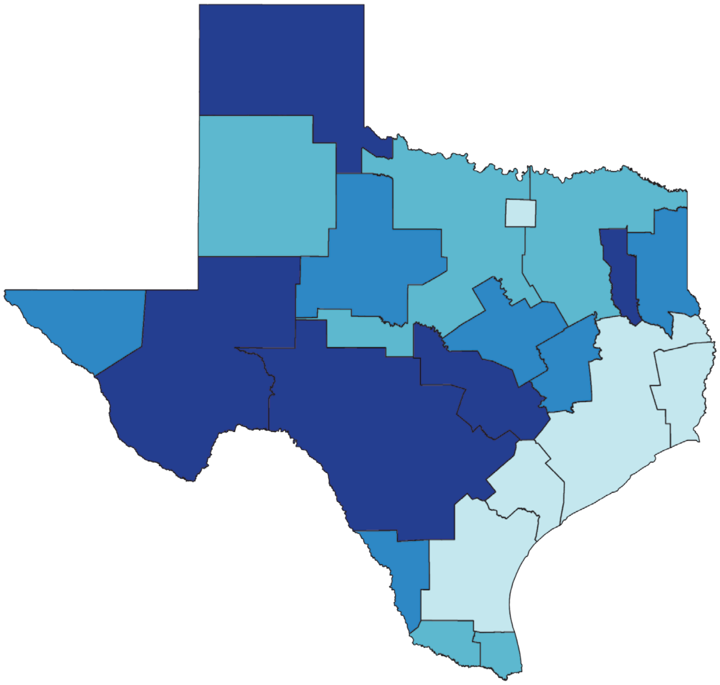


Figure 3.11. Relationship Between Special Care Days per Newborn among VLBW and LPT Singleton Newborns by Hospital (n=49) (2010-14)

The figure shows the correlation between rates of SCDs per newborn among VLBW and LPT newborns for the 49 hospitals with sufficient data to allow reporting among the 50 hospitals caring for the highest number of VLBW newborns in Texas.



Adjusted Rate of Special Care Days (Intensive or Intermediate) per LPT Singleton Newborn with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 4.7 to 6.1 days (5)
- 4.3 to < 4.7 (6)
- 3.8 to < 4.3 (5)
- 2.9 to < 3.8 (5)

Map 3.9. Adjusted Number of Special Care Days among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

Table 3.9. Adjusted Number of Special Care Days among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Special Care Days (Any)	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	632	628	3,187	5.1	4.9	5.2	4.6	4.4	4.8
Amarillo	1,133	1,128	7,959	7.1	6.9	7.2	5.8	5.7	6.0
Austin	4,087	4,077	25,170	6.2	6.1	6.3	5.0	4.9	5.1
Beaumont	1,175	1,170	5,254	4.5	4.4	4.6	3.7	3.6	3.8
Brownsville	2,608	2,602	11,144	4.3	4.2	4.4	4.1	4.0	4.2
College Station	626	626	2,777	4.4	4.3	4.6	4.3	4.2	4.5
Corpus Christi	2,294	2,282	10,047	4.4	4.3	4.5	3.3	3.2	3.4
Dallas	10,900	10,846	44,420	4.1	4.1	4.1	3.8	3.7	3.9
Denton	990	987	3,228	3.3	3.2	3.4	2.9	2.8	3.0
El Paso	3,550	3,538	16,787	4.7	4.7	4.8	4.6	4.6	4.6
Fort Worth	7,579	7,532	31,929	4.2	4.2	4.3	3.9	3.9	4.0
Houston	19,663	19,588	80,512	4.1	4.1	4.1	3.7	3.7	3.8
Laredo	1,323	1,319	5,888	4.5	4.4	4.6	4.4	4.3	4.6
Longview	2,314	2,308	9,703	4.2	4.1	4.3	4.4	4.3	4.5
Lubbock	1,725	1,714	8,742	5.1	5.0	5.2	3.9	3.8	4.0
McAllen	5,033	5,009	20,740	4.1	4.1	4.2	3.8	3.7	3.9
Odessa	1,763	1,756	9,342	5.3	5.2	5.4	6.0	5.9	6.2
San Antonio	8,134	8,100	50,272	6.2	6.2	6.3	5.3	5.2	5.4
Temple	1,254	1,246	5,797	4.7	4.5	4.8	4.4	4.3	4.6
Tyler	666	663	3,890	5.9	5.7	6.0	4.8	4.6	4.9
Victoria	564	561	2,253	4.0	3.8	4.2	3.5	3.3	3.6
Texas	**78,013**	**77,682**	**359,041**	**4.6**					

Extremal Ratio	**2.06**
Interquartile Ratio	**1.21**
Coefficient of Variation	**18**

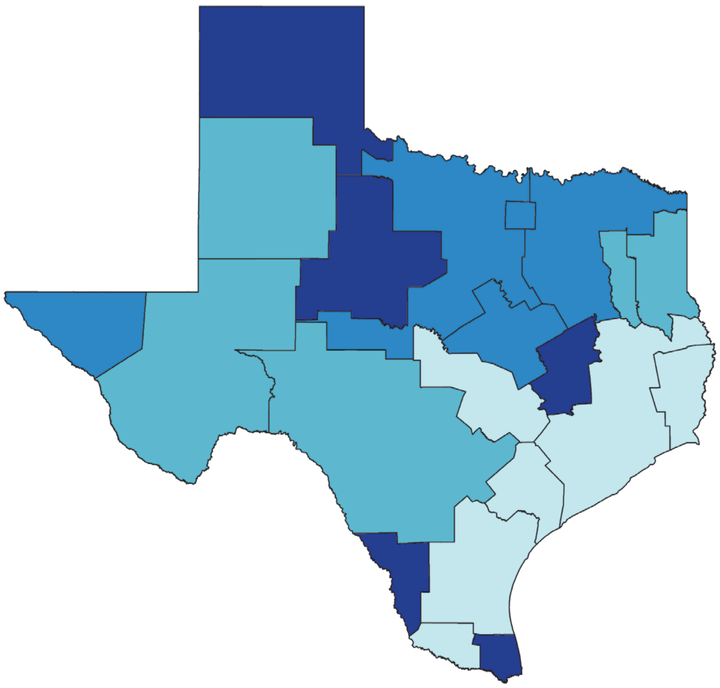
(1) Adjusted for mortality in the first 27 days of life

Percent of Special Care Days Billed as Intensive Days

The overall percent of SCDs billed as intensive days for LPT newborns with Texas Medicaid was 55.5%. There were striking differences in billing practices across NICRs. The crude percent of SCDs billed as intensive varied more than threefold, ranging from 28.5% in Corpus Christi to 89.5% in Laredo. Adjustment for differences in newborn characteristics made little difference in the degree of regional variation. Adjusted rates were particularly low in Corpus Christi (26.9%), Houston (39.9%), McAllen (48.6%), and Beaumont (49.3%). The highest adjusted rates were found in Laredo (88.5%), Amarillo (85.2%), Abilene (76.8%), and College Station (73.5%) (Map 3.10). The extremal ratio was 3.29 and the coefficient of variation was 24 (Table 3.10).

Table 3.10. Adjusted Percent of Special Care Days Billed as Intensive among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns with Special Care Days	Special Care Days	Intensive Special Care Days	Crude Percent	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Percent	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	318	3,187	2,410	75.6	72.6	78.6	76.8	72.5	81.5
Amarillo	704	7,959	6,360	79.9	77.9	81.9	85.2	81.1	89.4
Austin	1,840	25,170	12,450	49.5	48.6	50.3	49.9	47.6	52.2
Beaumont	701	5,254	2,618	49.8	47.9	51.7	49.3	46.6	52.2
Brownsville	1,204	11,144	7,962	71.4	69.9	73.0	68.3	65.1	71.6
College Station	258	2,777	1,960	70.6	67.5	73.7	73.5	69.2	78.2
Corpus Christi	1,128	10,047	2,868	28.5	27.5	29.6	26.9	25.4	28.4
Dallas	5,096	44,420	29,017	65.3	64.6	66.1	65.4	62.6	68.3
Denton	507	3,228	1,992	61.7	59.0	64.4	65.2	61.3	69.2
El Paso	1,827	16,787	10,859	64.7	63.5	65.9	66.8	63.8	70.0
Fort Worth	3,347	31,929	21,889	68.6	67.6	69.5	66.9	64.0	69.9
Houston	9,549	80,512	32,452	40.3	39.9	40.7	39.9	38.2	41.7
Laredo	555	5,888	5,267	89.5	87.0	91.9	88.5	84.2	93.0
Longview	968	9,703	5,835	60.1	58.6	61.7	61.3	58.3	64.4
Lubbock	740	8,742	5,706	65.3	63.6	67.0	64.7	61.6	68.0
McAllen	2,248	20,740	10,141	48.9	47.9	49.8	48.6	46.4	50.9
Odessa	769	9,342	4,791	51.3	49.8	52.7	53.0	50.4	55.8
San Antonio	4,456	50,272	27,353	54.4	53.8	55.1	54.3	52.0	56.8
Temple	575	5,797	3,924	67.7	65.6	69.8	68.1	64.6	71.8
Tyler	345	3,890	2,154	55.4	53.0	57.7	55.5	55.5	55.5
Victoria	325	2,253	1,195	53.0	50.0	56.0	50.6	47.1	54.3
Texas	**37,460**	**359,041**	**199,203**	**55.5**					
Extremal Ratio		**3.29**							
Interquartile Ratio		**1.35**							
Coefficient of Variation		**24**							



Adjusted Percent of Special Care Days Billed as Intensive among LPT Singleton Newborns with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 68.2% to 88.5% (5)
- 65.1% to < 68.2% (5)
- 52.9% to < 65.1% (5)
- 26.8% to < 52.9% (6)

Map 3.10. Adjusted Percent of Special Care Days Billed as Intensive among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The percent of SCDs billed as intensive—both crude and adjusted—was more than 25 times higher at the hospital with the highest rate than at the hospital with the lowest. Even after adjusting for differences in newborn risk, less than 10% of SCDs were billed as intensive at three hospitals (3.5%, 7.6%, and 8.4%). At two hospitals, more than 90% of SCDs were billed as intensive (93.6% and 93.3%) (Figure 3.12).

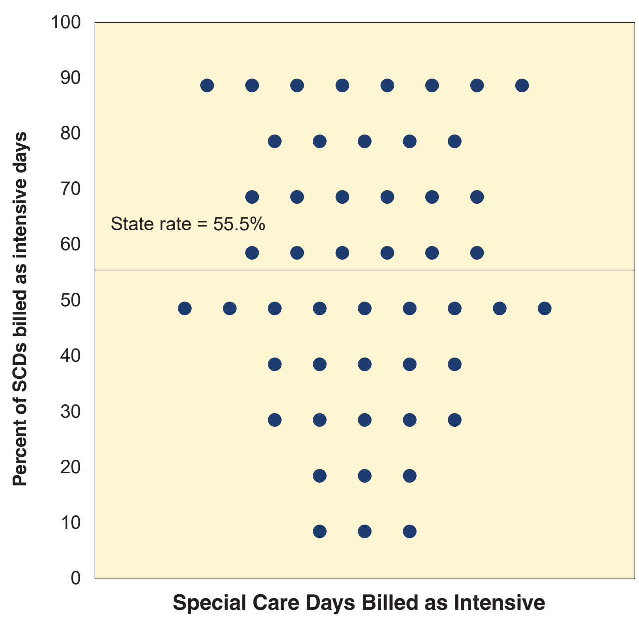


Figure 3.12. Adjusted Percent of Special Care Days Billed as Intensive among Late Preterm Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the distribution in rates for the adjusted percent of SCDs billed as intensive. Each blue dot represents one of the 50 hospitals caring for the highest number of LPT newborns in Texas.

Imaging

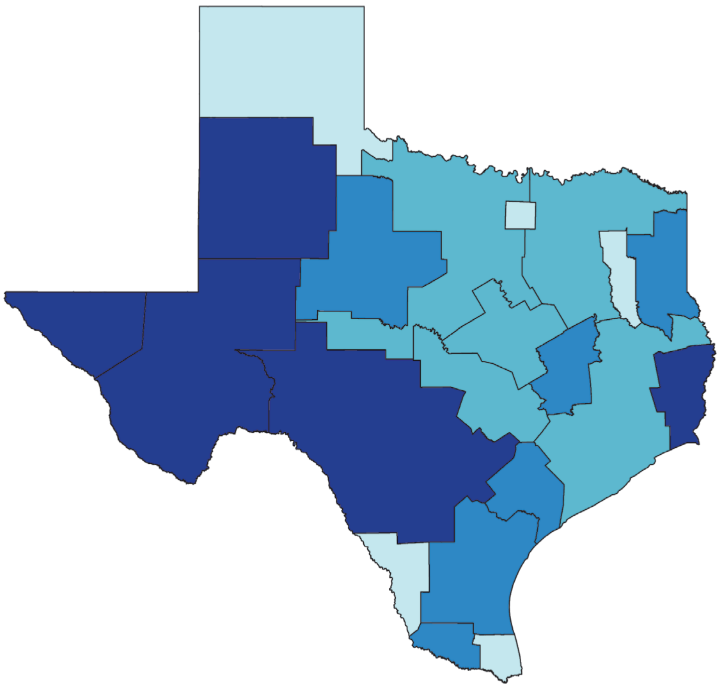
Chest Films

On average, each LPT newborn with Texas Medicaid received 1 chest film. The crude rate ranged from 0.5 in Denton to 1.7 in San Antonio. After adjusting for differences in risk, the four NICRs with the lowest rates were Denton (0.5 chest films per newborn), Tyler (0.6), Amarillo (0.6), and Brownsville (0.7). NICRs with high adjusted rates included El Paso (1.7 chest films per newborn), San Antonio (1.6), Odessa (1.4), and Beaumont (1.1) (Map 3.11). The extremal ratio was 3.41 and the coefficient of variation was 33 (Table 3.11).

Table 3.11. Adjusted Number of Chest Films among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number of Chest Films	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	632	628	572	0.9	0.8	1.0	1.0	1.0	1.0
Amarillo	1,133	1,128	690	0.6	0.6	0.7	0.6	0.6	0.7
Austin	4,087	4,077	3,481	0.9	0.8	0.9	0.8	0.7	0.8
Beaumont	1,175	1,170	1,421	1.2	1.2	1.3	1.1	1.0	1.2
Brownsville	2,608	2,602	1,626	0.6	0.6	0.7	0.7	0.6	0.7
College Station	626	626	444	0.7	0.6	0.8	0.9	0.8	1.0
Corpus Christi	2,294	2,282	2,810	1.2	1.2	1.3	0.9	0.8	1.0
Dallas	10,900	10,846	8,580	0.8	0.8	0.8	0.8	0.7	0.8
Denton	990	987	469	0.5	0.4	0.5	0.5	0.4	0.6
El Paso	3,550	3,538	5,250	1.5	1.4	1.5	1.7	1.5	1.8
Fort Worth	7,579	7,532	5,644	0.7	0.7	0.8	0.7	0.7	0.8
Houston	19,663	19,588	14,665	0.7	0.7	0.8	0.7	0.7	0.8
Laredo	1,323	1,319	884	0.7	0.6	0.7	0.7	0.6	0.8
Longview	2,314	2,308	1,967	0.9	0.8	0.9	1.0	0.9	1.1
Lubbock	1,725	1,714	2,309	1.3	1.3	1.4	1.1	1.0	1.2
McAllen	5,033	5,009	5,456	1.1	1.1	1.1	1.1	1.0	1.2
Odessa	1,763	1,756	1,823	1.0	1.0	1.1	1.4	1.3	1.5
San Antonio	8,134	8,100	13,995	1.7	1.7	1.8	1.6	1.4	1.7
Temple	1,254	1,246	1,021	0.8	0.8	0.9	0.8	0.8	0.9
Tyler	666	663	468	0.7	0.6	0.8	0.6	0.5	0.7
Victoria	564	561	626	1.1	1.0	1.2	1.1	1.0	1.2
Texas	**78,013**	**77,682**	**74,201**	**1.0**					
Extremal Ratio		**3.41**							
Interquartile Ratio		**1.54**							
Coefficient of Variation		**33**							

(1) Adjusted for mortality in the first 27 days of life



Adjusted Number of Chest Films per LPT Singleton Newborn with TX Medicaid

by Neonatal Intensive Care Region (2010-14)

- 1.10 to 1.68 films (5)
- 0.86 to < 1.10 (6)
- 0.70 to < 0.86 (5)
- 0.49 to < 0.70 (5)

Map 3.11. Adjusted Number of Chest Films among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The variation in the number of chest films per newborn among the 50 hospitals caring for the highest number of LPT newborns in Texas was striking. At the two hospitals with the lowest rates, LPT newborns received 0.2 chest films on average. At the two hospitals with the highest rates, LPT newborns received more than ten times that number (2.6 and 2.5 chest films per newborn) (Figure 3.13).

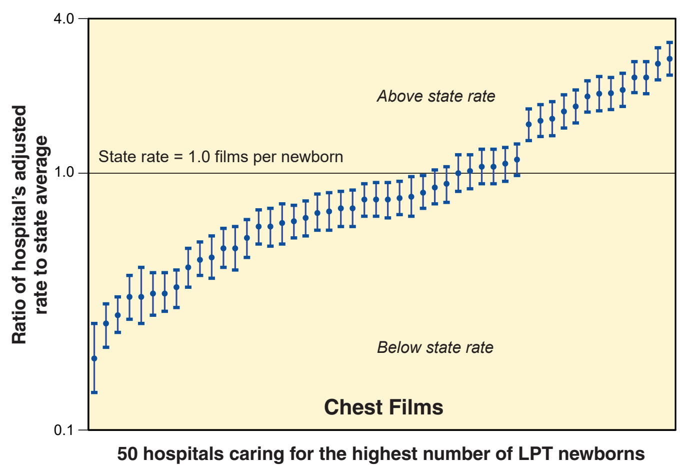


Figure 3.13. Standardized Adjusted Rate and 95% Confidence Interval for Chest Films among Late Preterm Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted rate of chest films per newborn to the state average for the 50 hospitals caring for the highest number of LPT newborns in Texas. The dot represents the hospital's rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

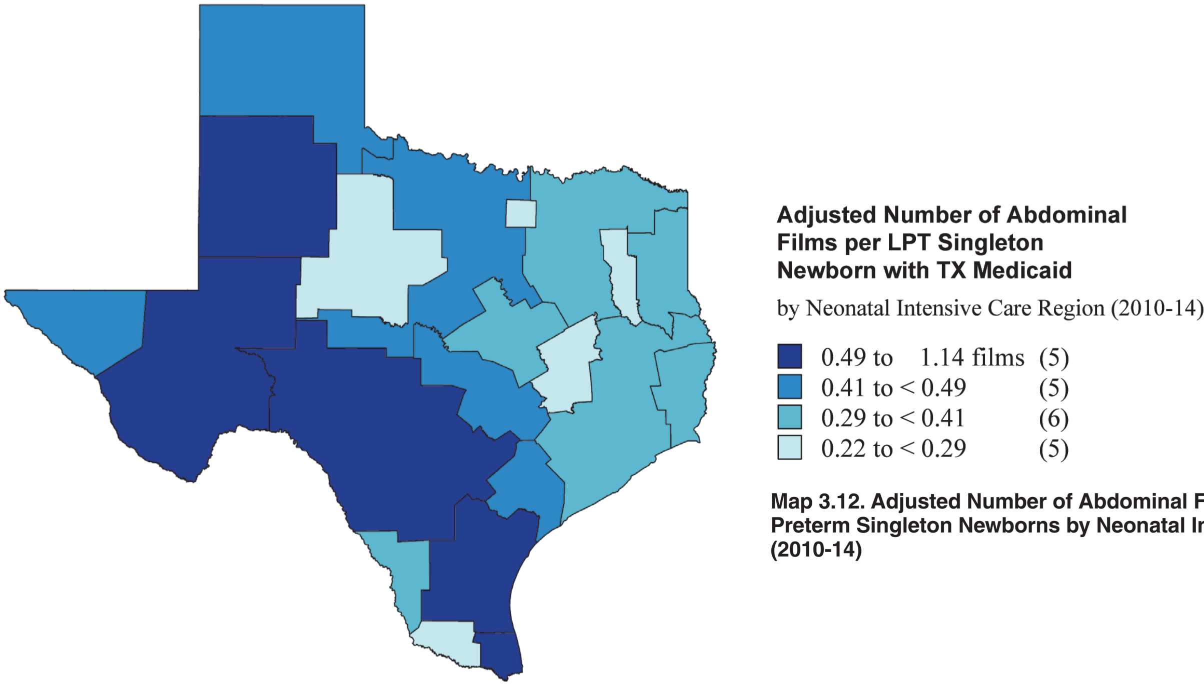
Abdominal Films

Each LPT newborn in Texas Medicaid received 0.42 abdominal films on average. The crude rate per LPT newborn varied more than sevenfold, from 0.15 in College Station to 1.15 in San Antonio. After adjusting for differences in newborn risk, the four NICRs with the lowest rates were Abilene (0.23 abdominal films per newborn), College Station (0.25), Tyler (0.28), and Denton (0.28). NICRs with high adjusted rates included San Antonio (1.13 abdominal films per newborn), Lubbock (0.67) Corpus Christi (0.54), and Odessa (0.53) (Map 3.12). The extremal ratio was 4.96 and the coefficient of variation was 46 (Table 3.12).

Table 3.12. Adjusted Number of Abdominal Films among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

NICU Region	Newborns	Adjusted Newborns (1)	Number of Abdominal Films	Crude Rate	Crude Lower 95 CI	Crude Upper 95 CI	Adjusted Rate	Adjusted Lower 95 CI	Adjusted Upper 95 CI
Abilene	632	628	109	0.17	0.14	0.21	0.23	0.19	0.28
Amarillo	1,133	1,128	413	0.37	0.33	0.40	0.47	0.42	0.52
Austin	4,087	4,077	1,675	0.41	0.39	0.43	0.42	0.42	0.42
Beaumont	1,175	1,170	412	0.35	0.32	0.39	0.40	0.36	0.44
Brownsville	2,608	2,602	1,030	0.40	0.37	0.42	0.49	0.46	0.53
College Station	626	626	97	0.15	0.12	0.19	0.25	0.20	0.30
Corpus Christi	2,294	2,282	1,581	0.69	0.66	0.73	0.54	0.50	0.58
Dallas	10,900	10,846	2,944	0.27	0.26	0.28	0.30	0.28	0.31
Denton	990	987	213	0.22	0.19	0.24	0.28	0.24	0.32
El Paso	3,550	3,538	1,251	0.35	0.33	0.37	0.47	0.44	0.51
Fort Worth	7,579	7,532	3,281	0.44	0.42	0.45	0.44	0.42	0.47
Houston	19,663	19,588	5,297	0.27	0.26	0.28	0.29	0.27	0.31
Laredo	1,323	1,319	440	0.33	0.30	0.36	0.38	0.34	0.42
Longview	2,314	2,308	488	0.21	0.19	0.23	0.31	0.28	0.35
Lubbock	1,725	1,714	1,232	0.72	0.68	0.76	0.67	0.62	0.72
McAllen	5,033	5,009	1,265	0.25	0.24	0.27	0.28	0.26	0.30
Odessa	1,763	1,756	578	0.33	0.30	0.36	0.53	0.48	0.58
San Antonio	8,134	8,100	9,334	1.15	1.13	1.18	1.13	1.07	1.19
Temple	1,254	1,246	351	0.28	0.25	0.31	0.33	0.30	0.37
Tyler	666	663	187	0.28	0.24	0.32	0.28	0.24	0.32
Victoria	564	561	222	0.40	0.34	0.45	0.48	0.41	0.55
Texas	**78,013**	**77,682**	**32,400**	**0.42**					
Extremal Ratio		**4.96**							
Interquartile Ratio		**1.64**							
Coefficient of Variation		**46**							

(1) Adjusted for mortality in the first 27 days of life



Map 3.12. Adjusted Number of Abdominal Films among Late Preterm Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The adjusted number of abdominal films per LPT newborn was nearly 50 times higher at the hospital with the highest rate (2.26 abdominal films per newborn) compared to the hospital with the lowest rate (0.05). Even discounting the extremes on either end of the distribution, rates varied by a factor of about 20, from less than 0.1 at two additional low-rate hospitals (0.07 and 0.08) to about 1.5 at two high-rate hospitals (1.57 and 1.46) (Figure 3.14).

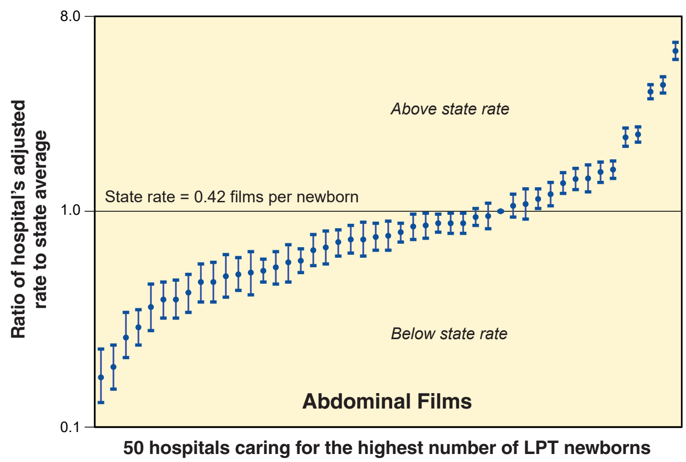


Figure 3.14. Standardized Adjusted Rate and 95% Confidence Interval for Abdominal Films among Late Preterm Singleton Newborns by Hospital (n=50) (2010-14)

The figure shows the ratio of the adjusted rate of abdominal films per newborn to the state average for the 50 hospitals caring for the highest number of LPT newborns in Texas. The dot represents the hospital's rate per newborn standardized to the state rate, while the lines above and below the dot indicate the 95% confidence interval.

Are More Special Care Days Better? Or Worse?

What is the right rate for the number of special care days and imaging tests? Do late preterm newborns have better outcomes in hospitals with higher rates of NICU admissions? Answers to these questions would help identify opportunities to limit under and overuse of advanced newborn care.

Studies from the California Perinatal Quality Care Collaborative, similar to the Texas Medicaid analyses presented above, have found that length of stay (LOS) for very premature newborns varies substantially across California NICUs, even after controlling for patient factors (e.g., differences in birth weight).[9] These and other studies support the idea that shorter LOS for very[9] and moderately[10] preterm newborns is not associated with adverse effects. Quality improvement efforts have been undertaken to reduce LOS in California with no increase in 72-hour readmission rates, a sensitive indicator of poor outcomes.[11]

In Texas Medicaid-insured newborns, fewer SCDs were not associated with higher 30-day readmissions for VLBW and LPT newborns. A slight positive association was observed, but most of the variation in readmissions was not explained by SCD rates. It should be noted that hospital lengths of stay are slightly longer than the number of SCDs per newborn; substituting length of stay for SCDs did not change these findings. The analyses suggest that there are opportunities to reduce hospital stays for newborns at both high and low risk without negatively affecting outcomes.

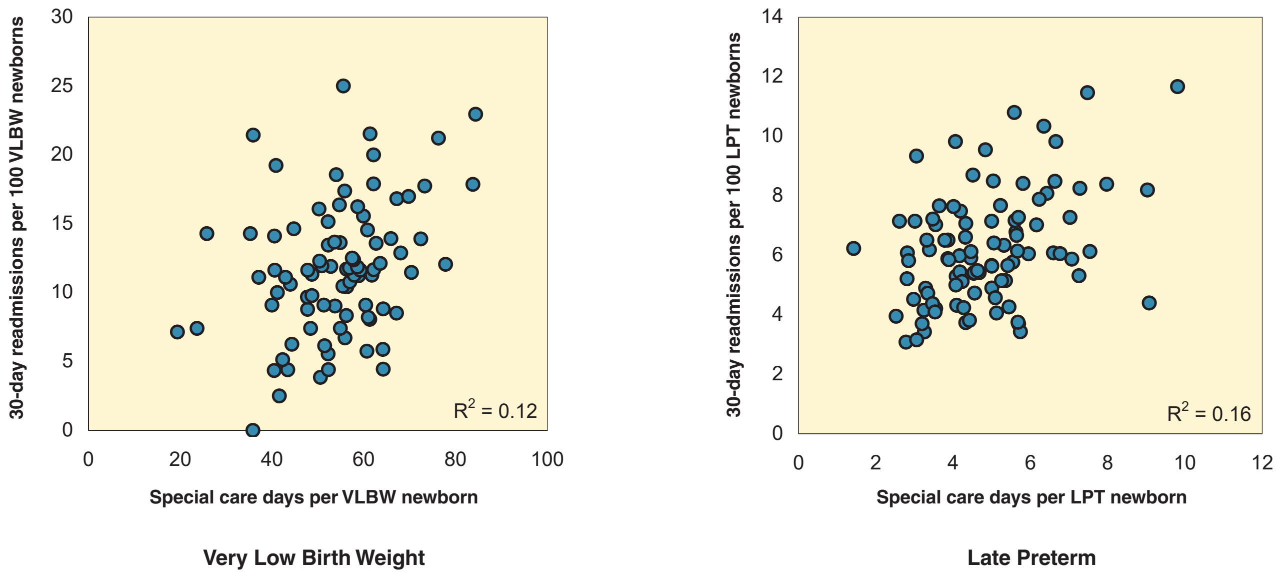


Figure 3.15. Association Between the Adjusted Number of Special Care Days per Newborn and 30-Day Readmission Rates among VLBW (left, n=87 hospitals) and LPT (right, n=95 hospitals) Singleton Newborns by Hospital (2010-14)

The figure shows the correlation between rates of SCDs per newborn and 30-day readmissions per 100 newborns among both VLBW (left, n=87 hospitals) and LPT (right, n=95 hospitals) newborns for the hospitals with sufficient data to allow reporting among the 100 hospitals caring for the highest number of newborns in each cohort in Texas.

Summing Up

The Texas Neonatal Intensive Care Project provides a detailed description of strikingly different approaches to newborn care and program payments across regions and hospitals in Texas for Medicaid-insured newborns. Table 3.13 provides an overview of the magnitude of variation at the hospital level for the measures reported. The admission of VLBW newborns to NICUs is a low-variation event; almost all of these newborns require NICU care and are admitted regardless of the hospital. However, the admission of LPT newborns to NICUs shows moderate variation, as does the number of special care days for both newborn cohorts, though again, variation in the LPT cohort is higher. Imaging rates have very high variation, particularly in the lower-risk LPT cohort.

Table 3.13. Variation in Utilization Rates Across 50 Hospitals Caring for the Highest Number of Newborns Within Each Cohort

Newborn Cohort	Percent Admitted to NICU	Special Care Days per Newborn	Percent of Special Care Days Billed as Intensive	Chest Films per Newborn	Abdominal Films per Newborn	Head Ultrasounds per Newborn	Percent with Head MRI
Very Low Birth Weight							
Extremal Ratio	1.45	1.92	2.59	9.71	33.5	4.93	13.1
Coefficient of Variation	6.9	13.8	19.8	55.3	88.6	36.3	63.6
Late Preterm							
Extremal Ratio	1.95	3.49	26.9	10.8	51.2	19.0	7.22
Coefficient of Variation	15.3	27.5	45.6	61.5	94.1	77.5	49.4

The extremal ratio is the highest rate divided by the lowest rate; the coefficient of variation is the standard deviation of the rates divided by the mean.

Little of this variation is explained by differences in health risk at birth, the diagnoses assigned once care is initiated, or the need for major procedures. There are likely to be many causes of this variation: the availability of resources in the hospital and the community, as seen in section 2; weaknesses in the medical evidence for any particular approach to providing care; differing interpretations by clinicians with regard to both research studies and practice guidelines; and the challenge of including family preferences in clinical decision-making.

Texas also has a particularly complex geography in terms of physical features, population, and medical services, ranging from rural frontier areas with marginally available perinatal services, to medium-sized cities that offer intermediate levels of perinatal care, to highly dense urban areas with hospitals competing to provide deliveries and NICU care. Further investigation into the causes of variation in newborn care need to consider these different communities, and efforts to improve care and reduce payments must be mindful of possible unintended consequences when altering well-established care patterns. But it is important to recognize that maintaining the status quo accepts the consequences of missed opportunities to improve care and outcomes while lowering payments. Health care is in a continual state of change. Knowledge gained from these population-based cohorts can identify needs and opportunities to nudge these changes in the direction of high-functioning perinatal health care, to which we aspire for all newborns.

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4. Regional Variation in the Treatment of Sick Newborns in Norway

Atle Moen, MD, PhD, Section Editor

Photo: Senter for Klinisk Dokumentasjon og Evaluering (SKDE)

Norway is the only country that has undertaken a detailed examination of regional health care patterns for their entire newborn population. This was made possible by the establishment in 2004 of the Norwegian Neonatal Network (NNN), a national quality registry, one of over 50 national quality registries that are maintained in Norway. Coupled with the Medical Birth Registry of Norway, the NNN files offer a unique resource to measure and improve perinatal care. In 2016, the Ministry of Health and Care Services and the Northern Norwegian Health Authority funded The Norwegian Neonatal Healthcare Atlas, 2009-2014,[1] covering five topics: admissions to a neonatal unit; infections and antibiotic treatments; ventilator treatment; hypoglycemia and phototherapy; and the use of intensive care. This section is adapted from that Atlas.

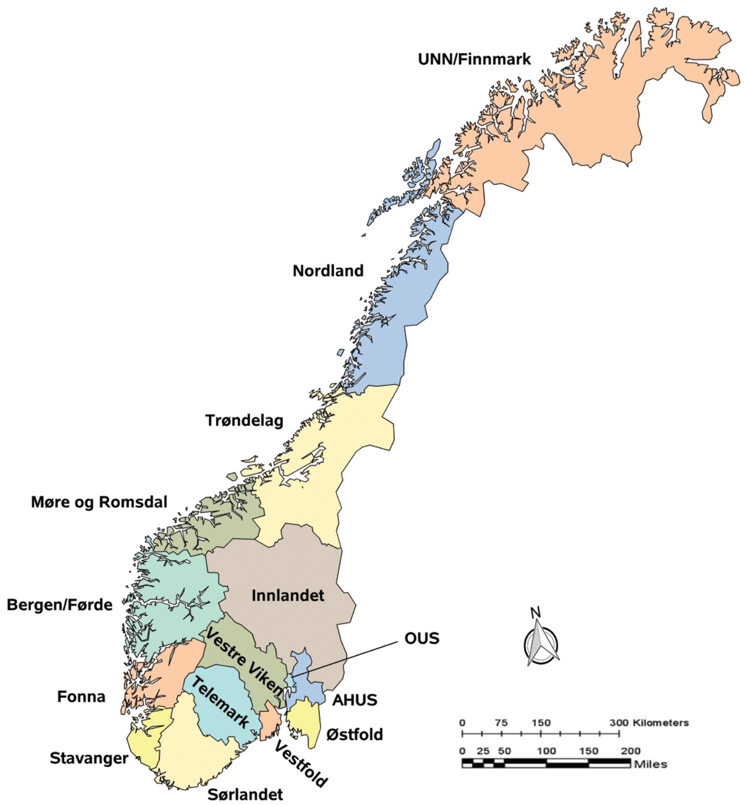
Nineteen neonatal units in Norway provide services for sick newborns, with four regional university hospitals generally responsible for extremely premature infants (< 28 weeks of gestation). One of these, Oslo University Hospital, also provides national services for newborns with complex congenital heart conditions and other congenital anomalies. These units are similar to Level II-IV NICUs in the United States. Most of the measures of newborn care in this section are presented across 15 hospital referral regions that are relatively self-contained areas for the care of most ill newborns (Map 4.1). All but three of these regions have single neonatal units (Table 4.1). Compared to the other newborn care reported, ventilator treatment in newborns less than 28 weeks gestation is much less frequent and is therefore presented for referral areas corresponding to the four administrative health care regions in Norway, which include all 15 hospital referral regions.

In 2014, there were 59,084 live births in Norway and 368,068 births for the period 2009-14. While the Norwegian perinatal population is relatively homogenous compared to the U.S., prematurity (< 37 weeks) rates ranged from 57 per 1,000 births in UNN/Finnmark to 74 per 1,000 births in Fonna, a 30% difference (Table 4.2). To adjust for these differences in risk, the measures presented are stratified by categories of gestational age.

Table 4.1. Number of Neonatal Units by Norwegian Hospital Referral Region

	National	Regional	Local
AHUS			1
Bergen/Førde		1	1
Fonna			1
Innlandet			2
Møre og Romsdal			1
Nordland			1
Østfold			1
OUS	1		
Sørlandet			1
Stavanger			1
Telemark			1
Trøndelag		1	1
UNN/Finnmark		1	1
Vestfold			1
Vestre Viken			1
Total	**1**	**3**	**15**

National and regional units also provide services to the local population.



Map 4.1. Hospital Referral Regions in Norway

Table 4.2. Prematurity Rate by Region and Gestational Age (2009-14)

		Prematurity rate per 1,000 births		
Region	Births	All births	Gestational age 34 - < 37 weeks	Gestational age < 34 weeks
AHUS	34,433	66	46	19
Bergen/Førde	40,458	63	43	19
Fonna	12,964	74	51	23
Innlandet	22,695	71	52	19
Møre og Romsdal	17,140	57	40	17
Nordland	13,656	67	47	20
Østfold	18,305	64	45	18
OUS	53,323	61	41	20
Sørlandet	21,131	65	48	18
Stavanger	30,193	69	48	21
Telemark	10,337	72	47	25
Trøndelag	31,692	62	43	19
UNN/Finnmark	17,771	57	39	18
Vestfold	13,750	64	45	20
Vestre Viken	30,220	62	42	20

A word about Norway…

Norway is a relatively small and wealthy Nordic country north of Denmark and sharing its eastern border with Sweden. Norway is the longest country in Europe, with a southwest to northeast distance of just over 1,000 miles and a width (greatest extant) of about 250 miles. Its land area is half the size of Texas. Of the 5.3 million inhabitants, 20% live in rural areas, including vibrant small cities above the Arctic Circle. In the most northern regions, there are also populations and communities consisting of mostly Sami people. Immigrants constitute 13% of the population, with the highest five countries of origin being Poland, Lithuania, Somalia, Sweden, and Pakistan.

On the whole, Norwegians enjoy excellent health, with a life expectancy of 82.5 years (U.S. 78.6 years) (OECD 2016), and an infant mortality rate of 2.3 deaths per 1,000 live births (U.S. 5.9 per 1,000) (OECD 2015). Norway's health expenditures are 10.4% of GDP (U.S 17.2%), or $6,351 per capita (U.S. $10,209) (OECD 2017). All residents of Norway are entitled to publicly funded health care services with modest out-of-pocket payments only for outpatient contacts. Health care is primarily delivered through a national health service, with responsibility delegated to hospital trusts owned by regional health authorities, and to municipalities for primary care. The geographically dispersed patient population is linked to these sites of care through a highly organized system of ground and air transport and telemedicine platforms. There are no private providers of healthcare for newborns in Norway.

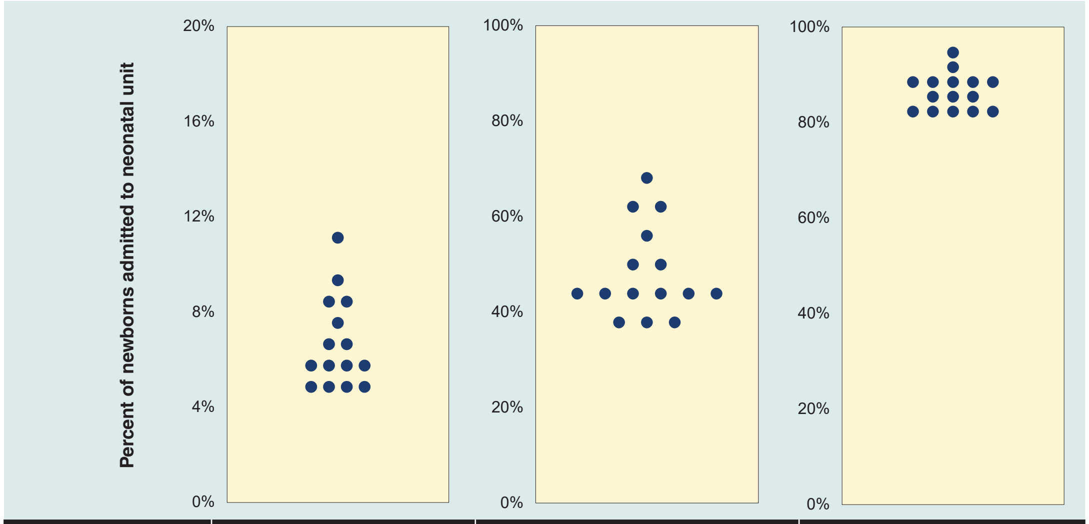
Admissions to Neonatal Units, Length of Stay, and Use of Intensive Care

Not all Norwegian hospitals with maternity services have neonatal units. When necessary, newborns are transferred to hospitals with neonatal units appropriate for the expected level of care needed. To reduce the maternal-newborn separation that occurs in neonatal units, neonatal unit admissions are avoided if possible, and newborns are transferred back to their local hospital when the level of care needed permits. In this section, three measures are presented that reflect specialized newborn care: the percent of newborns admitted to a neonatal unit, the length of stay per admitted newborn, and the number of days that they receive care at an intensive level. Newborns are grouped by gestational age: ≥ 37 weeks (full term), 34 to < 37 weeks (late preterm), and < 34 weeks (moderately, very, and extremely preterm).

Admission to Neonatal Care Units

Almost all (86.4%) newborns born at < 34 weeks were admitted to neonatal units during the period from 2009 to 2014. For late preterm newborns, just under half (45.3%) received neonatal unit care, and fewer than one in fifteen full-term newborns (6.2%) were admitted to these units (Figure 4.1).

The care of newborns < 34 weeks in a specialized unit is universally recognized as effective in improving outcomes, reflected in low variation in admission rates. Vestfold (80.7%) and Innlandet (80.8%) had the lowest admission rates, and Vestre Viken (96.2%) and Sørlandet (90.1%) had the highest. Treatment practice may have varied



	Gestational age ≥ 37 weeks	Gestational age 34 - < 37 weeks	Gestational age < 34 weeks
Overall rate	6.2%	45.3%	86.4%
Extremal ratio	2.62	2.05	1.19
Coefficient of variation	30	22	5

Figure 4.1. Percent of Norwegian Newborns Admitted to a Neonatal Unit, by Region and Gestational Age (2009-14)

Table 4.3. Percent of Norwegian Newborns Admitted to a Neonatal Unit, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 34 - < 37 weeks		Gestational age < 34 weeks	
Region	**Births**	**Percent admitted to neonatal unit**	**Births**	**Percent admitted to neonatal unit**	**Births**	**Percent admitted to neonatal unit**
AHUS	32,055	5.8%	1,598	44.1%	668	88.6%
Bergen/Førde	37,594	4.4%	1,754	34.8%	776	84.5%
Fonna	11,846	8.3%	664	58.6%	293	83.6%
Innlandet	20,787	4.9%	1,176	42.8%	442	80.8%
Møre og Romsdal	16,118	5.6%	687	43.2%	291	84.5%
Nordland	12,705	6.6%	638	40.9%	278	87.4%
Østfold	17,078	6.6%	827	50.7%	338	89.3%
OUS	49,765	5.2%	2,185	42.3%	1,077	81.6%
Sørlandet	19,630	8.8%	1,004	59.3%	373	90.1%
Stavanger	27,704	7.1%	1,441	38.8%	640	88.8%
Telemark	9,527	9.7%	481	63.6%	260	83.5%
Trøndelag	29,658	5.6%	1,368	40.8%	587	86.9%
UNN/Finnmark	16,700	5.5%	697	49.1%	315	88.6%
Vestfold	12,857	11.6%	613	71.1%	270	80.7%
Vestre Viken	28,225	5.1%	1,277	41.6%	599	96.2%

to some extent between referral areas for extremely preterm infants at the border of viability or with severe congenital malformations not compatible with life. These newborns may not have been registered as admitted if they died in the delivery room during this period of registration. Despite the differences, the overall magnitude of variation was low (coefficient of variation=5) compared with rates observed in less ill newborns with longer gestation (Table 4.3).

In late preterm newborns (34 to < 37 weeks gestation), there was a twofold difference in admission rates, with Bergen/Førde (34.8%) and Stavanger (38.8%) having the lowest admission rates and Vestfold (71.1%) and Telemark (63.6%) having the highest. Regional variation was moderately high (coefficient of variation=22).

As reported previously for national and Texan newborns, variation was highest in the lowest risk population, those born at ≥ 37 weeks gestation (coefficient of variation=30). Rates varied by a factor of 2.6 between the highest and lowest regions, with Bergen/Førde (4.4%) and Innlandet (4.9%) having the lowest admission rates and Vestfold (11.6%) and Telemark (9.7%) having the highest.

Regions with high admission rates in the late preterm cohort were generally the same regions with high rates for full-term newborns (R^2=0.83) (Figure 4.2). But there was little association between rates of admission for the very sickest newborns, who almost all received neonatal unit care, and the lower risk groups.

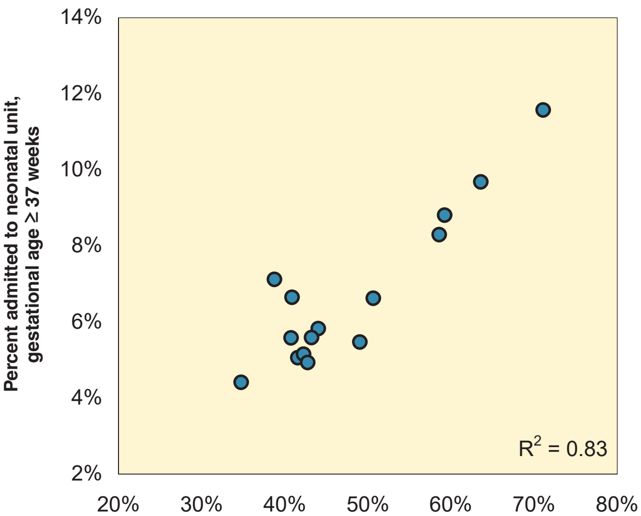


Figure 4.2. Relationship Between Neonatal Unit Admission Rates among Late Preterm and Full-Term Norwegian Newborns, by Region (2009-14)

Neonatal Unit Length of Stay

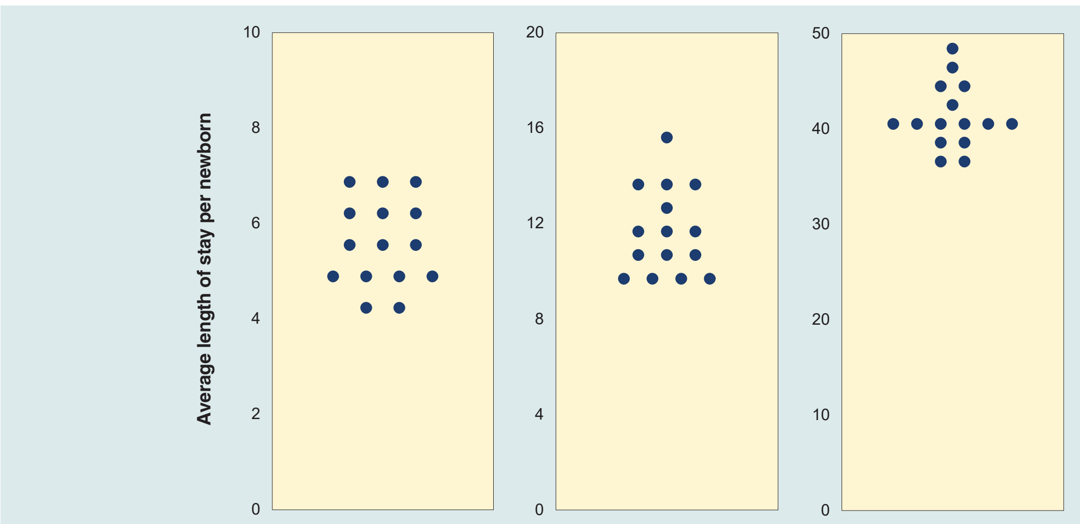
While neonatal care unit admission rates for preterm newborns < 34 weeks gestation varied little across regions, there was an almost 14-day difference in length of stay between the two regions with the fewest days per newborn, OUS and Vestre Viken (35.6 days), and the region with the most, UNN/Finnmark (49.4 days) (Table 4.4). The high rate in UNN/Finnmark may partially reflect the extremely rural nature of the region with longer distances to perinatal care. However, it should be noted that rural Norwegian populations still have high access to high quality health care. Overall, the variation across all regions was low, with a coefficient of variation of 9 (Figure 4.3).

For the newborns with higher gestational age, the average length of stay was much shorter (11.3 days for late preterm newborns; 5.3 days for full-term), but the variation was moderate. For late preterm newborns, the difference between the region with the highest rate (UNN/Finnmark; 16.1 days) and the lowest (Vestre Viken; 9.2 days) was almost 7 days, with a coefficient of variation of 16. For full-term newborns, the difference between the region with the highest rate (Nordland; 7.2 days) and lowest (Bergen/Førde; 3.9 days) was over 3 days, with a coefficient of variation of 17.

Table 4.4. Average Length of Stay per Norwegian Newborn Admitted to Neonatal Unit, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 34 - < 37 weeks		Gestational age < 34 weeks	
Region	Admitted newborns	Days in neonatal unit per admitted newborn	Admitted newborns	Days in neonatal unit per admitted newborn	Admitted newborns	Days in neonatal unit per admitted newborn
AHUS	1,868	5.5	704	11.8	592	43.8
Bergen/Førde	1,658	3.9	610	9.9	656	38.4
Fonna	983	6.0	389	11.5	245	39.9
Innlandet	1,026	6.6	503	13.3	357	40.1
Møre og Romsdal	901	6.7	297	11.8	246	43.7
Nordland	844	7.2	261	13.4	243	45.8
Østfold	1,131	6.0	419	13.2	302	41.0
OUS	2,564	4.9	924	9.5	879	35.6
Sørlandet	1,728	4.7	595	10.7	336	42.7
Stavanger	1,972	4.7	559	10.6	568	37.7
Telemark	922	5.3	306	10.8	217	41.1
Trøndelag	1,654	6.0	558	13.0	510	40.4
UNN/Finnmark	914	5.6	342	16.1	279	49.4
Vestfold	1,488	4.5	436	9.5	218	40.9
Vestre Viken	1,427	4.7	531	9.2	576	35.6

There was a moderately high association across regional neonatal unit lengths of stay between full-term and late preterm newborns (R^2=0.45; Spearman rho 80), and late preterm and moderate/very preterm newborns (R^2=0.60; Spearman rho 70). This means that the relative length of stay in a region was similar for both low- and high-risk newborn groups.



	Gestational age ≥ 37 weeks	Gestational age 34 - < 37 weeks	Gestational age < 34 weeks
Overall rate	5.3	11.3	40.0
Extremal ratio	1.85	1.75	1.39
Coefficient of variation	17	16	9

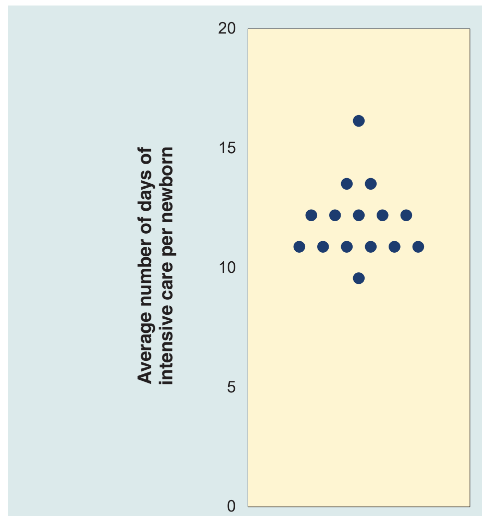
Figure 4.3. Average Length of Stay per Norwegian Newborn Admitted to Neonatal Unit, by Region and Gestational Age (2009-14)

Use of Intensive Care

For newborns admitted to a neonatal care unit, the provision of critical care is measured by days of intensive care. Preterm newborns (all those < 37 weeks gestation) received about 12 days of intensive care during 2009-14 (Figure 4.4). In Telemark, Fonna, and Østfold, newborns spent 8.9 and 10.4 days in intensive care respectively, while in Møre og Romsdal and AHUS they spent 16.8 and 13.7 days in intensive care (Table 4.5). The magnitude of variation was moderate, with a coefficient of variation of 16.

Table 4.5. Average Number of Days of Intensive Care per Preterm Norwegian Newborn Admitted to Neonatal Unit, by Region (2009-14)

	Gestational age < 37 weeks	
Region	**Newborns admitted to intensive care**	**Intensive care days per newborn**
AHUS	320	13.7
Bergen/Førde	322	10.9
Fonna	108	10.4
Innlandet	164	12.0
Møre og Romsdal	132	16.8
Nordland	135	12.0
Østfold	155	10.4
OUS	384	11.0
Sørlandet	189	12.1
Stavanger	235	10.5
Telemark	112	8.9
Trøndelag	244	13.2
UNN/Finnmark	168	11.0
Vestfold	112	12.3
Vestre Viken	233	12.0



	Gestational age < 37 weeks
Overall rate	11.8
Extremal ratio	1.89
Coefficient of variation	16

Figure 4.4. Average Number of Days of Intensive Care per Preterm Norwegian Newborn Admitted to Neonatal Unit, by Region (2009-14)

Use of Antibiotics

Suspected infection is the most common cause of admission to neonatal units for term infants. Symptoms of infection in neonates are non-specific, and it is often not possible to determine with certainty whether a newborn with non-specific symptoms, such as rapid breathing, has an infection in need of treatment or is only experiencing transient symptoms that can occur while adapting to life outside the mother's body. However, all experienced neonatologists have seen patients go from clinically healthy to critically ill in a matter of hours and sometimes die from an infection. Therefore, there is broad agreement among neonatologists that it is good clinical practice to start antibiotic treatment if neonates show symptoms suggestive of an infection.

The use of blood cultures to initially detect infections has limited use in newborns, with most (94%) episodes of sepsis diagnosed on the basis of the newborn's overall clinical picture.[2] In 2006, the Norwegian Society of Pediatrics' interest group for neonatal medicine established a consensus on diagnosing clinical sepsis with the following criteria, all of which must be met:

1. Clinical signs of infection
2. Maximum CRP (blood test infection marker) level > 30
3. Minimum five days of antibiotic treatment
4. Other causes that could explain the clinical picture must be excluded

Criteria 1 and 4 are subject to doctors' discretionary judgement. Therefore, the assignment of a sepsis diagnosis varies across physicians and regions. There is, however, no epidemiological evidence to suggest that the actual incidence of sepsis in neonates varies between hospital referral areas.

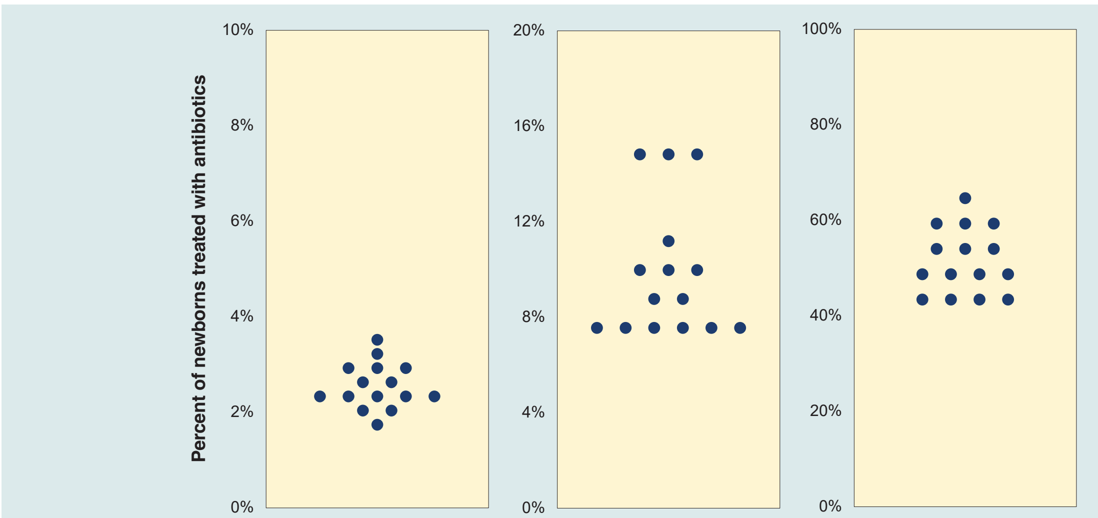
Each year in Norway, approximately 2,300 newborns (corresponding to 40% of infants admitted to a neonatal unit and 3.8% of all newborns) undergo a short or long course of antibiotic treatment. Generally speaking, the risk of infection increases as the length of pregnancy decreases; infants born before the 30th week of pregnancy are often routinely put on antibiotics after birth.

Recently, there has been concern in Norway and the U.S. that antibiotics are overused in newborn care, with improvement activities particularly focused on discontinuing antibiotic treatment early for infants who display no clinical symptoms or if laboratory findings do not confirm infection. Guidelines recommend discontinuing treatment within 36-48 hours if the suspicion of sepsis is no longer supported by clinical criteria[3] and this is now included as a recommendation in both the Norwegian and the American Choosing Wisely initiatives.[4]

Reflecting the low risk of sepsis in full-term newborns, 2.5% received a course of antibiotics during 2009-14. The percentage rose to 10.1% for late preterm and 51.6% for moderate/very preterm newborns (Figure 4.5).

The variation in antibiotic use was high in the less ill newborn groups. For full-term newborns, the two regions with the lowest rates of antibiotic treatment were Bergen/Førde (1.6%) and AHUS (2.0%), and the regions with the highest were Stavanger (3.7%) and Nordland (3.1%) (Table 4.6). The coefficient of variation was 20. For late preterm newborns, the two regions with the lowest percent treated with antibiotics were AHUS (6.9%) and Fonna (7.2%), and the regions with the highest were Vestre Viken (15.4%) and Sørlandet (14.6%). The coefficient of variation was 29.

For the moderate/very preterm newborns, the *relative* variation was low; the percent of newborns treated in the highest region (Vestre Viken; 67.3%) was 1.65 times higher than in the lowest region (Innlandet; 40.7%) and the coefficient of variation was 15. But the *absolute* difference (67.3% - 40.7% = 26.6%) was much higher because antibiotics were more commonly used for this group of newborns.



	Gestational age ≥ 37 weeks	Gestational age 34 - < 37 weeks	Gestational age < 34 weeks
Overall rate	2.5%	10.1%	51.6%
Extremal ratio	2.31	2.22	1.65
Coefficient of variation	20	29	15

Figure 4.5. Percent of Norwegian Newborns Treated with Antibiotics, by Region and Gestational Age (2009-14)

Table 4.6. Percent of Norwegian Newborns Treated with Antibiotics, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 34 - < 37 weeks		Gestational age < 34 weeks	
Region	**Births**	**Percent treated with antibiotics**	**Births**	**Percent treated with antibiotics**	**Births**	**Percent treated with antibiotics**
AHUS	32,055	2.0%	1,598	6.9%	668	43.4%
Bergen/Førde	37,594	1.6%	1,754	9.7%	776	58.6%
Fonna	11,846	2.4%	664	7.2%	293	47.1%
Innlandet	20,787	2.1%	1,176	7.4%	442	40.7%
Møre og Romsdal	16,118	2.3%	687	7.7%	291	49.1%
Nordland	12,705	3.1%	638	10.5%	278	50.0%
Østfold	17,078	3.0%	827	8.9%	338	54.1%
OUS	49,765	2.4%	2,185	10.8%	1,077	43.5%
Sørlandet	19,630	3.1%	1,004	14.6%	373	61.4%
Stavanger	27,704	3.7%	1,441	14.5%	640	59.5%
Telemark	9,527	2.4%	481	8.3%	260	52.7%
Trøndelag	29,658	2.5%	1,368	7.5%	587	48.0%
UNN/Finnmark	16,700	2.3%	697	9.9%	315	55.2%
Vestfold	12,857	2.6%	613	7.8%	270	42.2%
Vestre Viken	28,225	3.1%	1,277	15.4%	599	67.3%

Use of Ventilators in Treating Respiratory Illness

Ventilator treatment is required for serious lung disease or neurological symptoms when infants are unable to breathe on their own to maintain normal blood levels of oxygen and carbon dioxide.

The majority of Norwegian infants admitted to neonatal units do not need ventilator treatment. Ventilator treatment requires complex monitoring and management and is mainly carried out at regional hospitals. A small proportion of such treatment is carried out at local hospitals, primarily for preterm infants born after the 28th week of pregnancy, and sometimes for term infants.

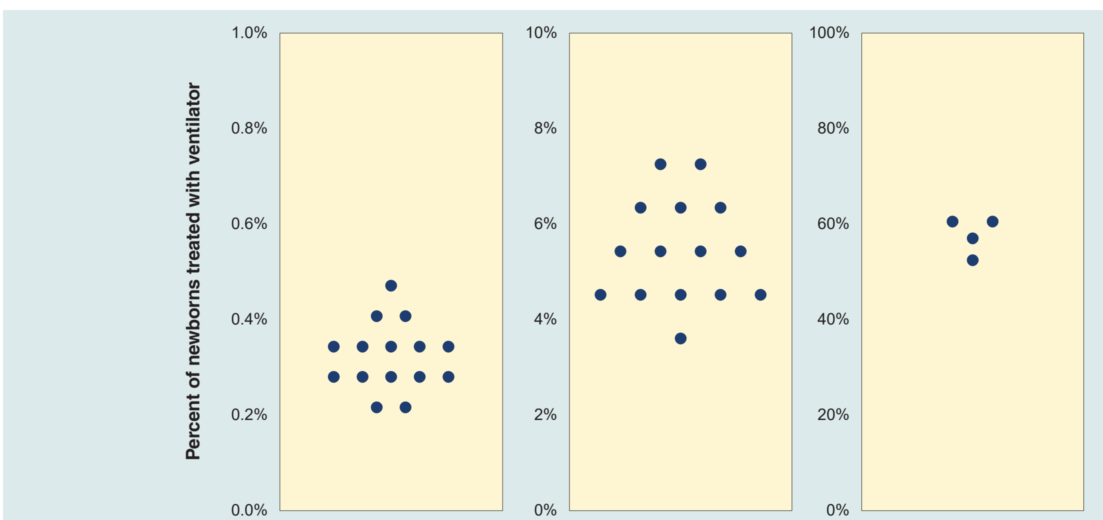
Breathing support for most preterm infants born after the 28th week of pregnancy requires only extra oxygen or CPAP, whereby a constant air flow is delivered through the newborn's nose to prevent the lungs from collapsing; the newborn breathes on their own without active help from a ventilator. Such non-invasive ventilation support is also increasingly successful for infants born before week 28, but a higher percentage of them still need ventilator support for a period of time. The most premature infants, those born before the 25th week of pregnancy, often need several weeks of ventilator treatment. In the period 2009-14, 8.9% of all patients admitted to Norwegian neonatal units underwent ventilator treatment, and 5.6% of all treatment days during this period were associated with such treatment.

Table 4.7. Percent of Norwegian Newborns Treated with Ventilator, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 28 - < 37 weeks	
Region	Births	Percent treated with ventilator	Births	Percent treated with ventilator
AHUS	32,055	0.3%	2,130	4.7%
Bergen/Førde	37,594	0.3%	2,347	6.3%
Fonna	11,846	0.3%	881	4.9%
Innlandet	20,787	0.3%	1,540	5.9%
Møre og Romsdal	16,118	0.5%	927	7.3%
Nordland	12,705	0.4%	846	6.1%
Østfold	17,078	0.3%	1,110	4.9%
OUS	49,765	0.3%	3,037	5.3%
Sørlandet	19,630	0.3%	1,303	5.3%
Stavanger	27,704	0.3%	1,949	4.6%
Telemark	9,527	0.4%	685	5.3%
Trøndelag	29,658	0.4%	1,830	5.4%
UNN/Finnmark	16,700	0.4%	947	7.7%
Vestfold	12,857	0.2%	821	4.9%
Vestre Viken	28,225	0.2%	1,748	3.1%

	Gestational age < 28 weeks	
Region	Births	Percent treated with ventilator
Central	176	60.2%
Northern	135	60.7%
Southern and Eastern	814	57.0%
Western	391	52.4%

Similar to other medical care events (e.g., admissions to NICU, number of intensive care days, antibiotic use), regional variation in the use of ventilators was lowest in the most premature infants (< 28 weeks gestation). The overall percent of ventilator use in this group was 56.5%, and this varied from 52.4% in the Western to 60.7% in the Northern region (coefficient of variation=7) (Figure 4.6). In newborns born at 28 to < 37 weeks, 5.3% were treated with ventilators, but this varied by a factor of almost 2.5, with the lowest rates observed in Vestre Viken (3.1%) and Stavanger (4.6%) and the highest in UNN/Finnmark (7.7%) and Møre og Romsdal (7.3%) (Table 4.7). The coefficient of variation was 21. In full-term newborns (≥ 37 weeks), only 1 out 330 received ventilator treatment, with the magnitude of variation similarly high (coefficient of variation=23). Regions with lower use were Vestre Viken (0.2%) and Vestfold (0.2%), and regions with higher use were Møre og Romsdal (0.5%), Nordland (0.4%), and UNN/Finnmark (0.4%).

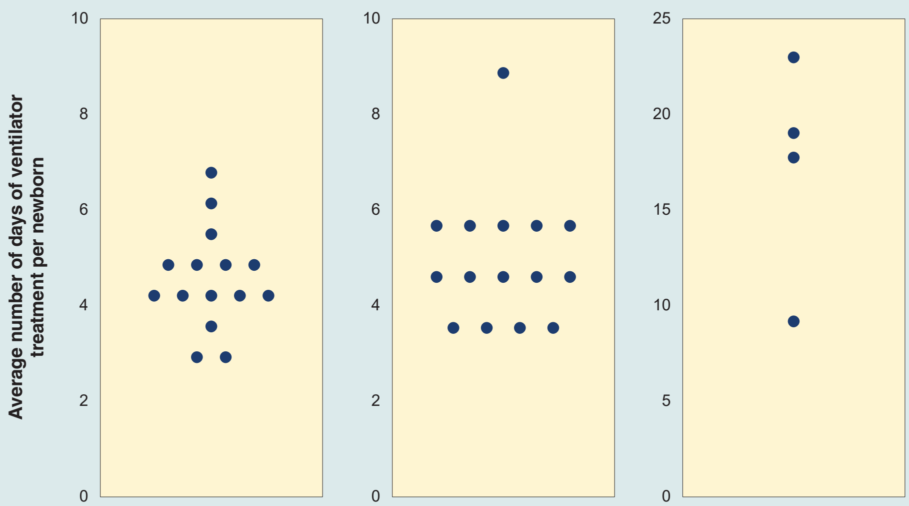


	Gestational age ≥ 37 weeks	Gestational age 28 - < 37 weeks	Gestational age < 28 weeks
Overall rate	0.3%	5.3%	56.5%
Extremal ratio	2.73	2.45	1.16
Coefficient of variation	23	21	7

Figure 4.6. Percent of Norwegian Newborns Treated with Ventilator, by Region and Gestational Age (2009-14)

Regardless of gestational age, there was marked variation in the length of ventilator treatment. For those receiving ventilator treatment, the average duration was 17 days among extremely preterm newborns (< 28 weeks), 4.7 days among those very/moderately preterm (28 to < 37 weeks), and 4.5 days among full-term newborns (Figure 4.7).

The absolute difference in the number of ventilator days was striking among extremely preterm newborns, with 9.2 days in the Western region and 23 days in the Central region (Table 4.8). However, there may have been differences between regions in treatment policy, and therefore survival, for infants at the border of viability in gestational week 23. More infants treated, with higher survival rates in some regions than in others, may greatly increase the average time on ventilator treatment for this group. The relative difference in the length of treatment across all gestational ages was similar (extremal ratios 2.50, 3.13, and 2.73), as were the coefficients of variation (34, 32, 25). There was no meaningful association across hospital referral regions in the length of treatment between full-term and very/moderately preterm newborns.



	Gestational age ≥ 37 weeks	Gestational age 28 - < 37 weeks	Gestational age < 28 weeks
Overall rate	4.5	4.7	17.0
Extremal ratio	2.73	3.13	2.50
Coefficient of variation	25	32	34

Figure 4.7. Average Number of Days of Ventilator Treatment per Norwegian Newborn Treated with Ventilator, by Region and Gestational Age (2009-14)

Table 4.8. Average Number of Days of Ventilator Treatment per Norwegian Newborn Treated with Ventilator, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 28 - < 37 weeks	
Region	**Newborns receiving ventilator treatment**	**Ventilator treatment days per newborn**	**Newborns receiving ventilator treatment**	**Ventilator treatment days per newborn**
AHUS	109	4.7	100	4.2
Bergen/Førde	110	2.6	149	3.9
Fonna	41	3.5	43	3.3
Innlandet	69	5.3	91	4.4
Møre og Romsdal	81	4.9	68	6.2
Nordland	50	3.9	52	5.2
Østfold	53	4.1	54	5.7
OUS	143	4.1	160	4.3
Sørlandet	57	4.6	69	9.4
Stavanger	73	4.5	89	5.3
Telemark	34	7.1	36	6.1
Trøndelag	107	5.0	98	3.6
UNN/Finnmark	65	4.2	73	4.1
Vestfold	30	3.2	40	4.4
Vestre Viken	52	6.4	55	3.0

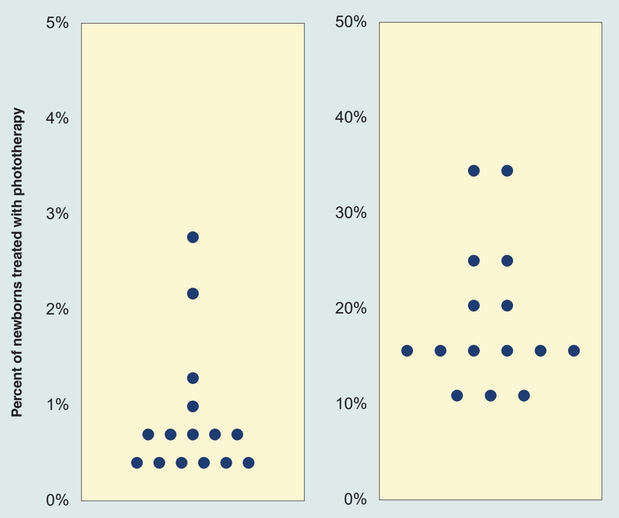
	Gestational age < 28 weeks	
Region	**Newborns receiving ventilator treatment**	**Ventilator treatment days per newborn**
Central	106	23.0
Northern	82	17.7
Southern and Eastern	464	19.0
Western	205	9.2

Phototherapy: Light Treatment for Jaundice (Hyperbilirubenemia)

Bilirubin is released when fetal red blood cells are broken down to be replaced by mature cells, which can result in a yellowish skin hue, termed jaundice. In most cases, jaundice is a normal physiological condition caused by a temporary and harmless reduction of the child's capacity to excrete bilirubin via the biliary tract into the intestine. In some cases, such as when the mother and newborn have different blood types or the newborn has rare blood or metabolic disorders, the levels of bilirubin can become very high and can enter the infant's brain, causing neurologic injury.

Bilirubin is broken down more quickly when the child's skin is exposed to ultraviolet light. Evidence-based guidelines for treatment of high bilirubin levels have been established in Norway through professional consensus on an algorithm used by all Norwegian maternity and neonatal units.

Between four and five percent of all newborns develop jaundice that requires phototherapy.[5] Where there are no other signs of illness, phototherapy can usually be administered to newborns in the maternity unit, with the supervision of a pediatrician, to avoid mother-infant separation. Whether the babies are physically moved from the maternity unit to the neonatal unit therefore largely depends on local procedures and guidelines.



	Gestational age ≥ 37 weeks	Gestational age 34 - < 37 weeks
Overall rate	0.7%	16.5%
Extremal ratio	11.6	4.30
Coefficient of variation	84	42

Figure 4.8. Percent of Norwegian Newborns Treated with Phototherapy in Neonatal Unit, by Region and Gestational Age (2009-14)

Table 4.9. Percent of Norwegian Newborns Treated with Phototherapy in Neonatal Unit, by Region and Gestational Age (2009-14)

	Gestational age ≥ 37 weeks		Gestational age 34 - < 37 weeks	
Region	Births	Percent treated with phototherapy	Births	Percent treated with phototherapy
AHUS	32,055	1.0%	1,598	17.3%
Bergen/Førde	37,594	0.3%	1,754	8.6%
Fonna	11,846	2.1%	664	32.8%
Innlandet	20,787	0.3%	1,176	11.0%
Møre og Romsdal	16,118	0.7%	687	18.5%
Nordland	12,705	0.7%	638	20.4%
Østfold	17,078	0.8%	827	23.7%
OUS	49,765	0.4%	2,185	13.0%
Sørlandet	19,630	0.6%	1,004	16.8%
Stavanger	27,704	0.6%	1,441	13.4%
Telemark	9,527	2.9%	481	36.8%
Trøndelag	29,658	0.5%	1,368	14.4%
UNN/Finnmark	16,700	0.5%	697	17.5%
Vestfold	12,857	1.4%	613	26.1%
Vestre Viken	28,225	0.4%	1,277	13.5%

The percent of newborns that received phototherapy in a neonatal unit was 0.7% in full-term and 16.5% in late preterm newborns during 2009-14 (Figure 4.8). These percentages reflect both the overall use of phototherapy and the unit practice in treating jaundice newborns in neonatal units instead of in the maternity unit. The variation in neonatal unit phototherapy was very high, particularly for full-term newborns, where rates varied by a factor of more than 11 between the lowest (Bergen/Førde; 0.3%) and highest (Telemark; 2.9%) regions (Table 4.9). The coefficient of variation was 84.

In late preterm newborns, the regions with the lowest rates were Bergen/Førde (8.6%) and Innlandet (11.0%), and the regions with the highest rates were Telemark (36.8%) and Fonna (32.8%). Variation was fourfold, and the coefficient of variation was 42. There was a strong association between full-term and late preterm newborns in the use of neonatal intensive care phototherapy across regions (R^2=0.88; Spearman rho 0.91).

Benchmarking Norwegian Newborn Care

What are the potential patient benefits if neonatal units adopt effective and efficient practices? The use of antibiotics in newborns can serve as an example. As discussed above, there is a professional consensus supported by research that antibiotics are overused in newborn care. From this it can be asserted that lower overall use of antibiotics is likely to be better. If all moderate/very preterm newborns were treated at the same rate as that of the Oslo university hospital referral area, 580 fewer premature newborns would have been exposed to antibiotics over the six-year study period, or 97 per year. Full-term newborns are much more common than preterm newborns, so small differences in their treatment rates can affect larger newborn numbers. Again using the Oslo referral area as a hypothetical benchmark, 418 fewer newborns, or 70 per year, would have received antibiotics. But if the Bergen/Førde referral area was used as the benchmark for full-term newborns, 3,156 fewer newborns, or 526 per year, would have received antibiotics. Calculations of the impact of changes in practice styles are clinically meaningful only when the “right rate” or the “gold standard” benchmark is known, so these calculations should be interpreted with caution. This points to the critical need for additional research to define best practices for the full range of newborn diagnostic and therapeutic measures.

Summing Up

The Norwegian analyses are different from studies of newborn care in the United States in a number of ways. They draw from the country’s entire population without regard for location or socioeconomic status. The U.S. is extremely diverse in income, social identity, language, and geography—all of which are factors that influence perinatal risk and prematurity rates—raising additional challenges in comparing newborn care from one region or one hospital to another. Norway is not without diversity, but the regional differences in prematurity rates are corrected for, and it is otherwise relatively homogenous compared to the U.S. Yet there are two notable similarities. The first is the degree of variation in newborn care practices, which is comparable to that observed in the U.S. across all levels of newborn risk. This is not to say that the causes of variation are always identical; each country has complex clinical, policy, and social factors beyond newborn health status that affect the availability of different types of perinatal care and local practice styles. Identifying the causes, consequences, and remedies for unwarranted variation requires consideration of these dynamics within specific regions. The second similarity is that Norway and the U.S. stand out as the two countries with the most advanced measurement of newborn care at the population level, encompassing the full range of newborn risk.

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5. The Problem of Variation in Newborn Care

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Families want and deserve the best health care for their newborns, but the type and quantity of services infants receive depends on where their families live, and the hospital of delivery. The diagnostic and therapeutic procedures reported in this Atlas are only the tip of the iceberg of medical practice variation, with many other provider differences in newborn technical quality, patient-centeredness, and costs documented in medical journals.[1-7] Unfortunately, the scope and scale of problems revealed to date by population-level perinatal analyses have received scant attention by health systems, payers, and policymakers. Parents have access to little information. It would not occur to families that two recently built and well-equipped NICUs in their own community, both staffed with well-trained clinicians, are likely to provide different care leading to disparate rates of mortality and morbidity.[8]

Compared to the detailed information available for guiding quality improvement for patients insured by Medicare, our understanding of newborn care is still in its earliest stages. How, then, should we interpret and use the information currently known about variation in newborn care? To answer this overarching question, we will answer five specific questions regarding the variation: Is the variation *unwarranted*? Is the unwarranted variation important? What are the causes of unwarranted variation, and what is the right rate? And how can this information lead to better perinatal care and outcomes?

Is the variation unwarranted?

Unwarranted variation is defined as variation in care not explained by patient needs and preferences.[9] Regional and hospital variation in newborn care, by itself, is neither a surprise nor a concern. Variation occurs throughout all human endeavors. Why would we expect that health care would be different? Health care should respond to the individual health risks and illnesses of different patients and populations. The average health of newborns in Baltimore, Maryland or Lubbock, Texas is poorer than that of newborns of Burlington, Vermont or Denton, Texas. Good newborn care, including neonatal intensive care, of these populations should result in different utilization rates for these regions. This variation is *warranted*. But how much is unwarranted?

The studies reported in this Atlas indicate that a higher proportion of the observed variation is unwarranted than in response to patient needs or family preferences. This conclusion is supported by a number of findings. First, regardless of the newborn's risk group or the method of adjustment, similarly high magnitudes of variation in utilization are observed. That is, whether the newborn population is more affluent (commercially insured) or less (Medicaid insured), from a very diverse country with heterogeneous health delivery models (the United States) or a relatively homogenous country with a single national health system (Norway), the degree of variation is similar. High levels of variation in utilization are seen for both high- and low-risk newborns, and large variation persists whether regional differences are controlled for by restriction (i.e., high- or low-risk newborn groups), standardization (i.e., indirect adjustment for Medicaid/commercial insurance mix), or statistical modelling.

Using the Texas Medicaid-insured newborn data, we can compare unadjusted rates against rates with very good adjustment for newborn health risk at birth. The Texas dataset has a comprehensive set of high-quality maternal and newborn variables. The adjustment models were developed for each newborn population (i.e., separately for very low birth weight and late preterm newborns) and extend established risk-adjustment models. The final models have high face validity and particularly good statistical characteristics.[10] (See online methods at http://www.dartmouthatlas.org/.) After adjustment for the many different maternal and newborn characteristics available, the amount of variation across regions and hospitals was only slightly reduced. Two examples are presented in Figures 5.1 and 5.2 for the total number of special care days. Adjusted regional rates were different from the unadjusted rates in the VLBW and late preterm newborn groups, but the overall amount of variation decreased little. In other measures, the coefficients of variation for measures unadjusted for newborn risk were very similar to the coefficients of variation after adjustment.[10] Said differently, relatively little of the variation was a result of differences in newborn health needs.

If the variation is not primarily caused by differences in newborn health needs, might it be due to family preferences for the care of their newborns? Most of the attention to preferences in the neonatal period has been in regard to choices in feeding, male circumcision, or care decisions for extremely premature newborns at the edge of viability.

Parents are also encouraged to express their preferences for and participate in non-medical aspects of care in NICUs (e.g., changing diapers, giving baths, or taking a temperature[11]).

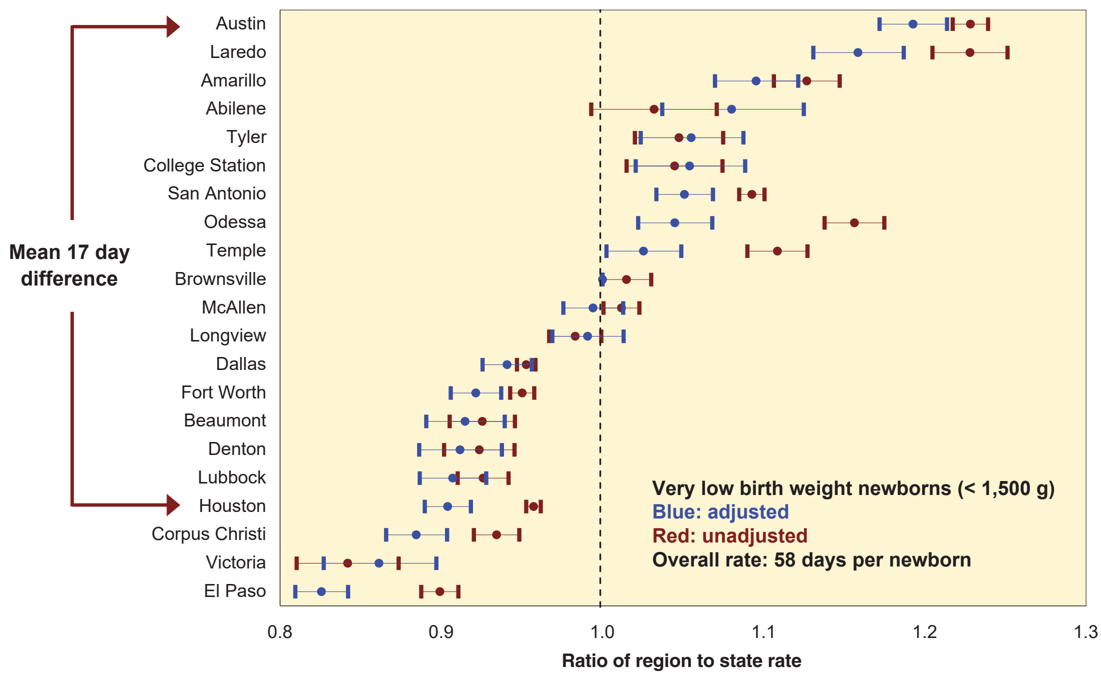

Figure 5.1. Number of Special Care Days (Intensive or Intermediate) among VLBW Births, Texas Neonatal Intensive Care Regions (2010-14)

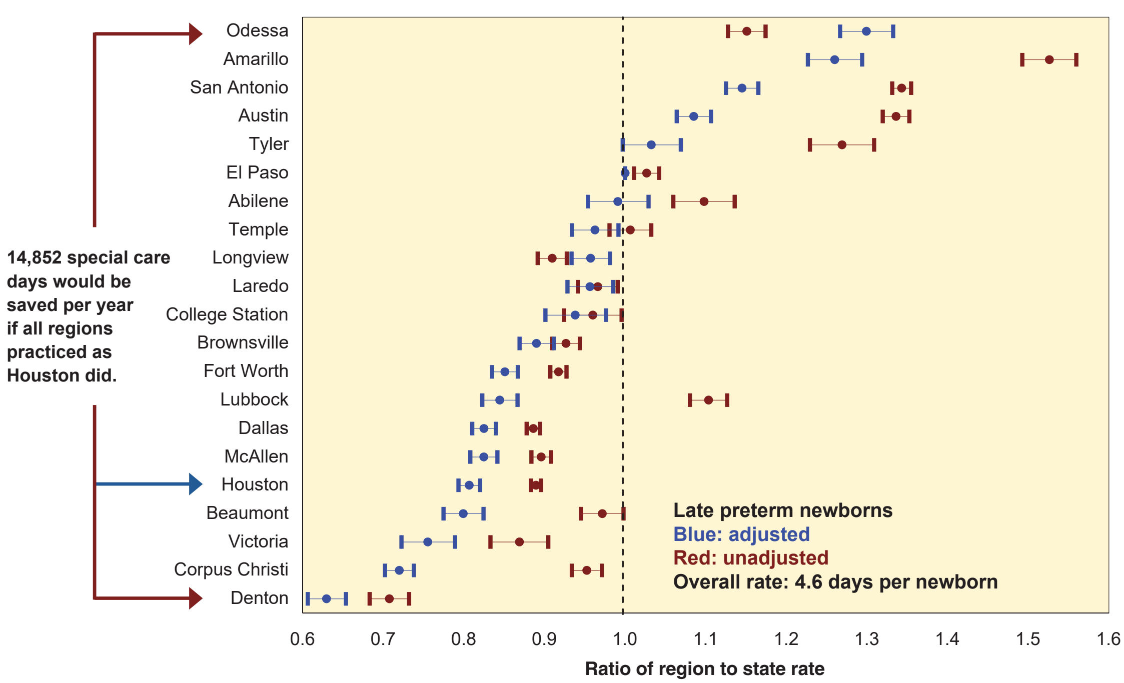

Figure 5.2. Number of Special Care Days (Intensive or Intermediate) among Late Preterm Births, Texas Neonatal Intensive Care Regions (2010-14)

There is interest in expanding the scope of shared decision-making in neonatal care,[12-14] but currently most decisions are made by neonatal clinicians acting in an agency role on behalf of the interests of newborns and families. Such decisions include readiness for discharge, whether a mildly ill newborn (i.e., late preterm or delayed transition after birth) requires intensive care, or frequency of lab draws and medical imaging. At this time, family preferences do not explain newborn health care variation.

Is the unwarranted variation important?

The observed unwarranted variations are large enough to have troubling consequences for newborn outcomes and costs. For high-risk newborns, the magnitude of provider differences in care is of obvious importance to families. The mean difference between Austin and Houston in the number of special care days per Texas Medicaid-insured VLBW newborn is 17 days (Figure 5.1). Regardless of whether it is better for a newborn to spend 70 days in special care—as in Austin—or 53 days in Houston, the difference is sizable: over two weeks of special care. Patterns of care are distributed differently across low-risk newborns. Most are healthy and receive only routine care; the chance that any single newborn is meaningfully affected by variation in care is low. But given the large population of low-risk newborns, the overall impact of practice variation can be significant. For example, the range in the number of special care days for Texas' late preterm newborns is 3 days. If the entire population of these mildly premature infants all received the number of days provided to Houston newborns (3.7 days), almost 15,000 days would be saved per year across the State (Figure 5.2).

Each of the events included in this Atlas has implications for newborns and families. If more special care days are better, then many newborns are deprived of its value. If lower rates of special care days are safe, then some infants are exposed to needless days of NICU care, with its risks and separation from families, for no measurable benefit. If the higher rates of antibiotic use or the use of active ventilation seen in some regions of Norway are medically unnecessary, then the potential adverse events are not balanced by improved outcomes.

Finally, the economic implications of under and overuse of care are large. Current estimates of costs associated with newborn and NICU care for the nation are elusive.[15-17] We do know with certainty that, in 2014, Texas Medicaid program payments for newborns were over $1 billion, with $916 million of the total payments going toward those with a NICU admission. As with utilization, program payments varied widely across Texas NICRs (http://www.dartmouthatlas.org/). Regardless of the perspective—family, health system, or payer—unwarranted variation in newborn care is an impediment to a better future for our children, and at the same time stresses public budgets and family finances.

What are the causes of unwarranted variation and what is the right rate?

There are a number of factors that can be viewed as responsible for unwarranted variation in general, and for newborn care specifically. These include scientific uncertainty of diagnostic value and treatment outcomes, leading to clinician uncertainty in what care constitutes best practice. Clinicians' knowledge base is not uniform, nor is their interpretation of the medical literature, which further adds to the variation. Fee-for-service reimbursement models incentivize hospitals and physicians to increase service volumes to the maximum that can be supported by local health care capacity. The relative organization or fragmentation of health care in a region is considered a contributing factor by some. It is useful to organize these connected and overlapping causes into the paradigm of the three primary causes of variation:

1. Variation in the provision of effective care. Many current services in perinatal care are known to be effective in improving newborns' health with relatively minor adverse consequences. This type of care—scientifically established for a well-defined patient group with an excellent balance of benefit over harm—is also referred to as high technical quality. For example, VLBW newborns delivered in a hospital with a Level III or IV NICU have lower mortality and morbidity than those born in hospitals with only routine care nurseries or Level II units.[18] The right rate is known, 100%, and while circumstances may preclude achieving that goal, improving the percentage is one of the objectives of Healthy People 2020.[19] Not surprisingly, there is regional variation in achieving this quality objective. Other examples of effective neonatal care are NICU admissions for each VLBW newborn, the timely use of surfactant in certain groups of preterm newborns to reduce respiratory distress syndrome, and hepatitis B vaccination for all newborns. The failure to consistently provide effective care can arise from clinician ignorance or the challenge of changing longstanding practices that involve complex systems of care. Importantly, in the daily work day of a pediatrician or neonatologist, most of the decisions are for medical care where the evidence of benefit is not well established, or where possible benefit is accompanied by significant risks of adverse effects.

2. Variation in preference-sensitive care. We have already established that family preferences play only a small role in the patterns of observed variation. In the case of a decision about effective care, the newborn benefit is great enough that most would argue that the appropriate role of the clinician is to educate and advocate for its use. In acute care scenarios, there is little room for family preferences when decisions need to be made rapidly, or when the newborn's surrogate, such as its mother, is indisposed. But there are many non-urgent decisions, such as those regarding breast feeding or the timing of discharge, for which there are different reasonable options, each with its own possible advantages and disadvantages. In these instances, practice variation at the population level reflects the different judgments of clinicians and NICU staff, sometimes locally codified in clinical practice guidelines. The important point is that the values assigned to the options differ between clinicians, between families, and between families and clinicians.[12] Excluding options which are simply ill-advised, the right rate for a region would reflect the decisions made during a process of shared decision-making where clinicians and families are informed and are jointly engaged in reaching a decision that reflects the family's values.

One example to consider is the use of head MRI at term-equivalent age in very preterm newborns. In a recent study, MRI in conjunction with ultrasound detected "brain injury" in 25% of newborns. Some of the abnormalities, but not all, were detected by head ultrasound alone.[20] The clinical importance of many of the subtle abnormalities detected is not known, and the available interventions—periodic neurodevelopmental assessments and interventions—are recommended for all VLBW infants. At the same time, diagnosing a radiologic "abnormality" with uncertain consequences for an infant's future and no specific treatment can cause parental anxiety, with its own adverse effects on the newborn.[21] To date, the benefit of the use of MRI in this setting appears to be low.[22]

The strikingly different use of head MRIs for VLBW newborns reported in this Atlas reflects the assorted opinions of neonatologists, neurologists, and child development pediatricians regarding its value. It seems unlikely that the benefit of head MRI in the foreseeable future will be so great that it would be considered effective care, and some clinicians currently view it to be an example of overuse.[23] As long as there is professional disagreement regarding its value, shared decision-making would be the means of turning unwarranted variation in head MRI use into warranted variation that incorporates the values of families.

3. Variation in supply-sensitive care. This term is best explained by an example. We reported in section 2 that variation in NICU admissions of lower-risk newborns is sensitive to the regional supply of NICU beds,[24] with recent expansions in overall NICU capacity extending these services to newborns of lower and lower risk. Furthermore, given that NICU capacity is not located where need is greater, it is unsurprising that more beds are not reliably associated with better outcomes.[25] There are a number of different ways to provide good care for newborns that could involve varying NICU admission rates, lengths of stay, and imaging rates. In this instance, the question of the "best care" does not lend itself to assessment by randomized clinical trials. In fact, there is no theoretical foundation to assert the benefit of a particular number of special care days or chest films. The phenomenon of greater supply leading to higher use without patient benefit is manifested as variation in supply-sensitive care[9] and has received increasing attention in neonatology in recent years.[26-29] In the near future, variation in head MRI use is likely to be partially caused by supply factors, in addition to the failure to adopt shared decision-making, as imaging firms market MRIs designed to be installed in NICUs. The availability of head MRIs in NICUs will increase with little regard to population need. Longstanding traditions of reimbursing care based on service volume (fee-for-service) are permissive of unwarranted variation, but particularly incentivize the growth of capacity in NICU beds and imaging devices with uncertain value for patients and populations.

How can this information lead to better perinatal care and outcomes?

There is critical need to improve perinatal outcomes in the U.S. While a large portion of illness burden is related to poor birth outcomes, such as elevated rates of prematurity compared to other high-income countries, the treatment-related outcomes of illness present at birth vary substantially across hospitals.[6,8,30-32] Outside the professional community of neonatal clinicians, there is limited awareness of differences in processes of care and risk-adjusted mortality and morbidity rates across NICUs.

The analyses presented in this Atlas examine processes of care. At a regional or hospital level, newborn services are expected to vary in accordance with average illness levels. Instead, much of the observed difference is likely due to local hospital and clinician practice styles. These are developed in the absence of adequate outcomes research; shaped by local NICU capacity, with limited consideration of parental preferences; and incentivized, particularly in the U.S., by poorly-designed systems of reimbursement.

A primary goal of this Atlas is to improve awareness of variation in newborn care and to spark curiosity into the causes. After this, what are some of the next steps? The rich, 45-year history of research and engagement with the causes, consequences, and remedies of medical care variation in adults is helpful for direction. Unwarranted variation has been reduced in many instances of effective care, and the knowledge gained through investigating other types of variation has been the basis for successful changes in health systems and health policy. One response in adult health care has been the development of provider-based improvement networks.[34] The Vermont-Oxford Network is an exemplar of this in pediatrics.

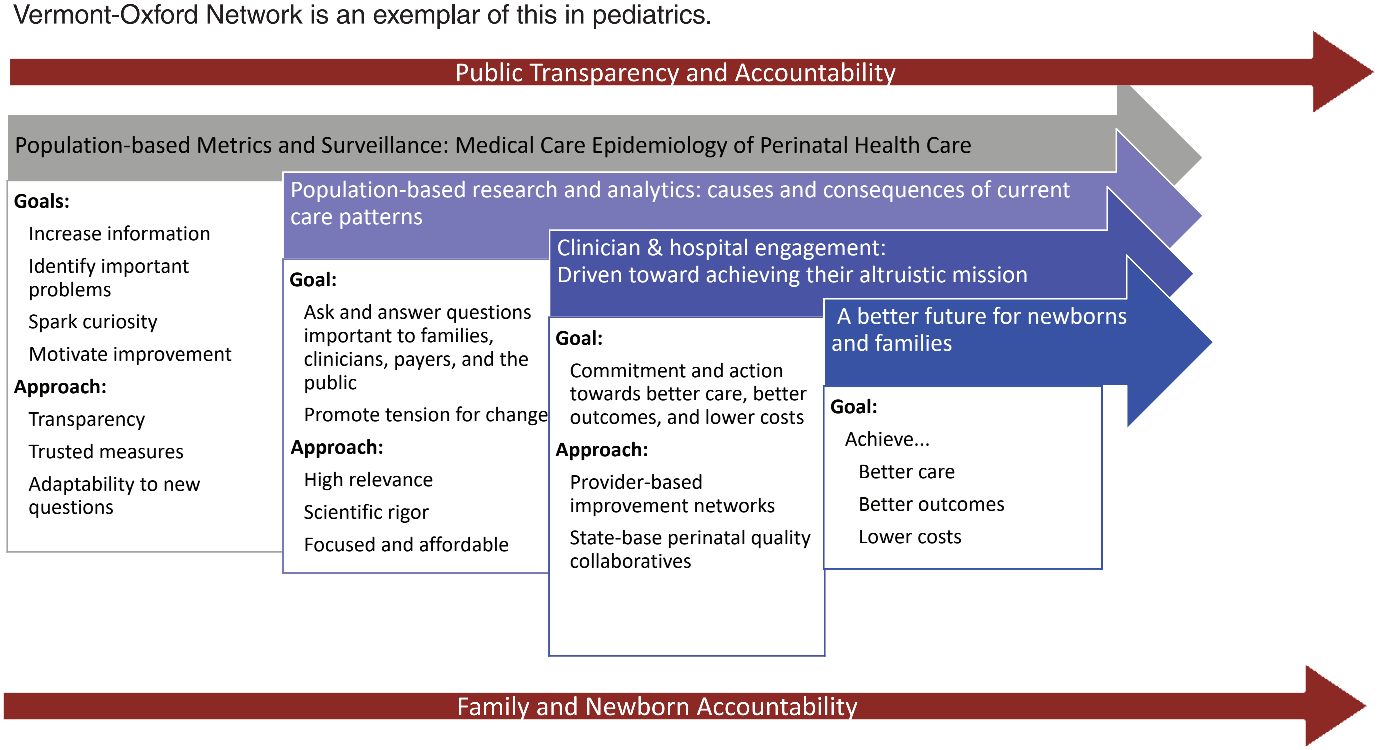

Figure 5.3. Meeting the Triple Aim in Perinatal Health

Many clinicians responsible for newborn care are already engaged in these efforts, but they need to be continued and expanded to a greater proportion of the newborn population, particularly the large number of mildly-ill newborns that are receiving elevated levels of care. Provider-based networks are not population-based and so do not include many NICUs and newborns. Also, improvement efforts are uncommon when the necessary changes would reduce hospital revenue under current DRG or per diem payment systems. This is a problem even for "single payer" health systems like Norway when payments from the public entity to the public hospital is by DRG. Our commitment to change in perinatal health care should not be subordinate to concerns regarding possible decreases in physician and hospital revenue.

But "in-the-unit" quality improvement efforts are only one part of meeting the Triple Aim of better care, better health, and lower costs. Surveillance and research in neonatal and pediatric health care has lagged, given the serious barriers in the availability of existing data.[33] Continued growth in the perinatal research and measurement portfolio is foundational to answer the questions: What is the right rate? Where would greater investments improve care? and What are the opportunities to reduce overuse and costs? Improved accountability to our patients is dependent on better data, better analyses, and greater public transparency that supports national awareness of shortcomings in newborn care and increases the tension for change. These population-based analyses complement the data from provider-based improvement networks, which tend to be focused on higher-acuity newborns and offer limited access to data for researchers outside the network.

Policymakers are well aware of the need to improve perinatal outcomes but again have limited information to judge the value of the large investments made in NICU care, particularly with the changing NICU population. Clinician engagement in improvement efforts often leaves unanswered questions regarding the pace and the areas of focus. The encouragement of the CDC in the development of state-based perinatal quality collaboratives has the potential to lead and expand both NICU improvement activities and population-based perinatal system development.[35,36] Still, the issue of public accountability and how to reconcile the interests of providers and patients remains unsolved. The expansion of available information can guide these activities and evaluate the progress toward better outcomes.

Families depend on the best efforts of clinicians and policymakers to develop effective and efficient systems of care for mothers and babies. Increasingly, families expect information about health care options and a greater role in the decisions being made, but they are generally unaware of the possibility that care could differ substantially from one hospital to another. There are many challenges to achieving health care performance transparency, but it is imperative, both professionally and ethically, that clinicians, health systems, and families are fully informed partners in improving the care of newborns.

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6. Statistical Methods

Photo: iStock.com/herjua

How is Utilization of Health Care Measured?

Counts, Proportions, and Rates

An important question when studying health care is how often an event (admission, diagnostic procedure, complication, etc.) occurs or how much of something (money, hospital days, etc.) is used. A count is the simplest measure used to express the quantity of care. Examples include dollars spent, number of births of very low birth weight newborns (VLBW; < 1,500 grams), and number of days spent in a hospital. However, a count, by itself, is often not very informative. For example, knowing that in the period from 2009 to 2014 there were 2,236 NICU admissions in the Houston, Texas region and 396 NICU admissions in San Antonio, Texas cannot answer the question of where a newborn was more likely to be admitted to a NICU, owing to the sizeable differences in the regions' newborn populations. Because of this, health care researchers commonly summarize their findings using proportions and rates, which adjust for relative population size. These are usually expressed as the number of events occurring within a certain population (the numerator) divided by the total number of individuals comprising that population (the denominator), with rates further incorporating the element of time. For example, if there were 100 live births in a region in 2018, and 20 of these newborns were admitted to a NICU, then the regional NICU admission rate was 20 per 100 live births. This can alternatively be expressed as a proportion: 20%. For events like NICU admission that tend to occur only once, the terms "rate" and "proportion" are often used interchangeably. However, if all 20 of the admitted newborns spent 5 days in the NICU, with each child receiving 4 chest films, then the proportion of admitted children receiving a chest film would be 100%, while the rate of chest films would be 80 per 100 NICU days. Counts, proportions, and rates can all be informative. Which measure is the most useful often depends on the specific question being asked.

Adjustment

For most of the measures presented in this report, newborn factors might affect how commonly an event occurs (i.e., the risk). For example, a premature newborn born at 28 weeks gestation (i.e., extremely preterm) will nearly always warrant admission to a NICU, while the vast majority of those born at 40 weeks will not. Therefore, shorter gestational age is a risk factor for NICU admission. If one region has a higher proportion of extremely preterm newborns, more NICU admissions would be expected to occur there. To make a fair comparison of NICU admission rates, or other measures of care across regions and hospitals, measures should be adjusted for patient factors associated with health care needs. After adjustment, the rates are more indicative of differences in the way care is delivered to similar newborns across hospitals. One way to account for these differences is to restrict to a key risk factor such as a birth weight range (i.e., examining admission rates for VLBW newborns). Another method is to adjust the rates for multiple risk factors, such as birth weight, gestational age, sex, and insurance coverage, among others. Adjustment, as opposed to restriction, allows the results to account for multiple risk factors simultaneously. This makes it unlikely that any observed variation in rates across areas can be explained by some regions having more premature births, a lower socioeconomic profile, or other differences affecting health status at birth. In addition to adjusting rates of neonatal health care events, regional measures of NICU supply are also adjusted according to expected need. Regions with a greater percentage of premature infants are expected to have a higher supply of NICU beds and neonatologists to meet the needs of the community. Therefore, NICU capacity is generally expressed as a ratio of the number of NICU beds divided by the number of VLBW births in a region.

How is Variation Across Regions and Hospitals Measured?

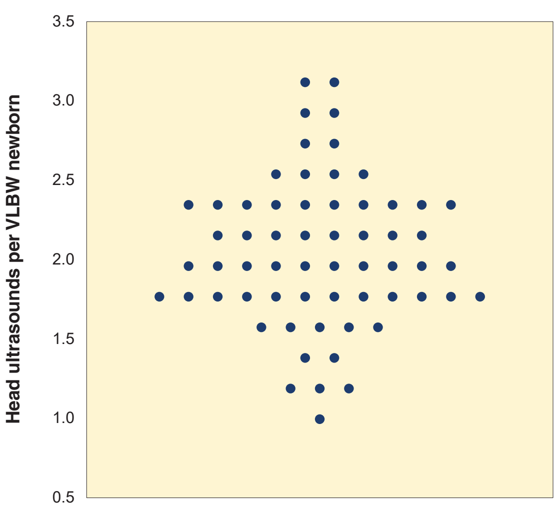
Ranges and Ratios

The simplest way the Dartmouth Atlas communicates variation is through ranges. A range reports the lowest and the highest regional rates. For example, in 2013, overall NICU admission rates ranged from 2.8 to 12.9 per 100 live births across the 208 national neonatal intensive care regions (NICRs) with sufficient data to report (see section 2). Ratios are similar to ranges except the variation is expressed as a relative measure. The extremal ratio for the rate reported above is 4.65 (12.9 divided by 2.8), indicating that newborns in the NICR with the highest admission rate were more than 4 times as likely to be admitted to a NICU than those in the region with the lowest rate. Both ranges and ratios are susceptible to the influence of "outlier" regions: NICRs that, for various reasons, are very different from the rest of the country or state. For this reason, ranges and/or ratios are often reported with these outliers excluded; one example is the interquartile ratio (the ratio of the regions at the 75th and 25th percentiles), which for overall admissions was 1.34 (8.2 to 6.1 per 100 live births).

Distribution Graphs

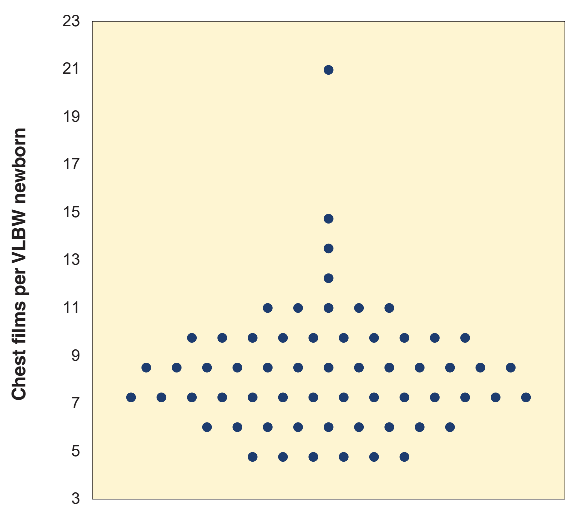
Sometimes referred to as “turnip graphs”, these charts are used to visualize the variation in health care rates across regions or hospitals. For example, Figure 2.14 shows the distribution of head ultrasounds per VLBW newborn across the 61 NICRs in the U.S. with sufficient data to report. The vertical axis represents the number of head ultrasounds per VLBW newborn, with each dot representing a single NICR. NICRs with very similar rates are arrayed on a single line because their rates fall into a “bin” between two values.

The chart summarizes two characteristics of dispersion, or variation, in the data. First, the vertical spread of rates offers a visual representation of the range to characterize the overall variability. In the example above, there is more than threefold variation, as indicated by a rate in the highest region that is 3.6 times greater than the rate in the lowest region. Second, it shows whether this variation is caused by just a few outliers, with the majority of NICRs clustered near the middle, or if the variation is pervasive, with more widespread dispersion of rates across NICRs. In Figure 2.14, there is widespread dispersion, with no one NICR clearly standing apart. Contrast this with Figure 2.15, which shows not only widespread dispersion, but also a clear outlier at the high end.



Overall rate	2.1
Extremal ratio	3.58
Coefficient of variation	23

Figure 2.14. Adjusted Number of Head Ultrasounds among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)



Overall rate	8.7
Extremal ratio	5.21
Coefficient of variation	33

Figure 2.15. Adjusted Number of Chest Films among Very Low Birth Weight Singleton Newborns by Neonatal Intensive Care Region (2010-14)

The Coefficient of Variation

A measure of dispersion that is less affected by outliers is the coefficient of variation (CV), which is calculated as the standard deviation divided by the mean of the data, multiplied by 100. The CV is useful to compare the amount of variation between outcomes that have different rates, such as the use of chest films (relatively frequent) and head ultrasounds (much less frequent). Generally, a CV of less than 10 indicates low variation, 10 to < 20 medium, and 20 or greater high variation.[1] Coefficients of variation for different utilization measures can be compared within the same set of regions; comparing coefficients of national NICRs with those defined for Texas or Norway can lead to incorrect interpretations of the relative magnitude of variation.

Can this Variation be Explained?

Much of the data presented in this report shows widespread geographic variation in the rates at which certain health care events and procedures are performed. The data demonstrate that some factors or regional characteristics are related to this variation in utilization. The strength of these relationships is presented in a number of different ways.

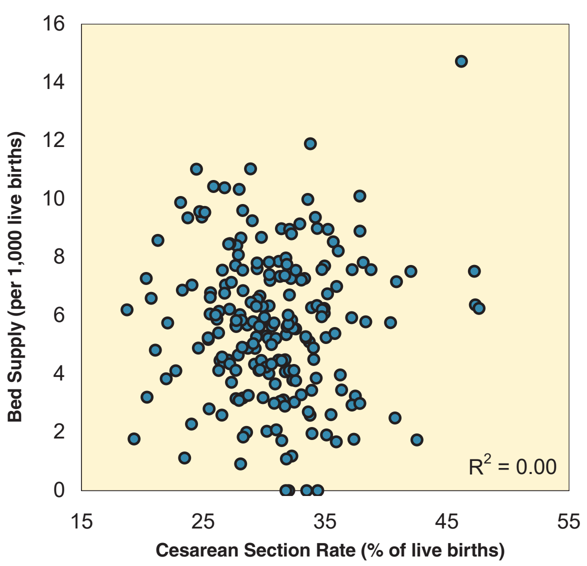


Figure 2.5. Relationship Between Cesarean Section Rate and NICU Bed Supply by NICR (2013)

Scatterplots, Regression Lines, and Correlation Coefficients

A straightforward method of assessing the relationship between two factors is by plotting their values against each other on a single graph, termed a scatterplot. An example is shown in Figure 2.5, which displays the relationship between regional bed supply (vertical axis) and the cesarean section rate (horizontal axis). If regions with higher rates of cesarean section also contained greater NICU bed supply, then the cloud of points would generally tilt upward from southwest to northeast. Conversely, if regions with higher cesarean section rates in fact contained fewer NICU beds, then the cloud of points would generally run downward from the northwest to the southeast on the graph. The direction and strength of this relationship may be difficult to discern visually, so a linear regression line is sometimes shown which best fits the data.

It is often difficult to discern from a cloud of points in a figure the strength of the relationship between two variables. The R^2 is a measure of the proportion of total variation in the vertical axis explained by variation in the horizontal axis. This is often referred to as the "goodness of fit" since it explains how well the regression line matches the actual data. In Figure 2.5, the R^2 for the relationship between cesarean sections and NICU bed supply is 0.00, indicating that 0% of the variation in regional bed supply is explained by regional variation in cesarean section rates, with 100% either random (due to chance) or explained by other factors.

The relationship between two factors can also be quantified using correlation coefficients. This report presents Spearman's coefficient (rho (ρ)) values to assess the degree of correlation of the rank order of the two factors. The value of ρ falls between -1 and +1. A value of +1 signifies a perfect positive correlation, in which every time one measure increases, the other measure does as well; the converse is true for $\rho = -1$ and a perfect negative correlation. If the two measures are not at all correlated, then ρ equals 0.

A final statistical test that is used in section 2 is the test of linear trend. This test is useful for interpreting whether a measure shows an increasing or decreasing trend that is statistically different from random behavior. For example, in answering the question, "are the chances of NICU admissions in regions greater when the category of NICU bed supply (very low, low, medium, high, very high) is higher," the test estimates the probability that the observed trend is consistent with random noise. Generally, if the probability is less than 0.05, the trend is considered "statistically significant" and not likely to be explained by chance.

Where Can I Find More Information About the Methods Used in the Atlas?

The Dartmouth Atlas web site provides detailed methods documents for each of the report sections. See http://www.dartmouthatlas.org/

References

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A Report of the Dartmouth Atlas Project

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