

Horizontally integrated health systems and neonatal intensive care unit (NICU) care for very preterm infants

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Abstract

Hospital care has consolidated rapidly into health systems in the United States. Infants born very preterm are among the most vulnerable pediatric populations, accounting for the majority of infant deaths each year. The pediatric health care delivery system for infants is unique as the birth hospitalization includes 2 patients, the mother and the infant. Further, regionalization goals for infants who are born preterm require care to be provided at neonatal intensive care units (NICUs) with the capacity to treat them. National patient-level data from the Vermont Oxford Network demonstrates that most very preterm infants were born in a horizontally integrated, multi-hospital system (84%), and they tended to remain in the system for their entire hospitalization, including for risk-appropriate NICU care. Half of the infants were cared for in large systems with more than 10 hospitals that were disproportionately cross-market systems. With high transfer rates between hospitals (21%) it will be important to determine the implications of consolidation for the quality of care and patient-centeredness for families. The care for very preterm infants is important from a policy perspective as hospitalized newborn infants account for 21% of hospitalizations in Medicaid each year and 10% of aggregate hospital costs.

Key words: health system; horizontal integration; very preterm infant; neonatal intensive care.

Introduction

Hospital care has consolidated rapidly into health systems in the United States.¹ In 2018, two-thirds of acute care hospitals and over 80% of hospital beds were in health systems.² The effects of consolidation on treatment patterns and access to high-quality care at the population level are understudied, due largely to a lack of population-level data about patients that can be linked to information on health systems. The limited information to date, based largely on adults, demonstrates price increases associated with consolidation but only marginal improvements in quality of care.^{2,3}

Of particular concern is how the care of vulnerable populations that need specialized hospital care may be affected by consolidation. Among pediatric patients, infants born very preterm are among the most vulnerable. Infants born with very low birth weights (VLBW) (<3.3 pounds [<1500 g] at birth) account for over half of infant deaths in the United States each year.⁴ These infants are at high risk for morbidities such as blindness and neurodevelopmental impairment, which may have lifelong consequences.⁵ They are also disproportionately Black. Black infants are 50% more likely to be born preterm and twice as likely to be born very preterm compared with White infants.⁶

The pediatric health care delivery system for infants is unique in several respects. The birth hospitalization includes 2 patients, the mother and the infant. Regionalization goals for infants born preterm require that infants receive care at

neonatal intensive care units (NICUs) with the capacity to treat them. However, not all infants are born in a hospital with the needed NICU care and some who are born in a hospital with a NICU may require a transfer to another NICU for more specialized care. As a result, there are high rates of patient transfers in this patient population. The consolidation of the health care delivery system into health systems has the potential to alter treatment patterns for these infants, particularly if system membership is a factor considered in patient transfers between hospitals.

The care of these infants is important from a policy perspective as hospitalized newborn infants account for 20.6% of hospitalizations and 9.7% of aggregate hospital costs each year in Medicaid.⁷ Medicaid is a primary payer for the care of infants, funding over 40% of all births.⁸ With average lengths of stay of 72 days for very preterm and VLBW infants,⁹ NICU stays are among the most expensive hospitalizations. Despite large amounts of federal funding for the care of these infants, access to high-quality NICU care in health systems is not known.

In this study, we use unique national patient-level data from the Vermont Oxford Network (VON) to study treatment patterns for very preterm infants. The VON is a voluntary collaborative network of NICUs dedicated to improving the quality, safety, and value of patient care for newborn infants and their families.^{10,11} The VON database contains abstracted medical record information for over 90% of VLBW infants admitted to a NICU in the United States each year. Linked to

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information on health systems that are horizontally integrated, this provides the first information available on how care is provided for these vulnerable infants in health systems.

Data and methods

Patient-level data were derived from the VON database for VLBW infants born in 2020. Overall, 38 685 very preterm infants (401–1500 g or 22–29 weeks' gestational age at birth) received care in 763 hospitals in the VON database. Very preterm infants are included if they are admitted to a VON member hospital within 28 days of birth. Infants are tracked from the birth hospitalization through any subsequent hospital transfers until death or discharge home. Infants who died in the delivery room were excluded. Overall, 1931 hospitals provided care to these infants at some point during their birth and initial hospitalization (see [Appendix S1](#)). Race is coded in the VON database based on maternal race as non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic other. The latter group includes Asian, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, and other. The data are for infants born in 2020, during the COVID-19 pandemic. Study results may differ somewhat in later years.

Horizontally integrated systems were defined as multi-hospital systems with 2 or more hospitals (derived from the 2020 American Hospital Association [AHA] Annual Survey of Hospitals). The study does not include information on vertical integration with physician groups. There are many physician arrangements in neonatology, including working for private physician groups that contract with hospitals. The affiliation of neonatologists is not possible to determine given existing data.

Hospital characteristics and the geographic location of systems were derived from the AHA data. System ownership was assigned based on the majority of hospital beds in the system into 3 mutually exclusive groups—public, not-for-profit, and for-profit—consistent with Beaulieu et al.² Among systems in this study, 28% have hospitals with multiple ownership types. Federal hospitals were excluded. Children's hospital status was classified into 4 types reflecting the degree of pediatric specialization.¹² Tier A hospitals served primarily children. Tier B did not primarily serve children but had a NICU, pediatric emergency department (ED), and pediatric intensive care unit (PICU). Tier C hospitals had limited pediatric services (a NICU or pediatric ED or PICU or general medical/surgical pediatric beds). Tier D hospitals were subdivided into hospitals with and without a NICU. Tier D hospitals had no pediatric services. To assess the NICU capacity of the delivery hospital, hospitals with either no NICU (in the AHA data) or a NICU with restrictions on the amount of time mechanical ventilation can be provided are classified as not having the needed NICU capacity to care for an infant born very preterm.

Teaching status was defined by membership in the Council of Teaching Hospitals. Safety-net status was defined based on the Centers for Medicare and Medicaid Services Healthcare Cost Report Information System (CMS HCRIS) data as a hospital in the upper quartile of the distribution of uncompensated and unreimbursed care as a share of total operating expenses. Sensitivity analyses included measures for the top quartile of the Medicaid share of inpatient days and the top quartile of the disproportionate share percentage (DSH).

Descriptive statistics were generated for the percentage of very preterm infants treated by health systems and for system characteristics.

Table 1. Birth and NICU care in horizontally integrated systems for very preterm infants.

	Percentage of very preterm infants (n = 38 685)
Infants receiving care in a horizontally integrated system	86.0
Born in a system hospital	83.8
Born outside of a system and transferred in	2.2
Among infants born in a system hospital	
Stay in system for entire stay	85.0
Transferred out of system at some point in initial hospitalization	15.0
Among infants transferred out of system, transfer to a tier A or B children's hospital	73.8

Abbreviation: NICU, neonatal intensive care unit.

Results

The consolidation of the health care system is highly evident in the care of these vulnerable infants. Most very preterm infants in 2020 were born in horizontally integrated systems (84%) and received NICU care in these systems (86%) ([Table 1](#)). Infants born in multi-hospital systems tended to receive all their care in the system (85%). Transfers out of the system were largely limited to receiving care at a level A or B children's hospital (74% of such transfers). These children's hospitals are the most highly specialized, either serving primarily children or having multiple pediatric intensive care units: NICU, pediatric ED, and PICU. Thus, health systems play an important role in the care of these infants, as most infants are both born in a system and receive all of their care in the system. Access to appropriate NICU care at birth may be problematic for some infants, however. Overall, 9% of very preterm infants were born in a hospital that either did not have a NICU or had a NICU that could not provide a high-enough level of care. Among these infants, 81% were born in a system hospital. However, infants who were not transferred to a NICU, including those who died at the delivery hospital, are not included.

While preterm infants are disproportionately Black, the fraction of infants receiving care in a system was similar for most population groups (non-Hispanic Black, non-Hispanic White, and other non-Hispanic infants; 86–87%) and slightly lower for Hispanic infants (82%). Black infants were more likely, however, to receive care in public systems (13%) compared with either non-Hispanic White infants or Hispanic infants (9%) or other non-Hispanic infants (7%).

In 2020, 316 horizontally integrated systems provided care for very preterm infants at some point in their initial hospitalization. Transfer rates were high in this patient population, with 21% of infants transferred at some point in their stay and 6% transferred between systems. Thus, more than 1 hospital or system can care for an infant ([Table 2](#)).

Approximately half of the care for very preterm infants was provided in large systems that have more than 10 hospitals ([Table 2](#)). A small fraction, 6%, were very large systems with 30 or more hospitals that provided care for 24% of infants. Systems with 11–30 hospitals accounted for 16% of systems and provided care for 22% of infants. However, half of the systems that provided care to very preterm infants were much smaller, with 4 or fewer hospitals. These smaller systems also cared for 22% of infants.

Table 2. Characteristics of horizontally integrated systems that treat very preterm infants.

	Percentage of horizontally integrated systems (n = 316)	Percentage of very preterm infants (n = 38 685)
System size		
2 hospitals	20.3	6.2
3–4 hospitals	28.5	16.0
5–10 hospitals	29.7	22.0
11–30 hospitals	15.8	22.2
>30 hospitals	5.7	24.2
Geographic location of hospitals in systems		
System has hospitals in multiple states	29.7	43.7
System has hospitals in multiple census regions	12.0	25.9
System ownership		
For-profit	6.3	11.9
Not-for-profit	81.3	67.6
Public	12.3	8.8
Highest tier children’s hospital in the system		
Tier A: restricted to children	5.7	11.5
Tier B: NICU, PICU, and pediatric ED	33.2	52.0
Tier C: limited children’s services		
Tier C with NICU	35.8	21.0
Tier C without NICU	13.3	1.8
No children’s services or missing data on children’s services	12.0	4.0
System has a safety-net hospital		
Uncompensated care definition	57.0	62.5
DSH definition	55.4	65.5
Medicaid days definition	49.7	57.9
System has a teaching hospital	41.8	62.0

Abbreviations: DSH, disproportionate share percentage; ED, emergency department; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.

Fourteen percent of very preterm infants are not treated in a horizontally integrated system and 6% of infants are treated in more than 1 system.

The care of very preterm infants was concentrated in systems with hospitals in more than 1 state. These multi-state systems provided care for almost half of infants. One-quarter of infants received care in systems that spanned more than 1 census region. Three in 10 systems that provided care for very preterm infants had hospitals in more than 1 state and 1 in 10 had hospitals in more than 1 census region. Most health care systems were not-for-profit (81%); they cared for more than two-thirds of infants (68%). Public systems accounted for a small fraction (12%) of systems and a correspondingly small number of infants (9%). Public systems included county or municipal hospitals and state university systems. For-profit systems accounted for a small fraction of systems, 6%, and only cared for 12% of infants.

Few systems, 6%, had a hospital that restricted admissions only to children (a tier A children’s hospital) and these systems cared for only a small fraction (12%) of very preterm infants. Most very preterm infants, 52%, received care in systems with at least 1 level B children’s hospital, which has intensive and emergency care for children. These systems accounted for

approximately 33% of the health care systems. Another 36% of systems had a tier C hospital with limited pediatric services as the highest level of pediatric care, including a NICU. They cared for 21% of infants. A small fraction of systems, 13%, were in tier C and had no NICU, providing care to 2% of infants. Overall, 4% of infants received care in a system with no pediatric specialty care or where data on pediatric services were missing from the AHA dataset.

More than half of systems providing care to very preterm infants had a safety-net hospital based on being in the upper quartile of uncompensated and unreimbursed care. Most infants (63%) received care in a system with at least 1 safety-net hospital. Sensitivity analyses to alternate definitions of safety net confirmed this finding (50% of systems and 58% of infants based on the Medicaid inpatient share and 55% of systems and 66% of infants based on DSH percentage). Among the systems, 42% had at least 1 teaching hospital and 62% of very preterm infants received care in a system that had a teaching hospital.

Discussion

Very preterm infants are among the most vulnerable pediatric patient populations, accounting for most of the infant mortality in the United States each year, and are at high risk of morbidities, which can have lifetime consequences. As the US health care system has consolidated into horizontally integrated health systems, there is very little information available on treatment patterns for pediatric patients, and for vulnerable infants in particular. The perinatal delivery system is unique in having 2 patients, mother and infant, and in the expectation of care for very preterm infants to be provided at appropriate levels of NICU care. The care received immediately after birth in a NICU is essential to achieving the best possible outcome for the infant. This study is the first to provide information on how care for very preterm infants is provided by health systems using population-based data.

The study demonstrates the central role that health systems play in the care of very preterm infants. Most very preterm infants were born in a horizontally integrated, multi-hospital system (84%), and they tended to remain in the system for their entire hospitalization (85%). Transfers out when they occurred tended to be for specialized pediatric care at a high-tier children’s hospital. The implications for quality and cost of care are unknown. For instance, was a hospital of equal or higher quality bypassed so an infant could remain in the same system? Patient-centered care requires the needs of families to be taken into consideration and the potential for increased travel times exists, with substantial implications for families as the average length of NICU stay for these infants is over 2 months.

Understanding how systems provide care for these infants and the extent to which quality may vary within and across systems will be important to determine, particularly for minoritized infants as more than half of preterm infants are Black. While rates of care received at a multi-hospital system do not vary widely by race, Black very preterm infants were found to be more likely to be cared for in public systems. The distribution of care across hospitals within systems should be determined in order to address issues of equity. Over half of systems and 60% of very preterm infants received care in a system with at least 1 safety-net hospital.

One potential advantage of health systems is the ability to address population health, particularly those that are also

vertically integrated, where physician groups are integrated with hospitals. It is currently not possible to measure vertical integration for neonatology as many neonatologists work for private physician groups. However, if pediatric practices are integrated with hospitals for care after the child is discharged home, the potential exists to “follow through” with needed care. Since the majority of infants receive their care in the same system, they are more likely to be able to provide the needed follow-up care. VON research has demonstrated the potential for this type of care to address health disparities for preterm infants.¹³ Multi-hospital systems also have the potential to engage in quality-improvement (QI) efforts at the system level, which not only improves patient outcomes but also reduces the costs of NICU care. In a QI initiative in the NICU each dollar invested in a QI initiative was associated with a 9-dollar reduction in patient care costs in the year following the intervention.^{14,15}

Determining the variation in outcomes across systems and system types will be needed to fully characterize the functioning of the perinatal health care delivery system in the presence of widespread consolidation. The study demonstrates substantial variations in the types of systems that provide care to these infants with unknown consequences for patient outcomes or costs of care. Half of the infants were cared for in large systems that have more than 10 hospitals. These systems are disproportionately multi-state systems, and they often cross census regions. A very large fraction of vulnerable infants were treated in cross-market systems, which have become increasingly prevalent.¹⁶ These systems have increasing market power, particularly in negotiations with private insurers.¹⁷ Newborn hospitalizations are the second most expensive type of hospitalization for private payers.⁷ Cross-market hospital mergers have been shown to increase prices,¹⁸ but the effect on patient quality of care and equity is unknown. Since Medicaid is a state-specific program, multi-state systems may also face restrictions in their ability to transfer Medicaid patients across state lines.

Conclusion

As hospital care has evolved from provision by individual hospitals to health systems, it will be essential to understand the implications of these consolidations on patient care, particularly for vulnerable populations. Future studies will be needed to determine the relationship of health system characteristics with patient outcomes and cost of care for infants born very preterm and the implications for health equity.

Supplementary material

Supplementary material is available at *Health Affairs Scholar* online.

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Conflicts of interest

Please see ICMJE form(s) for author conflicts of interest. These have been provided as [supplementary materials](#).

Notes

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