

Healthcare Utilization Among Infants Discharged From the Neonatal Intensive Care Unit: A Descriptive Cost Analysis

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ABSTRACT: The cost of readmissions of neonatal intensive care unit (NICU) graduates within 6 months and a year of their life is well-studied. However, the cost of readmissions within 90 days of NICU discharge is unknown. This study's objective was to estimate the overall and mean cost of healthcare use for unplanned hospital visits of NICU graduates within 90 days of discharge. A retrospective review of all infants discharged between 1/1/2017 and 03/31/2017 from a large hospital system NICUs was conducted. All unplanned hospital visits (readmissions or stand-alone emergency department (ED) visits) occurring within 90 days post NICU discharge were included. The total and mean cost of unplanned hospital visits were computed and adjusted to 2021 US dollars. The total cost was estimated to be \$785,804 with a mean of \$1,898 per patient. Hospital readmissions accounted for 98% (\$768,718) of the total costs and ED visits for 2% (\$17,086). The mean cost per readmission and stand-alone ED visit were \$25,624 and \$475 respectively. The highest mean total cost of unplanned hospital readmission was noted in extremely low birth weight infants (\$25,295). Interventions targeted to reduce hospital readmissions after NICU discharge have the potential to significantly reduce healthcare costs for this patient population.

KEYWORDS: Neonatal Intensive Care Unit, healthcare utilization, cost analysis, readmission

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Introduction

With the development of new technology and advances in neonatal care, the neonatal mortality rate has decreased more than 4-fold since the first neonatal intensive care unit (NICU) opened in 1960.^{1–3} There are an estimated 4 million live births in the United States (US) each year³ and the admission rates have increased for all birthweight categories, with 8% of births resulting in a NICU admission.^{3,4} Infants discharged from the NICU are often deemed “high-risk,” having a wide range of characteristics, including prematurity, special care needs, dependence on technology, significant family and social risks, and those at increased risk for early death.^{5,6} These infants are at higher risk for acute and chronic health problems, and rehospitalization after discharge, with 15%–37% requiring readmission within 1 year.^{4,7–10}

NICU graduates experience frequent hospital readmissions and these readmissions are 3 to 4-fold higher in preterm infants compared to term infants.¹¹ These readmissions pose a significant financial burden on the healthcare system, with an estimated cost of \$41 million annually in the state of California.¹⁰ In Texas, the mean cost of NICU admission of preterm Very Low Birth Weight (VLBW) and Low Birth Weight (LBW) infants were \$133,728 and \$36,182, respectively.¹² In 2014, the estimated cost of NICU admissions in Texas was \$916 million.¹²

In the overall scheme of the US healthcare system, NICU costs are quite minimal. The total economic cost of preterm birth in the US has been estimated to be \$26 billion, which is between 1% and 2% of the total healthcare spending.¹³ However, \$26 billion is still a substantial amount and can be reduced. Studies have shown that supporting families beyond NICU and the use of the Transition to a Home program after NICU discharge can help reduce healthcare utilization and decrease Medicaid expenditures.^{14,15} In efforts to decrease healthcare expenditure, current costs must be measured. Thus, this study was undertaken with an objective to estimate the overall and mean cost of healthcare use for unplanned hospital visits of NICU graduates within 90 days of discharge.

Methods

Study design and population

A retrospective review was conducted of all infants discharged from a large hospital system NICU between January 01, 2017 and March 31, 2017. This hospital system has NICUs at 8 community hospitals and 1 tertiary academic children's hospital located across the Greater Houston area. All 9 locations provide levels of neonatal care with 2 Level II NICUs, 6 Level III NICUs, and 1 Level IV NICU. Children's Memorial Hermann Hospital (CMHH) is our 118-bed level IV NICU



that provides the highest level of care for premature and critically ill newborn babies. At the time of the study, each NICU had its own unique processes for infant and parental preparation for discharge and post-discharge follow up. For our most complex infants who live within an hour of CMHH, follow-up care is offered through a specialized, multidisciplinary infant or pediatric clinic previously described by Mosquera et al.²⁰ This study was approved by the University of Texas Health Science Center at Houston institutional review board (HSC-MS-17-0564).

From review of the institutional electronic medical record (EMR) data, we identified the subset of infants who had any unplanned hospital visit (readmissions and emergency department (ED) visits) in any of the 9 hospitals within 90 days of NICU discharge. Patients with NICU stay less than 3 days or deceased prior to discharge were excluded as these patients have a different risk profile than those who have longer NICU stay.

Inpatient and outpatient medical records for each patient were reviewed. Demographic information abstracted from the EMR included sex, race, ethnicity, insurance type, and primary language of the parent or guardian. Clinical information was reviewed for birthweight, gestational age, and surgical procedures prior to NICU discharge. All data were abstracted directly into our institution's REDCap database, which is a secure, HIPAA-compliant web-based platform used to build and manage research data.

Hospital costs for the unplanned visits were assessed from the health system perspective. Only stand-alone visits to the ED were counted as ED visit as the costs of ED visits that result in an inpatient admission are lumped together with the hospitalization costs. For each stand-alone ED visit and readmission at any of the 8 community hospitals or the children's hospital occurring within 90 days of NICU discharge, the total hospital-specific costs were obtained from the institutional cost-accounting system. All costs were inflated to 2021 US dollars based on the medical component of the consumer price index.¹⁶ Moreover, descriptive statistics were utilized to characterize the study population. Continuous data for costs were expressed as mean with 95% confidence interval (CI).

Results

Of the 414 infants discharged from the NICU during the study period, 65 patients (16%) had an unplanned hospital visit within 90 days of discharge. Thirty-five patients had a stand-alone ED, 29 were readmitted to the hospital, and 1 patient experienced both an ED visit and hospital readmission. Among those with stand-alone ED visit, majority of them had respiratory distress (33%) and vomiting (29%) and those with hospital admissions, 21% had vomiting and diarrhea and ventriculoperitoneal shunt malfunction (11%). The majority of the patients with an unplanned visit were male (62%) and Medicaid insured (71%). Sixty percent were of low birthweight (<2500 g), 68% were preterm, and 92% required surgery prior to NICU discharge (Table 1).

Table 1. Characteristics of the study population.

CHARACTERISTIC	N=65
Sex—male	62%
Race	
Black	29%
White	26%
Asian	6%
Other	39%
Ethnicity	
Non-Hispanic	57%
Hispanic	42%
Unknown	1%
Primary language	
English	88%
Spanish	11%
Arabic	1%
Birthweight	
Normal birth weight	40%
LBW	21%
VLBW	17%
ELBW	22%
Gestational age	
Term	32%
Near term	25%
Very premature	21%
Extremely premature	22%
Insurance	
Medicaid/Public	71%
Managed/Private	23%
Self-pay	1%
Other	5%
Surgery Required prior to NICU discharge	92%

Abbreviations: ELBW, extremely low birth weight; LBW, low birth weight, VLBW, very low birth weight.

The total costs for the 65 infants with unplanned hospital visits were estimated to be \$785 804 with a mean of \$1898 per patient. Hospital readmissions accounted for 98% (\$768 718) of the total costs and ED visits for 2% (\$17 086). The mean cost per readmission and ED visit was \$25 624 (95% CI \$4390-\$46 858) and \$475 (95% CI \$233-\$716) respectively (Table 2).

Table 2. Total estimated and mean cost of hospital readmission and ED visits.

	ESTIMATED COST (%)	MEAN (95% CI)
Total	\$785 804	\$12 089 (\$2099-\$22 079)
Hospital readmissions	\$768 718 (98%)	\$25 624 (\$4390-\$46 858)
ED visits	\$17 086 (2%)	\$475 (\$233-\$716)

Abbreviation: CI, confidence interval; ED, Emergency Department.

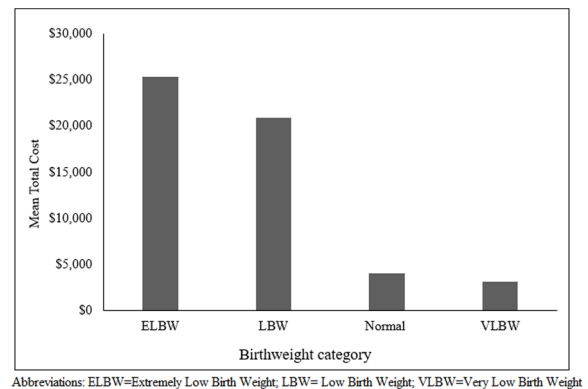
In comparison of the mean total cost of unplanned hospital visits by birth weight category, we found that extremely low birth weight (ELBW) infants had the highest mean total cost of \$25 295 followed by low birth weight (LBW) infants at \$20 879 (Figure 1). Surprisingly, we found that normal birth weight infants had the higher mean total cost (\$4012) than very low birth weight (VLBW) infants (\$3187) (Figure 1).

Discussion

Within a 3-month period, unplanned hospital visits of recent NICU graduates in a single hospital system cost our healthcare system nearly \$1 million. Although this only reflects costs over a 3-month period, it encompasses patients discharged from a total of 9 neonatal facilities within a single hospital system in metropolitan area. If estimated over a year, these costs could potentially average over \$3 million per year. In addition, these costs are likely underestimated since they do not consider potential unplanned hospital visits occurring outside of our hospital system for which data was not available. About half of the infants who had an unplanned hospital visit were readmitted, accounting for 98% of the total costs. Almost all these patients had required surgical intervention at their initial NICU stay. Most patients who had an unplanned hospital visit were Medicaid insured. This poses not only a financial burden on caregivers of these infants, but also on the healthcare system.

Preterm and LBW infants are more likely to be rehospitalized and consume more healthcare services.¹⁷ Various studies have described readmission rates of preterm and LBW, NICU graduates. In our study, 16% of the NICU patients had an unplanned hospital visit and 7% required readmission within 90 days. Readmission rates for all NICU graduates in the Medicaid database at 1 year have been estimated at 37%.⁴ Our 3-month estimate is significantly higher than a fourth of Kou et al's 1-year estimate. While their data is not broken down temporally, the immediate discharge period may pose higher risk for readmission. Ray et al reported a 12% rate of readmission at 90 days for premature infants discharged from the NICU, which is comparable to the rate in our study.¹⁸ Other studies have examined readmissions in slightly different contexts, typically focusing on only premature or LBW infants in a time frame of 9 months to a year. These estimates vary widely, between 15% and 50%.^{10,19-21} Further study on new methods of care post-NICU discharge is necessary to determine whether these unplanned hospital visits can be avoided.

Hospital visits carry a significant cost burden. Overall, the hospital cost for NICU admission and care for premature



Abbreviations: ELBW=Extremely Low Birth Weight; LBW= Low Birth Weight; VLBW=Very Low Birth Weight

Figure 1. Mean total cost by birthweight category.

infants is estimated at between \$5 and 10 billion yearly for the US.^{21,22} Many studies have attempted to estimate the cost burden of premature and low birth weight babies, often demonstrating that increased gestational age and birth weight correlates with lower cost of primary admission.^{17,21-23} These studies have also examined long-term cost of preterm and low birth weight babies, showing that economic burden goes far beyond in-hospital cost, extending to increased consumption of hospital and community health services as well as special education resources and limitations on the mother's ability to work. The studies focus on prenatal interventions to decrease cost.

Few studies have examined specifically cost after initial hospital discharge. Underwood et al found the average readmission cost within 1 year for preterm infants to be \$8468, resulting in an overall cost of \$41 million to the state of California.¹⁰ Kuo et al demonstrated that the majority of spending post NICU discharge occurs within the first year of life.⁴ Like Kuo et al our study found the majority of spending associated with inpatient hospital care.⁴ In fact, Kuo et al's estimates of hospitalization and ED spending are \$28 134.⁴ Our estimates of hospitalization and ED spending within the first 90 days are approximately \$26 099 per infant discharge from the NICU. This similar figure may demonstrate that not only does the bulk of spending post NICU discharge occur within the first year of life, but that a large majority of first year spending may occur within the first 90 days.

Studies have shown that there is an inverse relationship between birthweight and hospital costs.^{22,24,25} In our study, we observed that ELBW and LBW infants had a higher mean cost, which is congruent to those reported by Beam et al They found that an average spending of \$114 437 was linked to LBW infants and an average spending of \$537 624 was linked

to ELBW infants.²⁶ Our estimates are lower than those reported by Beam et al as we estimated our spending within the first 90 days post discharge from NICU while they estimated over 6 months period.

Infants are discharged from the NICU when they receive adequate calories when fed by mouth, are gaining weight and are able to breathe on their own. However, sometimes infants are discharged from NICU with supplemental oxygen therapy depending upon their complex medical conditions and needs. As parents move from the hospital environment to the home, where they assume all of the caregiving responsibilities, the time immediately following hospital discharge, a period of transition from hospital to home, is crucial for parents.²⁷ Studies have shown that parents of preterm experience difficulty in transitioning from the NICU to home and need support beyond the NICU.^{14,28} Additionally, studies have looked at implementing programs in order to decrease healthcare utilization including healthcare costs in both high-risk infants and children. Mosquera et al conducted a randomized trial, implementing an enhanced medical home for high-risk children and significantly decreasing serious illnesses, ED visits, and hospitalizations in the intervention group.²⁹ The intervention also reduced costs to the Texas Medicaid program by \$6243 per child-year.²⁹ Liu et al evaluated the effects of a transition to home intervention on total Medicaid spending, ED visits, and unplanned readmissions for preterm infants and high-risk full-term infants.¹⁵ Similarly, the intervention group had lower total Medicaid spending, saving \$4951 per infant per quarter, as well as fewer ED visits and readmissions than the historical comparison group.¹⁵ With the high cost burden in our cohort within 90 days of NICU discharge, a transition to home program may lead to cost reduction and improved quality of care.

This study has limitations. The costs outside our healthcare system were not obtained. As such, this study may have potentially underestimated the costs of unplanned hospital visits. Since this cost analysis was done from a healthcare system perspective, it did not consider additional costs that greatly add to the burden of the caregivers and their community such as home nurse services, outpatient treatment, transportation, food, accommodation, time loss from work for caregivers, informal caregiving, and others. Furthermore, this study does not capture outcomes of these infants and cannot describe a relationship between spending and patient outcomes.

Conclusion

This study describes the cost burden of unplanned emergency visits and readmissions within a large hospital system in a highly populated metropolitan city. Unlike large database studies, these cost estimates may be more generalizable to health care systems in other cities looking to understand the impact of these unplanned hospital visits immediately post NICU discharge.

Author Contributions

NBH was responsible for data analysis, interpretation of the results, drafting, editing, and revision of the manuscript. EG, AB, MBK, and MTA were responsible for the study conception and design. AB was responsible for data acquisition. EBCA was responsible for the data analysis and interpretation of the results. All authors were responsible for critical manuscript revisions and gave their final approval for publication.

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