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The Cost of Morbidities in Very Low Birth Weight Infants

Tricia J. Johnson, PhD^{1,2}, Aloka L. Patel, MD^{2,3}, Briana Jegier, PhD, CLC^{1,2}, Janet L. Engstrom, PhD, RN, CNM, WHNP-BC^{2,4}, and Paula Meier, PhD, RN, FAAN^{2,3}

¹Department of Health Systems Management, Rush University

²Department of Women, Children and Family Nursing, Rush University

³Department of Pediatrics, Rush University

⁴Frontier Nursing University

Abstract

Objective—The objective of this study was to determine the association between direct costs for the initial neonatal intensive care unit (NICU) hospitalization and four potentially preventable morbidities in a retrospective cohort of very low birth weight infants (VLBW; <1500g birth weight).

Methods—The sample included 425 VLBW infants born alive between July 2005 and June 2009 at Rush University Medical Center. Morbidities included brain injury, necrotizing enterocolitis, bronchopulmonary dysplasia, and late onset sepsis. Clinical and economic data were retrieved from the institution's system-wide data warehouse and cost accounting system. A general linear regression model was fit to determine incremental direct costs associated with each morbidity.

Results—After controlling for birth weight, gestational age, and socio-demographic characteristics, the presence of brain injury was associated with a \$12,048 ($p=0.005$) increase in direct costs; necrotizing enterocolitis with a \$15,440 ($p=0.005$) increase; bronchopulmonary dysplasia with a \$31,565 ($p<0.001$) increase; and late onset sepsis with a \$10,055 ($p<0.001$) increase in direct costs. The absolute number of morbidities was also associated with significantly higher costs.

Conclusions—This study provides the first collective estimates of the direct costs during the NICU hospitalization for these four morbidities in VLBW infants. The incremental costs associated with these morbidities were high, and these data can inform future studies evaluating interventions to prevent or reduce these costly morbidities.

Corresponding Author: Tricia J. Johnson, Ph.D., Associate Professor, Department of Health Systems Management, Rush University, 1700 West Van Buren Street, TOB Suite 126B, Chicago, Illinois 60661 USA; tricia_j_johnson@rush.edu; tel: 312.942.7107; fax: 312.942.4957.

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CONTRIBUTOR'S STATEMENT PAGE

Substantive intellectual contributions have been made by each of the authors, including:

Conception and design – Meier, Engstrom, Johnson, Jegier

Acquisition of data – Johnson, Jegier, Patel

Analysis and interpretation of data – Johnson, Patel, Meier, Engstrom, Jegier

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Keywords

Very low birth weight infants; NICU hospitalization; direct costs; payments; charges; brain injury; necrotizing enterocolitis; chronic lung disease; bronchopulmonary dysplasia; late onset sepsis

INTRODUCTION

Very low birth weight (VLBW; <1500g birth weight) infants represent only 1.5% of all live births in the United States(1), but the cost of neonatal intensive care unit (NICU) hospitalizations for this group ranks them among the most expensive of all patients. These costs represent \$13.4 billion annually and account for 30% of newborn health care costs in the United States (costs have been converted to 2009 dollars using the 2009 Consumer Price Index (CPI) throughout this article).(2–4) The average NICU hospitalization for VLBW infants is 57.5 days.(2) NICU hospitalization costs are higher for surviving infants since most non-surviving VLBW infants die during the first two weeks of life,(5–7) and both the length of stay (LOS) and costs vary inversely with birth weight (BW) and gestational age (GA) for infants who survive the NICU hospitalization.

These BW and maturity-related health care costs are further increased by the fact that surviving VLBW infants are susceptible to a number of costly and potentially preventable morbidities that often require additional treatments such as ventilation and surgery.(8–10) These morbidities not only increase NICU hospitalization costs, but also increase the risk of long-term chronic illness, rehospitalization, and developmental delay in this population.(11–14) Thus, these morbidities have lifelong economic consequences for society at large.(15–20) Few studies have examined how these morbidity-related costs impact total costs borne by the hospital. Additionally, the existing studies are limited in the economic analyses that were performed, because they reported either charges or adjusted charges using a ratio of cost-to-charges instead of reporting actual costs borne by the hospitals.(2, 9, 10, 18, 19, 21–24)

Thus, the purpose of this study was to use micro-level cost data to more precisely determine the direct costs associated with the morbidities of brain injury, defined as intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL) and acquired hydrocephalus(11); necrotizing enterocolitis (NEC); bronchopulmonary dysplasia (BPD); and late onset sepsis in surviving VLBW infants. By quantifying the direct costs, the potential cost savings of therapies targeted towards prevention of these morbidities can be evaluated.

METHODS

Sample

This retrospective study included all VLBW infants discharged alive between July 1, 2005 and June 30, 2009 from Rush University Medical Center (RUMC) with a principal or secondary *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9) diagnosis code of 765.01 – 765.05 (extreme immaturity, <1500g) or 765.11 – 765.15 (other premature infants, <1500g). We excluded infants who died during the initial NICU hospital stay, since most non-surviving VLBW infants die during the first two weeks of life, before the diagnosis of some of the morbidities we evaluated.(5–7) We also excluded infants born at or transferred to another hospital, because of incomplete cost data. In addition, infants with missing race/ethnicity or diagnosis code for GA were excluded. This study was approved by the Rush University Institutional Review Board.

Data Sources

Clinical and economic data were retrieved from RUMC's system-wide data warehouse and cost accounting system. The institution's data warehouse consists of detailed patient-level billing data, ICD-9 diagnosis codes, and clinical data extracted from the electronic medical record and associated data systems. The institution's cost accounting system reports the direct cost for each chargeable item (e.g., room and board, personnel excluding physicians, drugs, medical and non-medical supplies, equipment) used during the infant's hospital stay. The system also reports payments for the infant's hospital stay. A co-existing research database of these same surviving VLBW infants was used to determine the stage and treatment method of NEC.

Neonatal Morbidities

Neonatal morbidities were identified using principal and secondary ICD-9 diagnosis codes which were documented by the attending neonatologist. Morbidities included: brain injury (IVH (772.11–772.14), PVL (779.7) and acquired hydrocephalus (331.4))(11); NEC stages 2 and 3 (777.5, 777.52 and 777.53)(25); BPD (770.7); and late onset sepsis, which included culture-positive and culture-negative cases (771.81).

NEC was diagnosed when an infant demonstrated both clinical (abdominal distension, feeding intolerance, bloody stool, abdominal tenderness, or bilious residuals) and radiologic (pneumatosis intestinalis or portal venous gas or pneumoperitoneum) features of NEC. Each case was reviewed and confirmed by one of the investigators (ALP), including cases with a non-specific NEC diagnosis code. Cases of spontaneous intestinal perforation were not included in the NEC cases. The primary analysis included medically and surgically managed NEC combined together, but these were examined separately in a secondary analysis, since surgically managed NEC cases represent infants with more severe NEC.(12)

BPD was coded by the attending neonatologist once the infant reached the minimum criteria for mild BPD (treated with supplemental oxygen for 28 days but not on oxygen at 36 weeks postmenstrual age (PMA)) by the NICHD definition.(26) Thus the infants categorized as having BPD had one of the following: mild, moderate (need for <30% oxygen at 36 weeks PMA) or severe BPD (need for ≥30% oxygen or positive pressure at 36 weeks PMA).(26) Further clinical data to subdivide them into severity groups were not available for this study. Late onset sepsis was diagnosed when an infant greater than 72 hours of age presented with clinical signs and symptoms (apnea and bradycardia, increased respiratory distress, hypothermia, lethargy, pallor, feeding intolerance or hemodynamic instability) and laboratory tests (leukocytosis with elevated immature cells, leukopenia, neutropenia, thrombocytopenia, or elevated C reactive protein) consistent with sepsis and received antibiotic treatment for a minimum of 5 days. Infants with negative blood cultures were diagnosed with culture-negative sepsis if no other cause was confirmed (e.g., confirmed case of NEC would not be diagnosed with sepsis with negative cultures). Further clinical data to subdivide them into culture-positive and culture-negative groups were not available for this study. A dichotomous variable was created to indicate the presence or absence of each morbidity. In addition, a variable indicating the total number of unique morbidities (range: 0 – 4) was created.

Birth Weight, Gestational Age, and Socio-Demographic Characteristics

BW was classified as <750g (ICD-9 diagnosis codes 764.x1, 764.x2, 765.x1, 765.x2), 750 – 999g (764.x3 and 765.x3), 1000 – 1249g (764.x4 and 765.x4) and 1250 – 1499g (764.x5 and 765.x5). GA was classified into four categories: less than 25 weeks (765.21 – 765.22), 25–26 weeks (765.23), 27–28 weeks (765.24), and 29 to 36 weeks (765.25 – 765.28). The socio-demographic characteristics included infant gender, race/ethnicity (Non-Hispanic

Caucasian, African American/Black, Hispanic Caucasian or other), primary payer source (Medicaid or commercial payer), and total hospital LOS.

Direct Costs

Hospital direct costs were a sum of the actual direct costs for each chargeable item (e.g., electrolyte panel, room charges) incurred during the infant's hospital stay. Since physician fees were billed separately by the medical group rather than the hospital, physician fees were excluded from hospital costs. Other ancillary staff costs, such as respiratory therapy, nursing, physical therapy and occupational therapy, were billed directly by the hospital and were included in the costs.

Hospital direct costs were adjusted to year 2009 dollars using the Bureau of Labor Statistics CPI for urban consumers and all items.(4) Because costs are higher in the Chicago metropolitan area, we deflated costs to reflect national average costs using the Centers for Medicare and Medicaid Services occupational mix adjusted wage index for 2012.

Statistical Methods and Analysis

Frequencies and descriptive statistics were used to describe the sample. A generalized linear regression model was constructed to model the impact of the four morbidities on costs, controlling for BW, GA, and infant socio-demographic characteristics (gender, race/ethnicity and primary payer). The regression model was fit with a log link function and gamma distribution. A modified Park test was used to select the appropriate distribution for the mean-variance relationship in each model.(27) The marginal economic effect for each morbidity was computed for the mean predicted direct cost from the model. Marginal effects were then computed for infants with BW <750g, 750–999g, 1000–1249g and 1250–1499g separately using the modal characteristics (Medicaid, male, African American race/ethnicity, and <25 weeks GA for BW <750g, 25–26 weeks GA for BW 750–999g, 27–28 weeks GA for BW 1000–1249g and 29–36 weeks GA for BW 1250–1499g).(28) A critical value of .05 was used for all tests of statistical significance. Analyses were conducted using SAS for Windows version 9.2 (SAS Institute, Cary, NC).

RESULTS

Of the 587 VLBW infants born at the study site, 475 (81%) were born alive and 467 (98%) survived to discharge. Of the infants who were discharged alive, 27 (6%) had missing race/ethnicity, and 15 (3%) had missing gestational age. The study sample reported here included 425 VLBW infants who had complete data available. Males comprised 51% of the sample. The racial/ethnic distribution was African Americans 43%, Hispanics 32%, and Non-Hispanic Caucasians 16%. Table 1 reports the socio-demographic characteristics, number of morbidities and economic outcomes for the sample.

Table 2 presents the frequency of the four morbidities examined in this study, and compares LOS and the number of additional morbidities for infants with (present) and without (absent) each of these four morbidities. The presence of each morbidity was associated with a longer LOS and a greater number of additional morbidities. Table 2 also reports the mean direct costs by presence or absence of each morbidity. Costs were significantly greater in infants for whom these morbidities were present. When comparing the unadjusted direct costs for the presence versus the absence of each morbidity, these differences were sizeable: 1.6 times higher for brain injury; 1.4 times higher for NEC; 2.3 times higher for BPD; and 1.4 times higher for late onset sepsis.

Table 3 reports the direct costs for each of these morbidities after adjusting for potential confounders (BW, GA, race/ethnicity, gender and primary payer). The presence of each

morbidity translated into higher marginal direct costs. Since surgery is a major contributor to the hospitalization costs for infants with NEC, we performed a secondary analysis of these data to examine the separate effects of medically and surgically managed NEC. Average direct costs for surgically managed NEC were $\$133,888 \pm 26,696$, compared with $\$90,209 \pm 40,594$ for medically managed NEC. After adjusting for the above confounders, surgically managed NEC increased direct costs by $\$22,328$ ($p=0.039$), and medically managed NEC increased direct costs by $\$13,136$ ($p=0.034$) compared to infants without NEC. In addition, since IVH grades 1 and 2 are considered to be mild and require little additional medical treatment, we conducted a secondary analysis of severe brain injury that included only IVH grades 3 and 4, PVL and acquired hydrocephalus. These results showed that the presence of severe brain injury was associated $\$16,103$ ($p=0.027$) in additional direct costs, after controlling for the above confounders.

Figure 1 compares the marginal effect of each morbidity on direct costs for infants by BW. Using the coefficients from the regression model for direct costs, the marginal effects for each morbidity were computed for infants in each BW category separately for the modal socio-demographic characteristics (African American/Black, male, and Medicaid) and modal GA (<25 weeks GA for BW <750g; 25–26 weeks GA for BW 750–999g; 27–28 weeks GA for BW 1000–1249g; and 29–36 weeks GA for BW 1250–1499g). Direct costs were computed for six hypothetical morbidity scenarios: no morbidities; individually for each of the four morbidities, assuming no other morbidities were present; and for all four morbidities present together. The marginal effects on direct costs for each of the morbidities and for all four morbidities together were the greatest for infants with BW <750g.

We also examined the marginal effect of the morbidity burden by calculating the direct costs associated with the presence of an additional morbidity, without regard for which specific morbidity. After controlling for the same potential confounders, the marginal effect of each additional morbidity was a $\$16,543$ increase in direct costs ($p<0.001$).

DISCUSSION

This study provides the first collective estimates of the direct costs during the NICU hospitalization for four morbidities in surviving VLBW infants. The results indicate that both the presence and the number of morbidities were associated with significantly higher NICU costs, even after controlling for BW, GA race/ethnicity, gender and primary payer.

Our findings are similar to three previous studies (Online Table) that separately examined the costs associated with late onset sepsis(9) and NEC(10, 24), in that all three studies reported significantly higher NICU costs for infants in whom these morbidities were present. However, the methods used to calculate costs between these studies and our study differed, and they probably explain the differences in dollar amounts reported for the same morbidities, even after adjusting all figures to 2009 US dollars.

Payne et al.(9) reported that the presence of a nosocomial bloodstream infection (late onset sepsis) was the highest for infants with BW >750–1000g ($\$16,068$ in 2009 dollars). In contrast, our findings revealed that the direct costs for late onset sepsis were highest for infants with BW <750g ($\$23,317$) and lowest for BW 750–999g ($\$2,994$). There were four major differences between our study and that of Payne et al. First, our study based the definition of late onset sepsis using diagnosis code, which included both culture positive and clinically diagnosed septicemia, whereas Payne et al. included only infants with culture positive septicemia. However, the course of treatment is similar for culture positive and clinically diagnosed septicemia, so this difference is likely to have only a minimal impact on resource use and costs. A second major difference is that Payne et al. included ventilation

use as a potential confounder in its regression model, and we did not, because the presence of both septicemia and NEC increase the likelihood for ventilation use, which is costly. Because infants with BW <750g are more likely to need ventilation use and for a longer duration than infants with BW 750–1499g, controlling for it as a potential confounder may account for some of costs that are ultimately attributable to the morbidities themselves. Thus, the exclusion of ventilation use in our regression model may explain the differences in relative costs for the two BW groups between our study and Payne's.

A third major difference is that our study used micro-level cost data obtained from our cost accounting system to calculate the direct costs of hospital care, whereas Payne et al. estimated costs from charge data, using the ratio of cost-to-charge approach. Specifically, our findings reflect all hospital resources (excluding physician fees) used to provide direct care, where the total direct cost was calculated by summing the actual costs for each resource used during an infant's hospitalization. In contrast, the ratio of cost-to-charge approach used by Payne et al. estimated direct costs by adjusting department-level ratios of costs to charges. This commonly used approach is less accurate, because it does not reflect the actual cost of each resource used and because hospital charges are not necessarily set to reflect a constant relationship with costs across resources or across time, even within the same hospital. Finally, whereas Payne et al. used multiple linear regression with a log transformation of costs, our data were analyzed using generalized linear regression models, which are a better fit for skewed data.(27) These methodological differences and a time span of a decade between the two studies may explain the differences in our results.

Bisquera et al.(10) found that the unadjusted charges (adjusted to 2009 dollars) for infants with medical NEC were \$106,685 higher than for infants without NEC. This difference increased to \$269,536 for infants with surgical NEC compared to those without NEC. Although our findings also reveal increased costs associated with NEC, our adjusted differences in charges were smaller, with a difference of \$96,902 for infants with medical NEC and \$153,855 for surgical NEC compared to infants without NEC (results not shown). The discrepancy between our findings and those reported by Bisquera et al. may be related to the fact that their charges were generated between 1992 and 1994 and were not adjusted for potential confounders. Additionally, our data reveal that infants with NEC also have more morbidities than those without NEC (Table 2), and our cost calculations adjusted for the presence or absence of other morbidities, whereas Bisquera et al. did not include other morbidities in their analysis. Finally, the comparison of charges instead of direct costs is problematic because each hospital establishes its own charges, and these charges do not reflect "market prices." Ganapathy et al.(24) reported that medically managed NEC was associated with a \$70,592 increase in costs and surgically managed NEC was associated with a \$188,910 increase in costs (adjusted to 2009 dollars) for extremely premature infants 28 weeks GA in California. Our results were substantially smaller, with adjusted differences in costs of \$13,923 for medically managed NEC and \$22,359 for surgically managed NEC for infants 28 GA (results not shown). While Ganapathy et al. adjusted for several clinically relevant factors, they did not control for BW or GA, which are significant predictors of costs; we controlled for both of these factors. In addition, differences may be due to the statistical methods used, sample inclusion criteria, and their structure of charge data that were transformed into costs using ratio of costs-to-charges, although it is difficult to ascertain based on the information available.

We found substantial differences among morbidities in the absolute economic impact on costs (Table 3). The marginal impact on direct costs ranged from \$10,055 for late onset sepsis to \$31,565 for BPD. Of the four studied morbidities, the mean marginal costs associated with BPD were the highest, especially for infants with BW <750g, where costs were \$43,312 higher than infants without BPD. This is likely due to the fact that BPD is

defined by need for resources at specific time points during the NICU hospitalization. Thus, infants who develop BPD by definition require more costly resources (oxygen or CPAP or mechanical ventilation). This is not only true at the time of diagnosis, but earlier during the NICU hospitalization since VLBW infants with BPD receive a longer duration of mechanical ventilation after birth than VLBW infants without BPD.(29) This could be further examined by evaluating costs associated with different severities of BPD(26) or by confirming the diagnosis of BPD by using a physiologic definition.(30) To our knowledge, ours is the first study to report the costs associated with BPD in this population, and our findings underscore the importance of identifying strategies to prevent this costly morbidity.

Limitations of our study include the identification of neonatal morbidities using ICD-9 diagnosis codes assigned by the attending neonatologist, with the exception of NEC in which all cases were confirmed by one of the investigators. This database provided detailed economic data but limited clinical data, thus limiting our ability to perform more detailed analyses, such as grouping infants by severity of BPD. However, since the diagnoses were assigned by the attending neonatologist, we believe the ICD-9 codes are reasonably reliable indicators of each infant's NICU hospitalization. We hope to address this limitation in future studies that will combine a robust clinical database with detailed economic data.

There were 62,073 VLBW infants born in the U.S. in 2008. Based on a 15% in-hospital mortality rate(31), our estimates suggest that the direct costs totaled approximately \$4.0 billion (62,072 infants born alive multiplied by 85% survival rate multiplied by \$76,224 in total direct costs) for hospital care during the initial NICU hospitalization alone. This figure is an underestimate, however, of the total costs during the initial NICU hospitalization, since physician costs were excluded from our analysis. In addition to higher costs during the NICU hospitalization, these morbidities significantly increase the risk of long-term chronic illness, rehospitalization, and developmental delay, and frequently require additional educational resources, leading to lifelong economic consequences for society.(11–14) In a study of the long-term economic consequences of preterm birth, Mangham et al.(32) found that the NICU hospitalization costs represent the largest share of incremental costs to society for very preterm and extremely preterm infants who survive to age 18, compared to term survivors. More work is needed to understand how these morbidities impact the trajectory of costs over childhood for VLBW infants. It is critical that future work examine the impact of these morbidities over childhood, by either modeling the long-term health, healthcare and cost consequences of these morbidities or through a long-term observational study that measures health, healthcare and cost consequences over time. Our findings add to these figures by determining the actual incremental cost of these morbidities to hospitals and can inform future studies evaluating interventions to prevent or reduce the incidence of these costly morbidities in surviving VLBW infants.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

VLBW	very low birth weight
NICU	neonatal intensive care unit

BW	birth weight
GA	gestational age
LOS	length of stay
IVH	intraventricular hemorrhage
PVL	periventricular leukomalacia
NEC	necrotizing enterocolitis
BPD	bronchopulmonary dysplasia
PMA	postmenstrual age

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Figure 1.

Marginal Cost of Morbidities by Birth Weight, Adjusted for Infant Socio-Demographic Characteristics

Notes: Abbreviations: Brain injury includes the presence of one of the following: intraventricular hemorrhage, periventricular leukomalacia, or acquired hydrocephalus; NEC = necrotizing enterocolitis; BPD = bronchopulmonary dysplasia. Regression model fit with a gamma distribution and log link. Direct costs adjusted to 2009 dollars. Model controls for birth weight, gestational age, race/ethnicity, gender, and primary payer source. Adjusted costs from regression model are simulated for the modal characteristics of the sample, including African American/Black, male, Medicaid coverage, and 29–36 weeks GA (1250–1499g), 27–28 weeks GA (1000–1249g), 25–26 weeks GA (750–999g) and under 25 weeks GA (<750g). The marginal effect represents the difference in adjusted direct costs when the morbidity is present compared to costs when none of the morbidities are present. The marginal effect of all four morbidities is the difference in adjusted direct costs when brain injury, NEC, BPD, and late onset sepsis are all present compared to adjusted direct costs when none of morbidities are present.

Table 1

Characteristics of the Sample, N = 425

Characteristic	N (%) or mean±SD
Birth weight	
<750g	87 (20%)
750–999g	112 (26%)
1000–1249g	99 (23%)
1250–1499g	127 (30%)
Gestational age	
<25 weeks	54 (13%)
25–26 weeks	79 (19%)
27–28 weeks	128 (30%)
29–36 weeks	164 (39%)
Count of morbidities	
0	128 (30%)
1	166 (39%)
2	97 (23%)
3 or more	34 (8%)
Number of morbidities, mean	1.09±0.92
Hospital length of stay, days	72.35±35.74
Primary payer source	
Commercial	156 (37%)
Medicaid/self-pay	269 (63%)
Direct hospital costs, USD	76,224±46,074

Notes: percentages may not add to 100% due to rounding. Direct costs adjusted to 2009 US dollars.

Table 2

Length of NICU Hospitalization, Total Morbidity Burden and Direct Costs by Presence or Absence of Morbidity (in 2009 USD), N = 425

	n (%)	LOS mean±SD	Number of additional morbidities mean±SD	Direct costs (USD) mean±SD
Brain injury				
Present	51 (12%)	97.3±45.7 ***	1.37±0.72 ***	111,577±62,149 ***
Absent	374 (88%)	68.9±32.8	0.91±0.80	71,403±41,245
NEC				
Present	29 (7%)	87.4±32.3 **	1.34±0.77 *	100,752±41,838 **
Absent	396 (93%)	71.2±35.8	1.00±0.87	74,428±45,904
BPD				
Present	230 (54%)	94.4±31.4 ***	0.67±0.73 ***	103,151±43,842 ***
Absent	195 (46%)	46.3±19.2	0.40±0.60	44,465±23,300
Late onset sepsis				
Present	153 (36%)	83.4±38.8 ***	0.92±0.73 ***	91,521±52,299 ***
Absent	272 (64%)	66.1±32.4	0.63±0.66	67,620±39,760
Number of morbidities				
None				40,227±16,904
1				76,232±35,740
2				105,186±46,824
3 or more				129,080±55,145

Notes:

Abbreviations: NICU = neonatal intensive care unit; brain injury includes the presence of one of the following: intraventricular hemorrhage, periventricular leukomalacia, or acquired hydrocephalus; NEC = necrotizing enterocolitis; BPD = bronchopulmonary dysplasia. Length of stay is measured in days. Number of additional morbidities is a count of the number of additional morbidities present, excluding the specific morbidity compared (i.e., the number of additional morbidities for infants with and without brain injury includes necrotizing enterocolitis, chronic lung disease, and late onset sepsis).

* p<0.05;

** p<0.01;

*** p<0.001

Table 3

Marginal Effects from Generalized Linear Models Predicting Direct Costs (in USD), N = 425

	Marginal Effect (USD)	p-value
Brain injury	12,048	0.005
NEC	15,440	0.005
BPD	31,565	<0.001
Late onset sepsis	10,055	<0.001

Notes:

Abbreviations: Brain injury includes the presence of one of the following: intraventricular hemorrhage, periventricular leukomalacia, or acquired hydrocephalus; NEC = necrotizing enterocolitis; BPD = bronchopulmonary dysplasia. Regression models fit with a gamma distribution and log link. Models control for birth weight, gestational age, race/ethnicity, gender, and primary payer source. Direct costs, payments and charges adjusted to 2009 US dollars. The marginal effect represents the difference in adjusted direct costs when the morbidity is present compared to costs when none of the morbidities are present.