

Cost of Hospitalization for Preterm and Low Birth Weight Infants in the United States

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ABSTRACT

OBJECTIVE. The objective of this study was to estimate national hospital costs for infant admissions that are associated with preterm birth/low birth weight.

METHODS. Infant (<1 year) hospital discharge data, including delivery, transfers, and readmissions, were analyzed by using the 2001 Nationwide Inpatient Sample from the Healthcare Cost and Utilization Project. The Nationwide Inpatient Sample is a 20% sample of US hospitals weighted to approximately >35 million hospital discharges nationwide. Hospital costs, based on weighted cost-to-charge ratios, and lengths of stay were calculated for preterm/low birth weight infants, uncomplicated newborns, and all other infant hospitalizations and assessed by degree of prematurity, major complications, and expected payer.

RESULTS. In 2001, 8% (384 200) of all 4.6 million infant stays nationwide included a diagnosis of preterm birth/low birth weight. Costs for these preterm/low birth weight admissions totaled \$5.8 billion, representing 47% of the costs for all infant hospitalizations and 27% for all pediatric stays. Preterm/low birth weight infant stays averaged \$15 100, with a mean length of stay of 12.9 days versus \$600 and 1.9 days for uncomplicated newborns. Costs were highest for extremely preterm infants (<28 weeks' gestation/birth weight <1000 g), averaging \$65 600, and for specific respiratory-related complications. However, two thirds of total hospitalization costs for preterm birth/low birth weight were for the substantial number of infants who were not extremely preterm. Of all preterm/low birth weight infant stays, 50% identified private/commercial insurance as the expected payer, and 42% designated Medicaid.

CONCLUSIONS. Costs per infant hospitalization were highest for extremely preterm infants, although the larger number of moderately preterm/low birth weight infants contributed more to the overall costs. Preterm/low birth weight infants in the United States account for half of infant hospitalization costs and one quarter of pediatric costs, suggesting that major infant and pediatric cost savings could be realized by preventing preterm birth.

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Key Words

prematurity, newborns, infants, hospital costs, low birth weight, morbidities

Abbreviations

LBW—low birth weight
LOS—length of stay
NIS—Nationwide Inpatient Sample
HCUP—Healthcare Cost and Utilization Project
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*
C/C—cost-to-charge ratio
RDS—respiratory distress syndrome
BPD—bronchopulmonary dysplasia
IVH—intraventricular hemorrhage
NEC—necrotizing enterocolitis

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PREMATURITY IS the leading cause of neonatal mortality¹ and a major cause of pediatric morbidity and disability,²⁻⁴ associated with up to one half of all pediatric neurodevelopmental disorders.⁵ Furthermore, preterm birth and low birth weight (LBW) may also be associated with lifelong chronic conditions, such as hypertension and dyslipidemia.^{6,7} The rates of preterm birth (<37 completed weeks of gestation) in the United States have been steadily increasing to a current level of 12.3% of all 4 million annual births,⁸ higher than the rates in most major industrialized countries.⁹ Compared with term births, infant mortality rates are 15-fold and 75-fold higher for those who are born preterm and very preterm (<32 weeks), respectively.¹ Approximately 10% of all newborns are admitted to NICUs,¹⁰ many because of prematurity. Despite advancements in technologies and treatments in the past decade, the incidence of severe acute complications for very preterm/LBW infants, accompanied by risks for chronic medical conditions, have not markedly diminished since the mid-1990s.¹¹⁻¹³

A major proportion of pediatric hospital stays in the United States are for conditions in the neonatal period, which are among the most expensive diagnoses for all children.¹⁴ Previous studies have described a sizable financial toll from prematurity.¹⁵⁻²¹ Schmitt et al²² and Marbella et al²¹ both demonstrated in state-specific studies that preterm births contributed disproportionately to overall delivery costs, accounting for a small percentage of discharges and approximately half of all costs. Other studies have shown that hospital costs decrease with increasing birth weight and gestational age, with the smallest and earliest infants having the highest costs and longest length of stay (LOS).^{15,19,23,24} However, most of these studies focused on older data sets,²³ population subsets such as newborns who were privately insured,¹⁸ employer-sponsored health plans,²⁰ and data sets that were limited to local or regional reporting.^{21,22}

Marked shifts in treatment of high-risk mothers and infants, increasing viability for the earliest preterm infants, rapidly rising health care expenditures, and regional variations in preterm birth and NICU care^{8,11,13,25} have an impact on infant health care costs. We conducted a national analysis to estimate the US inpatient hospital costs for infants (<1 year of age) that are associated with preterm births and LBW, including deliveries and readmissions, using a nationally representative hospital discharge database.

METHODS

Study Design

A cross-sectional study of preterm birth/LBW-associated discharges, costs, and corresponding LOS for US infant hospitalizations was conducted using the 2001 Nationwide Inpatient Sample (NIS). The analysis included stratification by infant death during hospitalization, spe-

cific complications associated with preterm birth, and expected source of payment. The contribution of preterm/LBW infant hospitalization costs toward pediatric hospital costs was assessed.

Source of Data

The 2001 NIS database from the Healthcare Cost and Utilization Project (HCUP) is sponsored by the Agency for Healthcare Research and Quality in partnership with 33 state data organizations.²⁶ The NIS sampling design approximates a 20% sample of US "community" hospitals from participating states. A community hospital is defined by the American Hospital Association as "all nonfederal, short-term, general, and other specialty hospitals, excluding hospital units of institutions," which includes long-term hospitals, short-term rehabilitation hospitals, psychiatric hospitals, and alcoholism/chemical dependency treatment facilities.²⁷ This hospital definition includes public, private, and academic medical centers, inclusive of those that provide maternity and newborn services.²⁷ Hospitals were sampled on the basis of 5 strata (geographic region, rural/urban, number of beds, teaching status, and ownership), and all discharges from a sampled hospital are included in the NIS. Sample weights are provided and allow for analyses of nationwide estimates. Details of the NIS sample design and method for generating the weights to produce national estimates are described elsewhere.²⁷ The 2001 NIS contains 7 452 727 unweighted inpatient hospital stays from a total of 986 US hospitals from states that participate in HCUP and after weighting approximates the 35 million inpatient hospital stays in the United States annually, making it the largest all-payer inpatient care database that is publicly available in the United States.

Variable Definitions

Infant hospital stays were defined as all admissions, including the newborn admission at delivery, hospital transfers, and all readmissions up to 1 year of age. The NIS contains data regarding charges; LOS; diagnoses and procedures using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes; admission source; and transfer and discharge status. For newborn deliveries, the mother and the infant have separate admissions and are recorded as 2 individual stays in the NIS. Hospital stays were defined using the 15 primary and secondary ICD-9-CM diagnoses listed in the NIS and categorized into groups defined as preterm birth and/or LBW, uncomplicated newborn, and all other infants. Preterm/LBW infants were all infant stays with a diagnosis of short gestation, low birth weight, or slow fetal growth and malnutrition (ICD-9-CM codes 764-765 and V21.3). Most of the infants in this category were preterm and may or may not have been LBW. A small proportion of stays in the preterm/LBW group were assigned to this group because of an ICD-9-CM code of

slow fetal growth/malnutrition, and these stays may also have been LBW. All preterm/LBW hospitalizations were then identified as LBW (<2500 g), very low birth weight (<1500 g), not LBW (≥2500 g), or birth weight not stated using the fifth digit of the ICD-9-CM codes.

Uncomplicated newborn stays were defined as all stays at delivery with a principal diagnosis of liveborn (ICD-9-CM codes V30.0–V39.2, excluding stillbirths, V32, V35, or V36, and any diagnosis of disease). All other infant stays included stays that did not meet the criteria for the previous 2 groups and included admissions at delivery and readmissions with a diagnosis of disease other than preterm birth/LBW.

Preterm/LBW stays were stratified into short gestation/LBW or slow growth/fetal malnutrition (see Table 1 for specific ICD-9-CM codes) for better understanding the contribution of each of the groups to the overall costs for preterm/LBW infant stays. Because of the 15 diagnoses included in the NIS, it was possible for 1 stay to include a code for both of these groups, making them not mutually exclusive; however, this occurred in <1% of stays. Within the short gestation/LBW group, analyses were further separated to distinguish stays with a diagnosis of “extreme immaturity” or extremely preterm/LBW (gestation of <28 completed weeks and/or birth weight of <1000 g) and “other preterm” (gestation of 28–36 completed weeks of gestation and/or birth weight of 1000–2499 g), with a very small amount of overlap between these 2 groups (<0.01%). Slow growth/malnutrition and other preterm stays were further stratified using the detail provided by the fifth digit of the ICD-9-CM codes that reflect birth weight, which were collapsed into the categories <2500 g, ≥2500 g, and birth weight not stated.

Survival to discharge or death before discharge was determined using the discharge status reported in the NIS. Complications of preterm birth studied included respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), intraventricular hemorrhage (IVH), and necrotizing enterocolitis (NEC; ICD-9-CM codes shown in Table 2). Mechanical ventilation was defined using ICD-9 procedure codes 93.90 to 93.91, 96.04, and 96.70 to 96.72.

Source of payment reflects expected payer at time of discharge. An algorithm using primary and secondary payer variables was used to assign expected payer to 1 of 4 categories: Medicaid, private insurance, uninsured (including self-pay), and other (including Medicare).

Statistical Analyses

Data on hospital costs are presented as a better estimate of economic impact than the corresponding charges,^{22,23,28} which reflect pricing decisions that take into account payer policies and other factors that are unrelated to resource use.²⁹ Hospital charges were used to estimate costs by applying the cost-to-charge ratio (C/C)

TABLE 1 Hospital Costs and LOS for Infant Hospitalizations: United States, 2001

Classification	Discharges		LOS			Cost			
	n	95% CI	Mean	95% CI	Median	Mean	95% CI	Median	Total
Preterm/LBW	384 200	352 200–416 100	12.9	12.0–13.7	4	15 100	13 300–16 800	3000	4 896 718–6 677 146
Short gestation/LBW (ICD-9-CM codes 765.00–765.19)	334 500	305 700–363 400	14.0	13.1–14.9	5	16 700	14 700–18 600	4000	4 717 296–6 444 176
Extreme immaturity (ICD-9-CM codes 765.00–765.09)	29 200	25 200–33 100	42.2	38.5–45.9	26	65 600	57 700–73 500	36 800	1 544 728–2 282 655
Other preterm (ICD-9-CM codes 765.10–765.19)	305 500	279 800–331 100	11.4	10.7–12.0	5	12 100	10 800–13 400	3500	3 682 865
<2500 g (ICD-9-CM codes 765.11–765.18)	190 500	173 000–207 900	15.3	14.6–16.1	9	16 600	14 900–18 300	7500	3 157 740
≥2500 g (ICD-9-CM code 765.19)	112 900	103 700–122 100	4.7	4.4–5.0	3	4500	3900–5100	1200	435 643–584 147
Birth weight not stated (ICD-9-CM code 765.10)	2100	1700–2400	7.9	6.4–9.3	3	9700	7300–12 100	2300	14 737–25 738
Slow growth/malnutrition (ICD-9-CM codes 764.00–764.99)	58 600	53 300–63 900	7.8	7.1–8.5	3	7600	6500–8700	1100	367 207–522 893
<2500 g (ICD-9-CM codes 764.01–764.08 764.11–764.18, 764.21–764.28, 764.91–764.98)	43 800	39 900–47 800	9.4	8.6–10.3	3	9500	8100–10 800	1500	341 762–487 304
≥2500 g (ICD-9-CM codes 764.09, 764.19, 764.29, 764.99)	14 500	12 700–16 400	2.9	2.7–3.1	2	1900	1400–2500	700	20 096–36 244
Birth weight not stated (ICD-9-CM codes 764.00, 764.10, 764.20, 764.90)	200	200–300	7.8	4.4–11.3	4	5600	3200–7900	2600	1379
Uncomplicated newborns	1 929 800	1 776 300–2 083 300	1.9	1.9–2.0	2	600	600–700	500	1 223 076
All other infants	2 297 400	2 123 800–2 471 000	3.0	2.8–3.1	2	2300	2000–2700	800	5 338 421

Source: Agency for Healthcare Research and Quality, 2001 NIS. Number of discharges and total costs for these categories exceed 100% because of overlapping diagnoses, but total costs for any diagnosis of preterm birth/LBW were not double counted. CI indicates confidence interval.

TABLE 2 Selected Complications for Preterm/LBW Infants Who Weighed <2500 g Among Infants Who Were Not Transferred and Infants Who Were Transferred From Another Acute Care Hospital: United States, 2001

Condition/Procedure	Discharges			Cost		
	<i>n</i>	95% CI	%	Mean	95% CI	Median
Death						
Died during stay	11 200	9600–12 800	5.2	20 400	16 900–24 000	2100
Survived to discharge	202 600	184 400–220 800	94.8	21 400	19 000–23 900	7300
RDS (ICD-9-CM code 769)						
Condition present	49 900	42 600–57 100	23.3	56 800	52 100–61 500	36 000
Condition absent	164 100	150 700–177 500	76.7	10 700	9600–11 800	3600
BPD (ICD-9-CM code 770.7)						
Condition present	9400	7100–11 700	4.4	116 000	102 200–129 900	102 000
Condition absent	204 600	186 800–222 300	95.6	16 900	15 200–18 600	6300
IVH (ICD-9-CM codes 772.10–772.14)						
Condition present	8900	7200–10 700	4.2	76 000	68 400–83 700	54 600
Condition absent	205 000	186 800–223 300	95.8	18 900	16 800–21 000	6300
NEC (ICD-9-CM code 777.5)						
Condition present	2900	2300–3600	1.4	100 000	87 800–112 300	73 000
Condition absent	211 000	191 900–230 100	98.6	20 300	18 100–22 500	6800

Source: Agency for Healthcare Research and Quality, 2001 NIS.

developed by Agency for Healthcare Research and Quality using data from the Centers for Medicare and Medicaid Services for nearly every hospital that participated in HCUP in 2001.^{30,31} The 2001 group weighted average C/C for each hospital in the NIS is a weighted average of C/C for all hospitals in a group, which is determined by state, urban/rural, investor owned/other, and number of beds.³⁰ For stays that were missing data on charges (2.8% of infant stays) or missing a C/C (15.8% of infant stays), cost was imputed by assigning the mean cost for that analytic group. Stays with imputed costs were then included in total cost estimates.

Although it was not possible to track hospital stays for the same patient when transferred or readmitted because the NIS discharge records lack identifying information, algorithms were established using NIS variables to minimize the potential small error from overlapping hospital stays for transferred patients. The discharge disposition, admission source, and the ICD-9-CM codes for delivery from the discharge record were used to stratify the infant hospitalizations into 4 categories for analysis: not transferred, transferred out, transferred in, and readmitted (see Table 3 for details).

Potential double counting of transferred or readmitted infants was minimized by examination of deaths and complications only among 2 mutually exclusive groups of preterm/LBW infants: deliveries not transferred and infants transferred in from another hospital. The analysis was then further limited to the higher risk group of LBW stays within this group. The mean and median costs that were associated with death during hospitalization and specific complications were calculated.

Analyses of costs and LOS exclude outliers, defined as stays with charges less than \$25 and greater than or equal to \$1 000 000 and LOS >365 days, which were

0.03% of all discharges in 2001. SAS 8.2 (SAS Institute, Cary, NC) was used to conduct statistical analyses. All estimates of number of discharges and costs were rounded to the nearest hundred. PROC SURVEYMEANS in SAS was used to calculate appropriate SEs and 95% confidence intervals for discharges, mean LOS, and mean and total costs, taking into account the sampling design of the NIS.³² Significant differences in mean costs between 2 independent samples were assessed using a *t* test calculated in SAS. Differences in proportions of payer coverage between preterm/LBW infants and uncomplicated newborns were assessed using a χ^2 test of proportions using EpiInfo 3.3.2 (Centers for Disease Control and Prevention, Atlanta, GA).

RESULTS

Infant Hospitalizations

Costs for all 4.6 million infant hospitalizations totaled an estimated \$12.4 billion (Fig 1). Eight percent (384 200) of the total 4.6 million infant stays included a diagnosis of preterm birth/LBW yet accounted for 47% of all infant costs (\$5.8 billion; Fig 1). Sixty-six percent (253 200) of all preterm/LBW infant hospitalizations had an ICD-9-CM code that indicated that they were LBW and 17% were very LBW (<1500 g) and averaged \$20 600 and \$52 300, respectively. LBW discharges accounted for 90% (\$5.2 billion) of the total costs. In comparison, uncomplicated newborns composed 42% of infant stays (1 929 800) but only 10% of all infant costs (\$1.2 billion). The remaining infant hospitalizations accounted for 50% of all stays and 43% of all costs. These remaining infants represent a wide range of conditions and diagnoses, encompassing >2100 individual ICD-9-CM codes identifying the principal reasons for the stay

TABLE 3 Hospital Costs and LOS for Preterm/LBW Infant Hospitalizations According to Transfer Status: United States, 2001

	Discharges			Preterm Stays			LOS			Cost		
	n	95% CI	% of All Preterm Stays	Mean	95% CI	Median	Mean	95% CI	Median	Total, in Thousands	95% CI	
												Mean
Preterm infant hospitalizations (total)	384 200	352 200–416 100	—	12.9	12.0–13.7	4	15 100	13 300–16 800	3000	5 786 932	4 896 718–6 677 146	
Preterm delivery, no transfer ^a	306 000	278 800–333 300	80	12.1	11.3–12.8	4	12 900	11 600–14 200	2200	3 951 758	3 369 687–4 533 829	
Preterm delivery, transferred out ^b	30 000	25 300–34 600	8	6.6	5.0–8.2	0	12 000	8800–15 300	1600	360 080	261 724–458 435	
Preterm infant admitted from another hospital ^c	26 100	17 300–34 900	7	26.6	23.9–29.3	14	40 800	33 600–48 100	18 800	1 064 810	609 160–1 520 460	
Preterm infant readmissions ^d	22 100	18 000–26 200	6	16.4	14.7–18.1	8	16 400	13 900–19 000	6000	363 031	27 832–450 231	

Source: Agency for Healthcare Research and Quality, 2001 NIS. Hospital costs are for acute care only (see "Methods").

^a Includes infants with a principal diagnosis for delivery (ICD-9-CM codes V30.0–V39.2), a secondary diagnosis of preterm/LBW (ICD-9-CM codes 764–765 and V21.3), and a discharge status not equal to "transfer to acute care hospital."
^b Includes infants with a principal diagnosis code for delivery (ICD-9-CM codes V30.0–V39.2, excluding V32, V35, V36), a secondary diagnosis of preterm/LBW (ICD-9-CM codes 764–765 and V21.3), and a discharge status of "transfer to acute care hospital."
^c Includes infants up to 1 year of age with a principal or secondary diagnosis of preterm/LBW (ICD-9-CM codes 764–765 and V21.3), no diagnosis code for delivery, and an admission source of "acute care hospital."
^d Include infants up to 1 year of age with a principal or secondary diagnosis of preterm/LBW, no diagnosis code for delivery, and an admission source other than an acute care hospital.

and a total of >4300 different ICD-9-CM codes listed as the secondary diagnosis, with an interquartile range of costs from \$500 to \$1600 (25th and 75th percentiles) and a maximum cost of nearly \$546 000.

Infant hospitalization costs totaled 59% of all pediatric (<18 years) hospital costs, which totaled \$21.2 billion for the 6.4 million admissions in 2001. Hospitalization costs for preterm/LBW infants composed 27% of costs for all pediatric stays.

The mean cost for preterm/LBW infant stays was \$15 100, compared with \$600 for an uncomplicated newborn and \$2300 for all other infant hospitalizations (Table 1). The mean LOS for preterm/LBW, uncomplicated, and all other infants were 12.9, 1.9, and 3.0 days, respectively (Table 1). Median cost and LOS for preterm/LBW infants were lower than the mean cost and LOS, indicating a subset of costly stays that reflect an intense use of resources among more complicated stays.

Categories of Preterm/LBW Infants

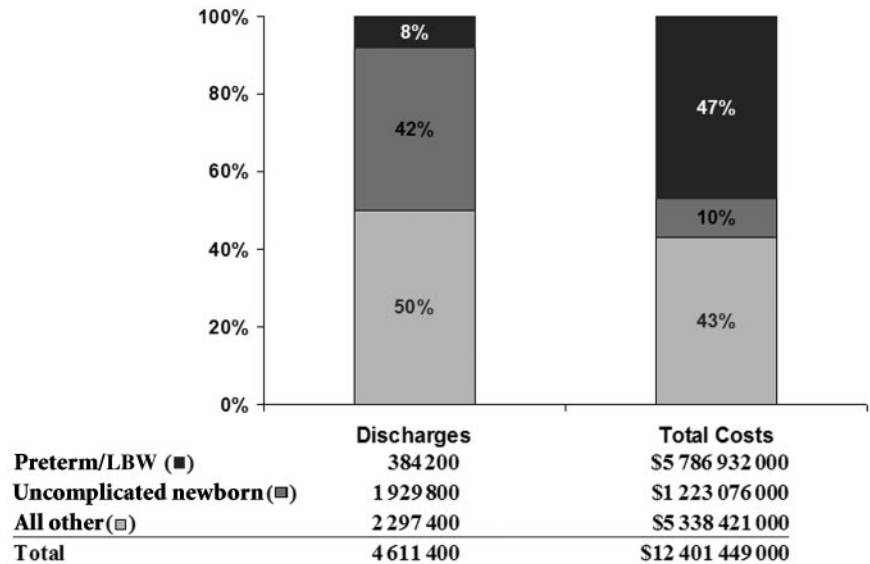
Costs were estimated for preterm/LBW infants who were diagnosed as short gestation and/or LBW compared with those who were growth restricted or coded as small for gestational age. More than 87% of preterm/LBW infants (334 500) were of short gestation/LBW (Table 1), whereas 15% (58 600) had slow growth/malnutrition, which included small for gestational age. The majority of stays with a diagnosis of slow growth/malnutrition were <2500 g (43 800). Costs for short gestation/LBW totaled \$5.6 billion and nearly \$450 million for slow growth/malnutrition.

Hospitalizations for extremely preterm/LBW infants (<28 weeks' gestation/birth weight <1000 g) represented 8% of preterm/LBW infants and had a mean cost of \$65 600 and mean LOS of 42.2 days. Other preterm infants (28–36 weeks' gestation/birth weight 1000–2499 g) had a mean cost of \$12 100 and an average LOS of 11.4 days. The majority of these other preterm stays had a birth weight of <2500 g. Average costs for these infants were nearly 4 times higher than for other preterm infants with a birth weight of ≥2500 g: \$16 600 and \$4500, respectively.

Admission and Transfer Status

Of all hospitalizations for preterm/LBW infants, 80% (306 000) were deliveries that involved no hospital transfer (Table 3). These infants had a mean LOS of 12 days and mean costs of nearly \$13 000. Eight percent of preterm/LBW infant admissions (30 000) were deliveries that resulted in a transfer to another acute care hospital, and half of these occurred on the day of delivery. Seven percent (26 100) of preterm/LBW stays were for infants who were admitted from another acute care hospital. The remaining 6% of all preterm/LBW infant stays (22 100) were readmissions after hospital discharge after delivery.

FIGURE 1
Distribution of infant hospital discharges and costs:
United States, 2001.



Infants who were transferred in from another hospital had the highest mean cost (\$40 800) and the longest mean LOS (26.6 days) of all admission categories ($P < .001$). On average, readmissions had a LOS of 16.4 days and a mean cost of \$16 400. Similar trends were seen for transfers and readmissions when the analysis was limited to preterm infants with a code that indicated LBW (data not shown).

Infant Complications

In 2001, 5.2% of preterm/LBW infants who weighed <2500 g died before discharge, compared with 3.5% of preterm infants of all birth weights (data not shown). Mean hospital costs for surviving infants were not significantly different for those who died before discharge (\$21 400 and \$20 400, respectively; $P = .65$). However, the median cost for deaths was \$2100, whereas the median cost among survivors was \$7300.

Mean hospital costs for preterm/LBW infants who weighed <2500 g and had specific complications were 4 to 7 times higher than those for infants without these complications. One fourth of stays studied had 1 or more of the following complications: RDS, BPD, IVH, and NEC. Costs for these 4 conditions totaled \$3.1 billion. Among these preterm/LBW infants, the single costliest

complication in terms of average cost per discharge was BPD, with an average cost of \$116 000, reported in 4.4% of cases (Table 2). The most common complication was RDS, reported in 23.3%, or 49 900, infants. Average cost for stays with RDS was \$56 800, compared with \$10 700 for infants without RDS. IVH was reported in 4.2% and NEC in 1.4% of all preterm/LBW infants who weighed <2500 g (Table 2). These infants had high hospital costs: \$76 000 for IVH and \$100 000 for NEC. Use of mechanical ventilation was identified among 27.3% of preterm/LBW infants who weighed <2500 g, with costs averaging \$55 100.

Source of Expected Payer

Among preterm/LBW infant stays, 42% had Medicaid listed as either the primary or the secondary expected payer, 50% had private/commercial insurance, 5% listed uninsured/self-pay, and 2% listed other sources as the expected payer, such as Medicare (Table 4). The mean costs for stays were similar whether covered by Medicaid (\$15 800) or by private/commercial insurance (\$15 000; $P = .58$). These costs were approximately twice as high as uninsured/self-pay stays (\$8700; $P < .001$). In contrast, regardless of payer group, costs for uncomplicated newborn stays averaged \$600. When

TABLE 4 Expected Payer for Selected Infant Hospitalizations: United States, 2001

Expected Payer	Preterm/LBW Infants			Uncomplicated Newborns		
	n (95% CI)	%	Mean Cost (95% CI), \$	n (95% CI)	%	Mean Cost (95% CI), \$
Medicaid	160 700 (144 200–177 200)	41.9	15 800 (14 000–17 700)	721 800 (643 800–799 700)	37.5	600 (560–630)
Private/commercial	193 300 (171 700–214 900)	50.4	15 000 (12 800–17 200)	1 049 400 (938 900–1 160 000)	54.5	660 (620–710)
Uninsured/self-pay	20 300 (14 700–25 900)	5.3	8700 (6900–10 400)	104 900 (83 400–126 400)	5.4	650 (580–710)
Other ^a	9000 (6700–11 400)	2.3	17 900 (13 200–22 600)	48 700 (33 800–63 500)	2.5	530 (490–580)

Source: Agency for Healthcare Research and Quality, 2001 NIS.

^a Includes Medicare.

compared with preterm/LBW stays, a significantly lower proportion of uncomplicated stays were covered by Medicaid (37.5%; $P < .001$) than by private/commercial insurance (54.5%; $P < .001$). The proportions of those designated as uninsured/self-pay (5.5%) and other sources (2.5%) were slightly larger among uncomplicated newborns ($P < .001$).

DISCUSSION

Preterm birth is a major obstetric and pediatric challenge,^{33,34} because it is a common, persistent, and often devastating condition with substantial medical, economic, emotional, and social impact. Our study, which includes all expected payers, quantifies on a nationwide scale the vastly disproportionate infant hospitalization costs that are associated with preterm birth/LBW: 47% of all infant costs for only 8% of all infant admissions, as well as 27% of all pediatric hospital costs for 6% of all pediatric admissions. Mean hospital costs for preterm/LBW infants were 25 times higher and average hospitalizations were 11 days longer than those for uncomplicated births. Marked disparate expenses for preterm infants include intensive care and treatment for acute and chronic conditions. As expected, respiratory complications were the most prevalent and costly for preterm/LBW infants, consistent with the intensity, duration, and rate of readmission³⁵ of care for affected infants. Costs for the 4 morbidities studied accounted for more than half of all preterm birth-related costs. The average cost of \$52 300 for each very LBW infant discharge (<1500 g) was consistent with those costs as estimated by others.^{36,37}

There are several key findings from our study that can help guide both clinical and policy decision-making. First, although admissions for extremely preterm infants (<28 weeks' gestation or <1000 g) accounted for only 8% of all preterm/LBW infant stays, this group of infants incurred approximately one third of total preterm/LBW infant hospitalization costs. Mean hospital costs for infants of 28 to 36 weeks' gestation and/or birth weight 1000 to 2499 g (other preterm) were one fifth as high as those for the extremely preterm infants. Importantly, admissions for these less severely preterm infants represented 80% of all preterm/LBW infant stays and accounted for 64% of the total hospitalization costs, clearly demonstrating the public health impact of these infants. The rates for very preterm births (<32 weeks) have been stable in the past several decades, at ~2% of all US births. In contrast, the steadily increasing rates of all preterm births in the United States in the past several decades have been driven by a rise in more moderately preterm births (32–36 weeks) and particularly the late preterm (34–36 weeks).³⁸ Although morbidity and mortality are comparatively less in this group, the much larger numbers of affected infants have a great impact on infant health care costs.

Second, our results are consistent with those from previous studies that demonstrated that the initial (ie, delivery) hospital stay incurred the majority of hospital expenses during the first year of life for preterm/LBW infants.^{35,39} Readmissions during the first year of life were only a small proportion of these preterm/LBW infant stays, accounting for only 6% of hospital admissions and \$363 million, or 6%, of total costs. In contrast, the 7% of infants who were transferred in from another hospital incurred by far the highest mean costs and LOS. Therefore, continued focused efforts to address causes for very preterm and moderate to late preterm births remain imperative. In addition, the subset of preterm infants who require transfer in the first few days of life require the greatest intervention.

Finally, private and public health care purchasers share the financial burden and, hence, the impact of preterm birth. It is interesting that Medicaid covered nearly 42% of preterm/LBW infant hospitalizations, compared with nearly 38% of uncomplicated newborn stays. This reflects the demographics of populations with higher preterm birth rates⁸ but may also include infants who qualify for Medicaid as a result of the costliness of care that is required for preterm infants.

Although the use of discharge data has coding limitations, this study used strengths of the NIS, including the detailed ICD-9-CM codes for birth weight, to target certain analyses to high-risk infants, as well as admission source and disposition to account for transfers. Analysis of transfers suggests that a small number of all preterm/LBW stays included in this study were transfers and thus may potentially lead to double counting of infants. Importantly, the identified number of infants whose discharge disposition indicated transfer to another facility nearly matched the identified number of infants whose admission source indicated a transfer in from another facility, a finding that supports internal validity of the data.

We acknowledge the limitations that are inherent in this study of hospitalization costs using discharge data. There is agreement within the literature that both hospital charge and cost estimates have limitations and that precise costs are difficult to derive because of the inherent limitations of standard cost conversion methods.²³ Specifically, C/Cs used here do not recognize differences in markups among services within a hospital, which may affect the estimated costs for preterm infants relative to others.^{22,23} The NIS database uses ICD-9-CM codes to capture the diagnoses on the hospital discharge record for all hospitalizations. Because the actual gestational age of each infant is not available in the 2001 database, we may be underestimating a portion of total number of discharges and total costs for preterm/LBW infants if the stays did not receive the proper ICD-9-CM codes or if the prematurity was not clinically significant.

Total health care costs for preterm/LBW infants are

certainly higher than our estimated costs, because inpatient costs in the NIS do not include physician and other professional fees, rehabilitation, or outpatient or home care expenses. Additional data sets linking hospital discharge with other databases, such as vital statistics and those that include outpatient care, could provide a more detailed picture of these costs but may be possible only by restricting analysis to a single health care system,^{18,20,39} precluding generalization to national health care costs. Maternal costs that are associated with hospitalization and treatment of preterm labor, which have been shown to be substantially greater than costs for term deliveries,⁴⁰ are another major expense of preterm birth. Other maternal costs include outpatient treatment, employer health care expenses, and lost work productivity. A recently released Institute of Medicine report³⁶ on preterm birth estimated the total societal economic cost of preterm birth to be \$26 billion, including medical costs from birth through early childhood, maternal delivery costs, early intervention and special education services, and lost household and labor market productivity. Although annual national inpatient hospital costs for preterm birth, extrapolated to the United States from a cohort of 24 000 Utah births that were covered by a single health care plan, were approximately twice as high as those found in our analyses, methodologic differences between these 2 estimates can likely explain the disparity.

The causes of preterm labor and birth are not wholly understood, and few successful interventions have been determined. Causes of preterm births at >32 weeks' gestation may be more amenable to prevention³⁴ than extremely preterm births and therefore may be a potential source of future cost savings and improvements in developmental outcomes. Promising prevention strategies include infection prevention, smoking cessation, and 17- α hydroxyprogesterone therapy to prevent recurrence among eligible women.³⁶ Our data on costs for specific neonatal morbidities that are associated with preterm birth also suggest that interventions that are aimed at prevention of complications could lead to significant cost savings.

CONCLUSIONS

This study provides a robust national estimate of infant hospitalization costs that are associated with preterm birth/LBW and demonstrates that health care that is associated with these outcomes compose a substantial portion of the cost of hospital care for all infants and children, especially for those who are at the lowest gestational ages. As the incidence of preterm birth grows⁸ and the limits of viability extend,¹ the economic impact of preterm birth will likely grow. Ongoing trend analyses by the authors indicate a rise in the hospital price tag for preterm/LBW infants (data not shown). The enormous costs of treatment for preterm infants relative to total infant and pediatric costs highlight the need for en-

hanced efforts and research that are targeted at prevention of preterm birth³⁴ and that would benefit private and public payers alike.

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