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RESEARCH ARTICLE

Increased Risk of Death among Uninsured Neonates

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Objective. To estimate the contribution of health insurance status to the risk of death among hospitalized neonates.

Data Sources. Kids' Inpatient Databases (KID) for 2003, 2006, and 2009.

Study Design. KID 2006 subpopulation of neonatal discharges was analyzed by weighted frequency distribution and multivariable logistic regression analyses for the outcome of death, adjusted for insurance status and other variables. Multivariable linear regression analyses were conducted for the outcomes mean adjusted length of stay and hospital charges. The death analysis was repeated with KID 2003 and 2009.

Principal Findings. Of 4,318,121 estimated discharges in 2006, 5.4 percent were uninsured. There were 17,892 deaths; 9.5 percent were uninsured. The largest risks of death were five clinical conditions with adjusted odds ratios (AOR) of 13.7–3.1. Lack of insurance had an AOR of 2.6 (95 percent CI: 2.4, 2.8), greater than many clinical conditions; AOR estimates in alternate models were 2.1–2.7. Compared with insureds, uninsureds were less likely to have been admitted in transfer, more likely to have died in rural hospitals and to have received fewer resources. Similar death outcome results were observed for 2003 and 2009.

Conclusions. Uninsured neonates had decreased care and increased risk of dying.

Key Words. Death, insurance, neonate

The high neonatal mortality rate in the United States relative to other developed countries is a national concern (Healthy People 2020 2010; World Health Organization 2010). The major clinical conditions associated with death in early infancy include premature birth; congenital malformation; sepsis; respiratory distress syndrome (RDS); necrotizing enterocolitis (NEC); hypoxia; intraventricular hemorrhage (IVH); and maternal conditions and complications involving the placenta, umbilical cord, and/or delivery (Guthrie et al. 2003; Shankaran et al. 2005; Heron et al. 2009). A system of regionalized perinatal care has evolved to deliver specialized care to high-risk obstetrical and neonatal patients (American Academy of Pediatrics Committee on the Fetus and Newborn 2012). However, in a voluntary system of regionalized perinatal care in which some patients are uninsured, health insurance status may affect access to neonatal intensive care and the neonatal mortality rate. Being uninsured is harmful to the health of older children and adults, and their health status may be improved by acquisition of insurance and access to health care services (Institute of Medicine 2009).

The aims of this analysis are to use a national hospital discharge survey database to estimate the contribution of insurance status to access to health care resources and to neonatal survival outcome, adjusted for the diagnoses and demographic characteristics that are associated with neonatal death.

METHODS

Data Sources

The study examined hospital discharges of patients with neonatal diagnoses using the Kids′ Inpatient Databases (KID) for 2003, 2006, and 2009; Healthcare Cost and Utilization Project (HCUP); and Agency for Healthcare Research and Quality (2011). Individual discharge records in the HCUP databases represent discrete hospital stays. Discharges include in-hospital deaths, as well as discharges to home or to another facility.

KID 2006 is a sample of discharges from 3,739 community, non-rehabilitation hospitals in 38 states that participated in HCUP in 2006. It was used for an extensive analysis, and the main outcome was repeated using the other databases. KID 2003 includes data from 3,438 hospitals in 36 states, and KID 2009 includes data from 4,121 hospitals in 44 states. In each database, the target universe includes pediatric discharges from community, non-rehabilitation hospitals in the United States. KID includes a sample of discharges from all hospitals in the sampling frame, that is, the State Inpatient Databases that agreed to participate in KID in a specific year. For sampling, pediatric discharges are stratified by uncomplicated in-hospital birth, complicated in-hospital birth, and all other pediatric cases. To insure an adequate representation of each hospital's pediatric case mix, the discharges are sorted by state, hospital, diagnostic related group (DRG), and a random number within each DRG. Systematic random sampling is used to select 10 percent of uncomplicated and 80 percent of complicated in-hospital births and other pediatric cases from each sampled hospital. Discharge weights are developed by stratum used

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to define the sampled hospitals and the three types of records, that is, uncomplicated in-hospital births, complicated in-hospital births, and all other pediatric cases (Agency for Healthcare Research and Quality 2008).

Study Sample and Definitions

The sample subpopulation was defined as discharge records flagged in the database with a principal or secondary International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) neonatal diagnosis or procedure code for which admission occurred within the first 28 days of life (Centers for Disease Control and Prevention 2010). The main outcome of interest was death during hospitalization. Insurance status was determined from the expected primary and secondary payer information, defining the *self pay* and *no charge* payer records as uninsured and *Medicare, Medicaid, private insurance,* and *other* payer records as insured. Diagnoses were defined using ICD-9-CM and Clinical Classifications Software (CCS) codes (Agency for Healthcare Research and Quality 2010).

The 2006 sample subpopulation for this study included 1,129,892 observations that estimate a weighted count of 4,318,216 discharges, including records for patients who were transferred from the hospital of birth or from home to the discharging hospital, as well as inborn patients. The sample subpopulations for the 2003 and 2009 analyses were 1,002,929 and 1,258,806, respectively.

Analysis

Weighted analyses were performed using SAS (SAS Institute 2010), SAS-Callable SUDAAN (Research Triangle Institute 2009), and Stata (StataCorp LP 2011) software. No missing data were imputed. Variables of potential interest with greater than 3 percent missing observations were not used in the main analyses. Weighted frequency distribution analyses were used to characterize the subpopulation and to compare the uninsured with the insured groups by chi-square tests. The weighted means and variances of continuous variables were computed and compared by *t*-tests. Weighted univariate and multivariable logistic regression analyses were employed to calculate the unadjusted and adjusted effect sizes of predictors of death and, separately, of admission by transfer. Models were constructed iteratively to optimize the model fit statistics. The c statistic, Akaike's Information Criterion, and the concordance of predicted and observed responses were used to evaluate and compare models.

Interaction terms were tested. The Wald chi-square test was used to determine significance of the adjusted odds ratios (AORs). The multivariable logistic regression analysis model that best described the 2006 data for the main outcome of death was repeated separately with the 2003 and 2009 data.

Separate weighted multivariable linear regression analyses were performed by manual stepwise selection to estimate mean adjusted lengths of stay (LOS) and mean adjusted hospital charges, respectively. Model selection was based on maximized R^2 values for LOS outcome for all patients, and the same predictor variables were used in other LOS models for patients who died and, in a sensitivity analysis, for those not admitted by transfer. The study was approved by the Institutional Review Board.

RESULTS

Subpopulation Characteristics

Characteristics of the KID 2006 subpopulation are shown in Table 1. Of the estimated 4,318,216 neonatal discharges, 231,806 (5.4 percent) were uninsured. An estimated 17,892 neonatal deaths occurred, including 1,695 (9.5 percent) without insurance. Seven of the nine leading causes of death during the first 12 months of life are included among the clinical conditions used to characterize the neonatal subpopulation in Table 1 (Heron et al. 2009). IVH is examined instead of all causes of hemorrhage during infancy because it is the hemorrhage of particular concern during the neonatal period. Additional important causes of death among neonates, but not among the leading causes of infant deaths, that is, intrauterine hypoxia and birth asphyxia (grouped as hypoxia) (Shankaran et al. 2005; Azzopardi et al. 2009) and NEC (Guthrie et al. 2003), are estimated in Table 1. Gender and multiple birth cohorts, characteristics that are known to be associated with increased risk of neonatal death also are included (Mathews and MacDorman 2010). Congenital malformations, deformations, and chromosomal abnormalities are grouped as congenital malformation.

The national quartile for median household income for a patient's residence ZIP code was examined as an estimate of family socioeconomic status. For all patients, the distribution of median household income was skewed toward the lower quartiles. Uninsured patients were represented in all income quartiles. Almost one half (47.4 percent) of discharges were from urban teaching hospitals. Children's hospitals and general hospitals with children's units together accounted for 20.0 percent of discharges.

Table 1: Characteristics of Discharged Neonatal Patients in the 2006 Kids' Inpatient Database by Insurance Status

Characteristic	*All, Weighted N*	*All, Weighted% (95% CI)*	*Uninsured, Weighted% (95% CI)*	*Insured, Weighted% (95% CI)*	*Uninsured vs Insured, p-Value**
Died during hospitalization	17,892	0.41 (0.39, 0.44)	0.73 (0.64, 0.83)	0.40 (0.37, 0.42)	<.0001
Male	2,207,182	51.40 (51.26, 51.65)	50.82 (50.20, 51.44)	51.43 (51.29, 51.58)	.0564
Diagnoses (codes)					
Preterm, low birth weight, IUGR (CCS 219)	487,039	11.28 (10.09, 11.64)	9.53 (8.90, 10.20)	11.38 (11.02, 11.75)	<.0001
Congenital malformation (CCS 213-217)	329,176	7.62 (7.38, 7.87)	7.00 (6.27, 7.82)	7.66 (7.42, 7.90)	.0831
Life-threatening congenital anomalies†	62,095	1.44 (1.36, 1.52)	1.07 (0.95, 1.20)	1.46 (1.38, 1.55)	<.0001
Maternal, placental, umbilical cord, delivery complication with effect on fetus or newborn (ICD-9-CM 760xx–763xx)	161,312	3.74 (3.49, 4.00)	4.56 (4.13, 5.05)	3.69 (3.44, 3.95)	<.0001
Multiple birth cohort	134,642	3.12 (3.03, 3.21)	1.98 (1.79, 2.18)	3.18 (3.09, 3.28)	<.0001
RDS (CCS 221)	113,354	2.60 (2.49, 2.72)	1.70 (1.50, 1.93)	2.65 (2.54, 2.77)	<.0001
Sepsis (ICD-9-CM 77181)	107,641	2.49 (2.33, 2.67)	1.89 (1.67, 2.15)	2.53 (2.36, 2.70)	<.0001
Hypoxia (CCS 220)	21,939	0.51 (0.48, 0.54)	0.49 (0.42, 0.58)	0.51 (0.48, 0.54)	.604
IVH (ICD-9-CM 77210-77214)	11,011	0.25 (0.24, 0.28)	0.13 (0.11, 0.16)	0.26 (0.24, 0.28)	<.0001
NEC (ICD-9-CM 7775x)	7,504	0.17 (0.16, 0.19)	0.09 (0.06, 0.12)	0.18 (0.17, 0.19)	<.0001
Location of patient's county of residence					<.0001
Central counties of metro areas ≥ 1 million population	1,486,222	34.50 (32.25, 36.83)	33.25 (28.36, 38.54)	34.57 (32.33, 36.89)	
Fringe counties of metro areas ≥ 1 million population	1,017,279	23.62 (21.80, 25.54)	24.04 (20.58, 27.89)	23.59 (21.78, 25.52)	
Counties in metro areas of 250,000–999,999 population	805,306	18.70 (16.82, 20.73)	16.37 (13.64, 19.53)	18.83 (16.93, 20.88)	
Counties in metro areas of 50,000–249,999 population	352,020	8.17 (7.23, 9.22)	8.78 (6.83, 11.23)	8.14 (7.20, 9.18)	
Micropolitan counties‡	412,462	9.58 (9.01, 10.18)	9.88 (8.42, 11.58)	9.56 (8.99, 10.16)	
Non-core counties§	234,003	5.43 (5.07, 5.82)	7.67 (6.66, 8.82)	5.31 (4.95, 5.69)	

Continued

Table 1 *Continued*

Characteristic	*All, Weighted N*	*All, Weighted% (95% CI)*	*Uninsured, Weighted% (95% CI)*	*Insured, Weighted% (95% CI)*	*Uninsured vs Insured, p-Value**
Median household income national quartile for patient's ZIP code					<.0001
Lowest	1,143,178	27.04 (25.76, 28.35)	31.70 (29.00, 34.54)	26.77 (25.5, 28.08)	
Next lowest	1,038,058	24.55 (23.73, 25.38)	28.04 (26.28, 29.88)	24.35 (23.54, 25.19)	
Next highest	1,049,068	24.81 (24.06, 25.58)	22.88 (21.61, 24.21)	24.92 (24.16, 25.70)	
Highest	998,174	23.61 (22.28, 24.98)	17.37 (15.00, 20.03)	23.96 (22.62, 25.35)	
Uninsured	231,806	5.37 (4.92, 5.86)	100	0	
Hospital region¶					<.0001
Northeast	711,669	16.48 (15.23, 17.82)	13.37 (11.17, 15.93)	16.66 (15.36, 18.09)	
Midwest	925,106	21.42 (20.28, 22.61)	23.70 (19.87, 28.02)	21.29 (20.13, 22.50)	
South	1,633,509	37.83 (36.08, 39.61)	47.18 (42.46, 51.95)	37.30 (35.55, 39.08)	
West	1,047,933	24.27 (22.40, 25.69)	15.75 (13.41, 18.41)	24.75 (23.35, 26.21)	
Location/teaching status of hospital					.0065
Rural	490,187	11.45 (10.82, 12.11)	14.20 (12.20, 16.47)	11.30 (10.66, 11.96)	
Urban non-teaching	1,759,853	41.12 (39.44, 42.81)	43.67 (39.16, 48.29)	40.97 (39.29, 42.62)	
Urban teaching	2,030,236	47.43 (45.68, 47.19)	42.13 (37.30, 47.12)	47.73 (45.97, 49.50)	
NACHRI hospital type					.088
Not a children's hospital	3,453,808	79.98 (77.33, 82.40)	81.52 (77.03, 85.31)	79.89 (77.23, 82.32)	
Children's general or specialty hospital	60,715	1.41 (1.05, 1.88)	0.80 (0.36,1.75)	1.44 (1.08, 1.92)	
Children's unit in a general hospital	803,693	18.61 (16.22, 21.27)	17.68 (13.94, 22.16)	18.66 (16.26, 21.33)	
Hospital bed size					.294

Continued

Table 1 *Continued*

Characteristic	*All, Weighted N*	*All, Weighted% (95% CI)*	*Uninsured, Weighted% (95% CI)*	*Insured, Weighted% (95% CI)*	*Uninsured vs Insured, p-Value**
Small	501,410	11.71 (11.62, 11.81)	10.34 (8.73, 12.22)	11.79 (10.65, 13.04)	
Medium	1,160,241	27.11 (26.98, 27.23)	26.97 (23.35, 30.92)	27.11 (25.69, 28.59)	
Large	2,618,626	61.18 (61.04, 61.32)	62.69 (58.44, 66.76)	61.09 (59.41, 62.75)	
Admitted as transferred patient	76,730	1.78 (1.57, 2.01)	1.38 (0.94, 2.02)	1.80 (1.59, 2.04)	.088

*χ^2 test.
†As defined in Table A-3 of Phibbs et al. 2007.
‡Urban areas around a core city or town with a population of 10,000 to 49,999.
§Rural area with no urban cluster of at least 10,000 people.
¶States included in each region are as follows: Northeast–; Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont; Midwest– Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin; South– Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia; West– Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.
CCS, Clinical Classifications Software; CI, confidence interval; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; IUGR, intrauterine growth restriction; IVH, intraventricular hemorrhage; NACHRI, National Association of Children's Hospitals and Related Institutions; NEC, necrotizing enterocolitis; RDS, respiratory distress syndrome.

Comparison of Uninsured and Insured Discharges

There were significant differences between insured and uninsured discharged patients in characteristics in Table 1, except for distributions of gender, hypoxia, congenital malformation, hospital type, hospital bed size, and admission by transfer. In general, uninsured discharges occurred relatively more often in the South; in families that resided in "non-core counties" (those with no urban cluster of 10,000 or more residents); in the lower half of median household incomes; and from hospitals in rural areas. There were differences in the distributions of conditions associated with neonatal death: uninsured discharges had smaller percentages of preterm, low birth weight, intrauterine growth restriction (PT/LBW/IUGR), and multiple birth status, as well as lower rates of RDS, sepsis, IVH, and NEC. In a restricted sample of KID 2006 that excluded the nine states that did not report race data for newborn discharges, the estimated weighted proportions of Hispanics were 36.8 percent among uninsureds and 24.0 percent among insureds.

Predictors of Death

The AORs for death during hospitalization in the multivariable logistic regression analysis of KID 2006 that includes insurance status, clinical diagnoses, gender, hospital characteristics, and patient location as predictors are presented in Table 2. In Model 1, the effect size associated with PT/LBW/IUGR is the largest of any variable, with AOR (95 percent CI) = 13.7 (12.9, 14.5). IVH; hypoxia; NEC; congenital malformation; sepsis; maternal, placental, umbilical cord, and delivery conditions and complications; RDS; cohort size and gender, in decreasing AOR order from 6.0 to 1.1, were all significant independent predictors of death. Patients who resided in counties with lower population densities had greater risk of death than did those who resided in more heavily populated counties. Patients who were discharged from urban teaching hospitals had greater risk of death than did those cared for in other hospitals.

Importantly, uninsured neonates were 2.6 (95 percent CI: 2.4, 2.8) times as likely to die as were those with private insurance, Medicaid, Medicare or other expected primary or secondary payer. Models with interaction terms for PT/LBW/IUGR and other diagnoses resulted in significant AORs for these variables, but larger Akaike's Information Criterion values, a smaller c statistic or models that failed to converge. A sensitivity analysis in which uninsured was redefined as only *self pay*

Table 2: Adjusted Odds Ratios of Predictors of Death of Neonatal Patients in the 2006 Kids' Inpatient Database Estimated by Weighted Multivariable Logistic Regression Analysis

Variable	*Model 1 Adjusted Odds Ratio*	*Model 1 Adjusted 95% Confidence Interval*	*Model 2 Adjusted Odds Ratio*	*Model 2 Adjusted 95% Confidence Interval*
Preterm, low birth weight, or intrauterine growth restriction	13.67	12.91, 14.47	13.19	12.46, 13.97
Intraventricular hemorrhage	6.04	5.58, 6.54	6.27	5.76, 6.84
Hypoxia	5.97	5.40, 6.60	6.10	5.50, 6.76
Necrotizing enterocolitis	3.38	3.03, 3.77	3.44	3.07, 3.86
Congenital malformation	3.08	2.93, 3.22	n.a.	n.a.
Life-threatening congenital malformations*	n.a.	n.a.	8.84	8.32, 9.39
Uninsured	2.58	2.41, 2.77	2.66	2.49, 2.85
Sepsis	1.61	1.52, 1.70	1.63	1.53, 1.73
Maternal, placental, umbilical cord, or delivery complication	1.59	1.49, 1.69	1.66	1.56, 1.77
Respiratory distress syndrome	1.43	1.36, 1.51	1.72	1.63, 1.82
Multiple birth cohort	1.10	1.09, 1.17	1.20	1.13, 1.27
Male	1.07	1.03, 1.11	1.09	1.04, 1.13
Location of patient's county of residence				
Central counties of metro areas ≥ 1 million population	Ref		Ref	
Fringe counties of metro areas ≥ 1 million population	1.00	0.95, 1.05	0.99	0.934, 1.04
Counties in metro areas of 250,000–999,999 population	1.13	1.06, 1.19	1.10	1.04, 1.17
Counties in metro areas of 50,000–249,999 population	1.22	1.13, 1.32	1.19	1.10, 1.29

Continued

Table 2 *Continued*

Variable	*Model 1 Adjusted Odds Ratio*	*Model 1 Adjusted 95% Confidence Interval*	*Model 2 Adjusted Odds Ratio*	*Model 2 Adjusted 95% Confidence Interval*
Micropolitan counties[†]	1.29	1.18, 1.41	1.23	1.13, 1.35
Non-core counties[‡]	1.17	1.06, 1.30	1.11	0.99, 1.23
Hospital	1.00	1.00, 1.00	1.00	1.00, 1.00
Hospital bed size				
Large	Ref		Ref	
Medium	0.79	0.75, 0.83	0.79	0.75, 0.83
Small	0.83	0.77, 0.89	0.82	0.76, 0.88
Location/teaching status of hospital				
Urban teaching	Ref		Ref	
Urban non-teaching	0.50	0.47, 0.52	0.51	0.49, 0.54
Rural	0.42	0.37, 0.48	0.45	0.40, 0.50

For Model 1 the c statistic is 0.85; concordance is 82.1% and discordance is 11.9%. Goodness of fit is indicated by <0.78% differences between weighted observed percentages and weighted means of predicted probabilities for each predictor variable. Sum of model weights used is 4,245,279.
For Model 2 the c statistic is 0.86; concordance is 83.1% and discordance is 10.4%. Goodness of fit is indicated by <0.78% differences between weighted observed percentages and weighted means of predicted probabilities for each predictor variable. Sum of model weights used is 4,245,279.
*As defined in Table A-3 of Phibbs et al. 2007.
[†]Urban areas around a core city or town with a population of 10,000 to 49,999.
[‡]Rural area with no urban cluster of at least 10,000 people.

discharges resulted in no meaningful difference in outcome. An iteration of the model without the *hospital* predictor altered the AOR only slightly: with hospital variable AOR = 2.58 (95 percent CI: 2.41, 2.77); without hospital variable AOR = 2.59 (95 percent CI: 2.45, 2.73).

Because the diagnostic criteria used in Model 1 for *congenital malformation* are broad and the distribution of lethal conditions may have been different between insured and uninsured patients, we performed an analysis in which Model 1 was reiterated without adjustment for *congenital malformation* for comparison. The AOR for the uninsured status was 2.5 (95 percent CI: 2.3, 2.7). In addition, we calculated Model 2 (Table 2), which substitutes for *congenital malformation* a variable for *life-threatening congenital anomalies* as defined in Appendix A-3 of Phibbs, Baker, Caughey et al. (2007). The Model 2 AOR for uninsured status was 2.66 (95 percent CI: 2.49, 2.85). Iteration of Model 2 without the life-threatening congenital anomalies predictor resulted in an AOR for uninsured status of 2.68 (95 percent CI: 2.48, 2.88).

Appendix Table S1 displays the results of a weighted multivariable logistic regression analysis in which the PT/LBW/IUGR variable was replaced by a nine-level birth weight (BW) range variable for those discharges for which BW was recorded in the database. The model is limited by the smaller number of observations used for the analysis; however, the AOR for death of uninsured patients is 2.1 (95 percent CI: 1.9, 2.4). To assess for possible bias in the estimate of the AOR for insurance status in the Table 2 model, reiteration of Model 1 was performed on the restricted database that includes the BW and resulted in an AOR for death of uninsured patients of 2.66 (95 percent CI: 2.30, 3.07). Thus, there is a range of AOR estimates for the insurance effect among the models of 19.5 percent; the Model 1 AOR may be an overestimate or an underestimate.

Appendix Table S2 displays the results of Model 1 for the outcome of death in which a five-level variable for payer replaced the two-level insurance variable. With private insurance as the reference, the AOR for *self pay* patients is 2.9 (95 percent CI: 2.7, 3.1) and for Medicaid-insured patients, the AOR is 1.2 (95 percent CI: 1.1, 1.2).

Because NICU annual volume is a predictor of VLBW mortality rate (Phibbs et al. 2007), but the KID database has no variable for NICU volume, a proxy for NICU volume was created and substituted in Model 2 for all other hospital characteristics. As described in Appendix Table S3, adjustment of the model for neonatal death outcome for the NICU volume proxy, as well as for congenital anomalies regarded as life-threatening (Phibbs et al. 2007), results in an AOR of 2.7 (95 percent CI: 2.5, 2.9) for uninsured status.

Table 3: Adjusted Odds Ratios for Admission by Transfer of Neonates Who Subsequently Died, Calculated by Weighted Multivariable Logistic Regression Analysis of the 2006 Kids' Inpatient Database

Variable	*Adjusted Odds Ratio*	*Adjusted 95% Confidence Interval*
Uninsured	0.90	0.85, 0.94
Congenital malformation	5.15	5.03, 5.27
Preterm, low birth weight, or intrauterine growth restriction	3.68	3.59, 3.78
Hypoxia	3.54	3.30, 3.81
Sepsis	2.60	2.51, 2.70
Necrotizing enterocolitis	2.56	2.34, 2.82
Respiratory distress syndrome	2.54	2.45, 2.64
Intraventricular hemorrhage	2.15	1.99, 2.32

The c statistic for the analysis = 0.73; concordance = 64.3%; and discordance = 17.8%.
Sum of model weights used is 4,318,216.

The multivariable logistic regression analyses (Model 1) repeated separately for the outcome of death using the KID 2003 and 2009 databases yielded results that were similar to that of 2006: the AOR values for the predictor *uninsured* were 2.4 (95 percent CI: 2.2, 2.6) in 2003 and 2.9 (95 percent CI: 2.7, 3.1) in 2009.

Admission by Transfer and Resource Allocation

In a separate multivariable logistic regression analysis of KID 2006 for the outcome of admission by transfer (Table 3), admission by transfer was less likely for uninsured than for insured patients with AOR = 0.90 (95 percent CI: 0.85, 0.94); $p < .001$.

Resource allocation in 2006 was less for uninsured than for insured patients (Table 4). Fewer procedures were performed on uninsured than on insured discharges. The adjusted weighted mean LOS was shorter for those who were uninsured than for those who were insured for all discharges (2.7 vs. 3.7 days); for all non-normal discharges (4.5 vs. 7.2 days); and for those who died (2.2 vs. 11.6 days). The adjusted weighted mean LOS for uninsured normal discharges, although significantly shorter than that for normal insureds, was clinically insignificant, that is, 2.01 versus 2.12 days ($p < .001$). Among discharged patients who died, the adjusted weighted mean hospital charge was less for uninsured than for insured discharges ($24,474 vs. 82,673). Complete models for these analyses are described in Appendix

Tables S4 and S5. When a five-level payer variable replaced the two-level insurance status variable in the same model as that reported in Appendix Table S5, the adjusted weighted mean hospital charge for patients insured by Medicaid ($10,533) and by Medicare and *other* ($14,225) exceed and those who were *self pay* ($5,442) and *no charge* ($5,197) are less than the adjusted weighted mean hospital charge for patients insured by private insurers ($8,394). To the extent that weighted charges/day adjusted for the *hospital* variable reflect intensity of care and not differential charge structures for various payers, small but significant differences were noted between the insured and uninsured discharges in the estimated charge/day for all discharged patients and for those that survived (Table 4).

Hospitals Where Deaths Occurred

In unadjusted weighted analyses, uninsured discharged patients who died in 2006 were more likely than insured ones to have died in rural hospitals (8.7 percent vs. 4.2 percent), hospitals without a children's unit (62.7 percent vs. 49.7 percent), and to have been inborn in the hospital where they died than were insured discharged patients who died (78.2 percent vs. 73.0 percent) (Appendix Table S6).

DISCUSSION

Effects of Insurance Status

As expected, the predictors with the largest adjusted risks for death during hospitalization of neonatal patients estimated using the KID 2006 database were clinical conditions commonly encountered in neonatal intensive care units, that is, PT/LBW/IUGR, IVH, hypoxia, NEC, and congenital malformation. In this analysis, uninsured status was the next largest adjusted risk for death, for which the AOR, 2.6, was greater than those for sepsis, obstetrical conditions and complications, RDS, multiple birth, and male gender. Lack of insurance was also a significant predictor of death in analyses of both the 2003 and 2009 KID databases. The estimate of the effect of insurance was not changed in models for the outcome of death that excluded the hospital variable, indicating that the disparity is a within-hospital disparity.

Recent analyses of large U.S. databases have found that health insurance status is a significant determinant of survival of older patients. Adults who were uninsured at the time of participation in the Third National Health and

Table 4: Resource Allocation to Neonatal Discharges, by Insurance Status, in the 2006 Kids' Inpatient Database

Resource	*Uninsured Weighted Mean (±SE)*	*Insured Weighted Mean (±SE)*	*p-Value**
Total procedures, *N*			
All discharges	0.75 (±0.005)	0.92 (±0.001)	<.001
Discharges, died during hospitalization	1.99 (±0.10)	3.79 (±0.04)	<.001
Discharges, survived	0.74 (±0.005)	0.90 (±0.001)	<.001
Adjusted length of stay†, days			
All discharges	2.74	3.66	<.001
All non-normal newborns	4.54	7.19	<.001
Discharges, died during hospitalization	2.22	11.56	<.001
Discharges, survived	2.75	3.62	<.001
Adjusted total hospital charges‡, $			
All discharges	5,401	9,556	<.001
Discharges, died during hospitalization	24,474	82,673	<.001
Discharges, survived	5,267	9,277	.207
Adjusted total hospital charges/day§, $			
All discharges	1,381	1,500	<.0001
Discharges, died during hospitalization	12,677	12,890	.798
Discharges, survived	1,354	1,475	<.0001

**t*-test; in multivariable linear regression analyses for length of stay and for total hospital charges, significance of *t*-test for insurance variable when included in the models described in Appendix Tables S4 and S5, respectively. Additional regressions using a Poisson distribution model for each of the procedures analyses were computed to confirm the significance of the covariate for insurance status in each.

†Predictor variables in weighted multivariable linear regression model for length of stay outcome include the following: insurance status; survival, preterm, low birth weight, intrauterine growth restriction; congenital malformation; sepsis; respiratory distress syndrome; necrotizing enterocolitis; multiple birth cohort; hypoxia; intraventricular hemorrhage; maternal, placental, umbilical cord, or delivery complication; region of hospital; location of patient's county of residence; hospital; hospital bed size; and hospital location/teaching status. Full model is given in Appendix Table S4. Additional adjusted multivariable regressions using a Poisson distribution model for each of the length of stay analyses were computed to confirm the significance of the covariate for insurance status in each.

‡Predictor variables in weighted multivariable linear regression model for total hospital charges include insurance status, survival, length of stay in days, and hospital. Full model is given in Appendix Table S5.

§Adjusted for hospital dummy variable.

SE, standard error.

Nutrition Examination Survey were more likely to die within the following 5 years than were those who were insured, with an adjusted hazard ratio of 1.4 (95 percent CI: 1.1, 1.8). (Wilper et al. 2009). An analysis of two large databases for the years 1988–2005 found an AOR of 1.6 (95 percent CI: 1.5, 1.8) for the outcome of inpatient death for uninsured children compared with insured ones, adjusted for some variables, but not including diagnoses (Abdullah et al.

2010). An analysis of very low birth weight (VLBW) neonates, that is, those of BW <1,500 g, in California in 2000, which included extensive adjustment, including the NICU level of care and annual volume, found an increased risk of death for uninsured patients, with AOR 1.20 (95 percent CI: 1.04, 1.39) (Phibbs et al. 2007). Following discharge of neonates from an NICU affiliated with the NICHD Neonatal Research Network, unknown maternal insurance status was a predictor of the adjusted infant mortality rate among extremely LBW infants (De Jesus et al. 2012).

Analyses of registry databases also demonstrated an increased mortality risk for uninsured patients. In a study of 37 children's hospitals, inpatients who were self pay ones were more likely to die than were those who had insurance, with unadjusted ORs of 8.7 for neonates and 1.6 for all children (Slonim et al. 2010). Lack of insurance was found to be associated with comparably higher odds of death among 174,921 children who experienced trauma and who were included in the National Trauma Data Bank in 2002–2006 (Rosen et al. 2009). The AOR for death of uninsured children compared with commercially insured children was 3.3 (95 percent CI: 3.0, 3.7).

Expansion of state Medicaid eligibility for adults in three states since 2000 compared with neighboring states that did not expand Medicaid programs was associated with reduced adjusted all-cause mortality for adults aged 20–64 years (Sommers, Baicker, and Epstein 2012).

Access to Neonatal Intensive Care and Resource Allocation

One possible explanation for the increased odds of death associated with lack of insurance is decreased access to neonatal intensive care (Phibbs et al. 1996, 2007; Cifuentes et al. 2002; Lasswell et al. 2010). In this analysis of KID 2006 adjusted for diagnoses, uninsured discharged patients were less likely than were insured ones to have been admitted by neonatal transfer (Table 3). This may have occurred because high-risk pregnancies had been transferred before delivery to appropriate facilities. However, uninsured neonates who died were more likely than insured neonates who died to die in rural hospitals without children's units (Appendix Table S6). Thus, uninsured neonates whose mothers were not transferred before delivery may not have gained universal access to regionalized perinatal care. Further investigation of linked maternal and neonatal records is needed to resolve this issue.

Regionalized perinatal health care is a voluntary system of referrals of obstetric and neonatal patients within a geographic area to the most appropriate care facility, which has evolved to reduce neonatal mortality and morbidity

(Lorch, Myers, and Carr 2010; American Academy of Pediatrics Committee on the Fetus and Newborn 2012). Optimally, pregnant women with high-risk pregnancies, such as imminent preterm delivery, are referred to regional perinatal centers staffed by maternal-fetal medicine specialists, as well as neonatologists and other specialists in a neonatal intensive care unit (NICU). Less optimally, neonates with potentially life-threatening conditions are transported from a birth hospital to an NICU for care. Delivery of preterm pregnancies in facilities with maternal-fetal medicine and neonatology services is associated with lower neonatal mortality and morbidity than delivery in a facility without these specialists, even if infants subsequently are transferred to a NICU (Warner et al. 2004). NICUs provide various levels of care and may have only a few high-risk infants or a high volume of such patients. Mortality among VLBW infants is lowest for deliveries that occur in hospitals with NICUs that have both a high level of care and a high volume of patients (Phibbs et al. 2007). In California, where there is evidence of deregionalization of perinatal services, which might be expected to increase access to service, the volume of patients under care at a facility had a greater effect on neonatal survival than did level of care (Chung et al. 2010, 2011). Deregionalization that results in lower volume perinatal/neonatal services might experience higher odds of in-hospital mortality of fetuses and neonates despite providing higher levels of care.

Referral of a pregnant patient requires that decisions be made by both primary obstetrician and the patient (Bronstein et al. 2011). In the United States, where differences in perinatal regionalization approaches among states exist, there are differential benefits regarding death rate and complications for neonates of 23–37 weeks' gestational age associated with being delivered at a high-level NICU (Lorch et al. 2012). However, not all identifiable high-risk pregnancies are referred to an appropriate center. For example, in California in 2000, 21.2 percent of VLBW infant deliveries occurred in hospitals that were not equipped to provide mechanical ventilation (Phibbs et al. 2007). In Arkansas during 2001–2006, only 52.7 percent of newborn infants born before 33 weeks gestation were delivered in hospitals that were staffed by neonatologists (Bronstein et al. 2011).

In the absence of a high-risk pregnancy referral to an appropriate center for delivery, moreover, not all infants who after birth require NICU care are transferred to an NICU. The responsible physician must make a determination to transfer the infant or not, and if so, to which facility and when. The possibility of transfer may depend on location of the birth hospital and distance to an appropriate level NICU, timely availability of transportation, and an identifiable payer for a potentially lengthy and expensive hospitalization at the accepting NICU.

A second possible explanation for the increased risk of death associated with lack of insurance is that resource utilization was reduced for uninsured patients, wherever they were cared for. Indeed, uninsured discharged patients had shorter adjusted lengths of stay than did insured ones, and those who died had lower hospital charges than did insured discharged patients who died, adjusted for LOS (Table 4). A study of all discharged newborns in California in 1987 with evidence of serious medical problems found that sick newborns without insurance received fewer inpatient services than did privately insured newborns, although they were at higher medical risk (Braveman et al. 1991). However, a more recent study in Michigan, a state with a low rate of uninsured children, found that when uninsured and publicly insured neonates were grouped together for analysis, their hospital stays, charges, and death rates exceeded the respective rates for privately insured neonates, findings that may be attributable to the preponderance of publicly insured patients in the combined group (Peterson et al. 2011).

A third possible explanation of the disparity in outcomes between the uninsured and insured patients is that LOS for patients initially admitted as uninsured biased the results. Uninsured infants who survived and whose LOS were sufficiently long and costly to make them eligible for Medicaid prior to discharge became Medicaid discharges, whereas those with short LOS because of death may have remained Medicaid ineligible and were uninsured discharges.

An alternative interpretation of this analysis is that discharges in the KID databases for which the expected primary or secondary payer was coded as *self pay* or *no charge* represented default coding for patients whose payer was not identified at the time of discharge or closure of the administrative record, but not necessarily lack of insurance or eligibility for it. It is possible that some neonates who did not qualify for Medicaid at discharge subsequently qualified because of spend-down of family resources; however, at the time care decisions were made, the primary and secondary insurance status would have been uninsured or unknown.

If, indeed, hospitalized neonates classified as uninsured in this analysis subsequently were found to be eligible for insurance for their hospitalizations, then the interpretation of this analysis would be that neonates with serious conditions whose expected primary and secondary payers had not yet been identified had reduced access to regionalized neonatal care and health care resources and, consequently, greater risk of death. Arguments against the interpretation that *self pay* and *no charge* do not represent lack of insurance, however, are that a hospital had two opportunities to record an expected payer, that is, both a primary and a secondary payer; that the neonatal uninsured rate of 5.4 percent in this analysis is less than the estimated 14 percent infant uninsured rate in the United States in 2006 (Kaiser Commission on Medicaid and the Uninsured 2007); and that admission of pregnant mothers of the infants who were subsequently born provided advance notice and incentive for hospitals to identify insurance, if any, that would reimburse for the impending hospitalization of the infants. Moreover, HCUP organizers have sufficient confidence that the collection of expected payer data in State Inpatient Databases, the source of HCUP data, is sufficiently complete when compiled to make valid an analysis of all uninsured discharges, including adults and newborns, using the 2008 Nationwide Inpatient Sample (Stranges, Kowlessar, and Davis 2011).

Socioeconomic Position, Relative Isolation, and Race

Socioeconomic position, place of residence, race, and health insurance status are interrelated factors, each of which may independently predict the hospital death of a newborn, adjusted for clinical predictors and each other. However, it is difficult to separate the effect of lack of health insurance in the United States from socioeconomic conditions that may predispose to that condition. A significant unadjusted association exists in this analysis between uninsured status and the distribution of median household income indicated by ZIP code toward lower quartiles; a separate association exists between uninsured status and rural residence (Table 1). Measures of poverty, income inequality, and social deprivation, not including health insurance status, have been associated with adverse neonatal or infant survival risks (Singh and Kogan 2007; Olson et al. 2010). In England, a nation with universal health insurance, the most deprived socioeconomic decile in 2006–2007 experienced a rate of 35.9 neonatal deaths per 10,000 live births compared with 14.9 per 10,000 live births for the least deprived decile (Smith et al. 2010).

Our main analysis does not include race as a predictor. Although large national datasets have the potential to disentangle race from socioeconomic position, place of residence and health insurance status as an independent factor in health disparities (Griffith, Neighbors, and Johnson 2009), too many states do not permit inclusion of this variable in the KID databases for evaluation of race in our main analysis. Moreover, race as coded in hospital administrative databases may not reflect a parent's self-assignment, but that of an observer. Analyses of vital statistics and study cohorts have found higher neonatal and/or infant mortality rates for infants born to black mothers than for those born to white mothers (Bruckner et al. 2009; Mathews and MacDorman 2010). Black newborn infants in linked national birth/death datasets had a greater unadjusted risk of dying during infancy than did white infants (Mathews and MacDorman 2010). In California, the neonatal mortality rate among VLBW infants was greater for non-Hispanic black infants than for non-Hispanic white infants, adjusted for maternal characteristics, including health insurer (Bruckner et al. 2009), but no racial difference in risk-adjusted mortality rates of VLBW neonates in minority-serving hospitals in the Vermont Oxford Network from 1995 to 2000 was identified (Morales et al. 2005). In the Bruckner et al. 2009 study, the AOR for death among neonates born to mothers whose insurer was unknown or missing was 1.6 (95 percent CI: 1.2, 2.1) relative to those who had insurance, adjusted for race. The lower proportion of PT/LBW/IUGR discharges among the uninsureds (Table 1) may reflect a greater proportion of immigrant Hispanics among them, as suggested by the restricted sample analysis. Immigrant Hispanics have a lower rate of low birth weight (Fuentes-Afflick, Hessol, and Pérez-Stable 1998).

The main strengths of this analysis are the very large databases that are intended to represent the entire United States and are rich in recorded variables, permitting extensive adjustment and analysis. The weaknesses are as follows: the databases are administrative ones that may contain errors made by the reporting hospitals; some variables of potential interest, such as race, birth weight, gestational age, postnatal age at death, and hospital identification, are not reported by all states, and others, such as parental education and occupation, are not included, and the available measure of family income may incompletely adjust for socioeconomic position (Braveman et al. 2005; Blumenshine et al. 2010). Because the maximum number of diagnoses reported in the KID databases varies by state, the adjustment for diagnoses may be inconsistent. Certain of the diagnoses used for adjustment, that is, RDS, sepsis, NEC, and IVH, may be censored in instances of death soon after birth.

In summary, there was increased risk of death among uninsured hospitalized neonates in the United States that was not explained by the major clinical causes of neonatal death. High-risk neonates for whom no insurer had been identified may have had restricted access to appropriate care.

This analysis of neonatal discharges adds to a growing body of evidence that lack of insurance affects mortality by limiting access to appropriate medical care. For neonates, improved access to care will depend on the development of a regionalized system that optimizes births and neonatal care in the most appropriate facilities, which the present voluntary system does not do. The health care reforms called for in the Patient Protection and Affordable Care Act (U.S. Government Printing Office 2010) may have a small impact on delivery of perinatal care if an expansion of insured lives results in currently uninsured neonates being known to be insured at birth.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Table S1. Adjusted Odds Ratios of Predictors of Death of Neonatal Patients in the 2006 Kids' Inpatient Database Estimated by Weighted Multivariable Logistic Regression Analysis, Adjusting for Birth Weight

Table S2. Adjusted Odds Ratios of Predictors of Death of Neonatal Patients in the 2006 Kids' Inpatient Database Estimated by Weighted Multivariable Logistic Regression Analysis, Adjusted for Five Payer Categories

Table S3. Adjusted Odds Ratios of Predictors of Death of Neonatal Patients in the 2006 Kids' Inpatient Database Estimated by Weighted Multivariable Logistic Regression Analysis, Adjusted for Life-Threatening Congenital Anomalies* and for a Proxy of NICU Annual Volume†

Table S4. Weighted Multivariable Linear Regression Analysis for Mean Length of Stay of Neonatal Discharges in the 2006 Kids' Inpatient Database

Table S5. Weighted Multivariable Linear Regression Analysis for Mean Hospital Charges of Neonatal Discharges in the 2006 Kids' Inpatient Database

Table S6. Comparison of Hospitals Where Neonatal Patients Died, by Insurance Status, Estimated by Weighted Univariate Frequency Distribution Analyses of the 2006 Kids' Inpatient Database

Appendix SA1: Author Matrix.