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Time Trends and Payer Differences in Lengths of Initial Hospitalization for Preterm Infants, Arkansas 2004–2010

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Abstract

Objective—To examine the time trend in length of stay (LOS) and explore potential differences in neonatal LOS by insurance type for preterm infants in Arkansas between 2004 and 2010.

Study Design—There were 18,712 preterm infants included in our analyses. Accelerated failure time (AFT) models were used to model neonatal LOS as a function of insurance type and discharge year while adjusting for key maternal and infant characteristics, and **complication/anomaly indicators**.

Results—Prior to adjusting for the complication/anomaly indicators, the LOS for preterm infants delivered to mothers in the Medicaid group was 3.2% shorter than those in the private payer group. Furthermore, each subsequent year was associated with a 1.6% increase in the expected LOS. However, after accounting for complications and anomalies, insurance coverage differences in neonatal LOS were not statistically significant while the trend in LOS persisted at a 0.59% increase for each succeeding year.

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Conclusion—All of the apparent differences in LOS by insurance type and more than half of the apparent increase in LOS over time are accounted for by higher rates of complications among privately insured preterm infants and increasing rates of complications for all surviving preterm infants between 2004 and 2010.

Keywords

Length of stay; preterm infants; accelerated failure time model; time trend

BACKGROUND

In 2011, approximately 12% ($n = 474,431$) of all live births in the United States were preterm (less than 37 completed weeks of gestation). Despite recent declines in the total preterm birth rate since 2006, current rates are higher than those of the 1980s and 1990s.¹ Preterm infants are at greater risk of disability and death than infants born term and near-term, and place a burden of over 2 billion dollars on the U.S. health care system annually.^{2,3} These newborns often receive the highest-level care in labor suites and neonatal intensive care units (NICUs) to minimize morbidity and mortality. Although some of these newborns are discharged within hours or days, many remain chronically and acutely ill in the NICU for weeks, months, or longer depending on individual patient treatment needs.^{4,5}

Prolonged hospitalization of preterm infants compared to term and near-term newborns contributes significantly to the high neonatal hospital costs associated with prematurity.^{2,6} Patient length of stay (LOS) serves as a useful measure of healthcare system performance⁷, and is a primary driver of neonatal hospital costs. Patterns in the allocation of scarce resources within the neonatal system in particular are reflected in LOS trends, among other indicators.⁸ Prior research studies estimate that overall mean LOS for all births may have increased over time, with significant variation among demographic groups.^{9,10,11}

Potential reasons for variation in neonatal LOS can be categorized into perinatal risk factors, infant medical indications, and hospital characteristics. Well-established perinatal risk factors which influence LOS include obstetric considerations such as type of delivery, delivery procedures, and delivery complications, as well as maternal characteristics, most notably insurance status.^{4,9,12,13} Infant medical indications include gestational age, birth weight, and pathological conditions such as hematologic, cardiac, and neurological issues, respiratory distress syndrome, bronchiopulmonary dysplasia, apnea crises, and infection.^{4,6} Hospital characteristics with evidence of significant effects on LOS include local care management practices, unit census, and provider beliefs.^{13,14,15,16,17}

This study examines the time trend in LOS and also explores potential differences in neonatal LOS by insurance type (Medicaid and privately insured) for preterm infants in Arkansas between 2004 and 2010.

METHODS

Data

We analyzed newborn hospital discharges for Arkansas from January 1, 2004 to December 31, 2010 linked to birth records obtained from the hospital discharge and vital records databases of the Arkansas Department of Health (ADH). Vital records through calendar year 2010 were final data. Of 268,030 baby discharges, 246,816 were matched to birth certificates, for a rate of 92.1%. We used hospital discharge records as the source of data for pregnancy complications and infant morbidities, because birth records often under-report complications of pregnancy, labor and delivery.^{18,19,20}

In practice there is a common set of major congenital anomalies that physicians can identify right after delivery, such as anencephaly, spina bifida, and gastroschisis.²¹ We took these anomalies into account, and a list of neonatal complications, using a combination of input from maternal fetal medicine practitioners, neonatologists, and the work produced by Gregory and colleagues (2002).²² Due to the sparseness of any one of these anomalies or complications in our study, indicator variables were created based on body systems for anomalies and clinically similar diagnoses for complications. The congenital anomaly rates and ICD-9-CM diagnosis codes are shown in Appendix 1 while complication rates and codes are provided in Appendix 2.

We coded deliveries as PROM if premature rupture of membranes was flagged on the birth certificates, and coded deliveries as indicated if PROM was not flagged but the birth certificate indicated that the birth was induced, performed via cesarean section, or both. In assessing LOS, clinical estimates of gestational age were used. Then, in order to account for any additional impact of fetal growth restriction or macrosomia (small or large for gestational age) on LOS, infants were placed into one of eight gender-gestational age birth weight centile categories based on Olsen and colleagues (2010).²³ Because we had an interest in assessing payer differences in length of stay, we excluded the records of 33,674 infants with payer coded as “other.” Of the 213,142 remaining matched infants, 18,712 singleton live birth infants were identified as having a gestational age between 24 and 36 weeks with recorded birth weights that were reasonable for gestational age (based on Alexander et al 1996).²⁴ This included 12.1% of singleton infants covered by Medicaid and 9.1% of singleton infants covered by private insurance, for an overall singleton preterm rate of 11.0%.

Statistical Analysis

The event of interest is the infant’s discharge-to-home date, and the infant’s length of stay (LOS) is measured as the difference between discharge date and birth date. However, there were infants who were censored due to incomplete data. This arose from three different scenarios: 1) infants who died prior to discharge, 2) infants who were transferred to another hospital, or 3) infants who had an unusually short LOS given their birth weight and gestational age (LOS=1–2 days, birth weight < 2,000 grams, and gestational age < 34 weeks). We assume that this latter group either was transferred or died prior to discharge, but the transfer or deceased codes were not included on the discharge data.

Initially, bivariate analyses were performed to assess the distribution of key maternal variables such as race, marital status, and maternal age group along with infant gender and delivery modality across payer type using Pearson's chi-square statistic or a Cochran-Mantel-Haenszel statistic based on mid-ranks to account for ordinality in the data. Next, the Kaplan-Meier (KM) product limit estimator was used to estimate the mean LOS and standard deviation for each payer group due to censoring and because the LOS data were positively skewed. In addition, the log-rank test was used to evaluate equal LOS distributions between the two payer groups. Next, the accelerated failure time (AFT) model approach was used to analyze LOS where data were fitted to various parametric models including log-normal, log-logistic, and Weibull distributions.²⁵ From these models, log-likelihood statistics along with Akaike's information criterion (AIC) were calculated to assess the adequacy of the fitted data. All three of these models included the following base set of predictor variables: payer type, discharge year, gestational age, gender specific birth weight for gestational age centile, gender, maternal age category, maternal race, marital status, and delivery mode. The congenital anomaly and complication group indicator variables were added to the base AFT model to evaluate potential payer type differences and trends in LOS. While investigating time trends and potential differences in neonatal LOS by insurance payer type were the main objectives, we also performed exploratory analyses in time trends for the complication and anomaly indicators themselves using logistic regression.

RESULTS

As noted, there were 18,712 preterm infants included in our analyses whose gestational age ranged between 24 and 36 weeks. The average birth weight was 2,464 grams (SD = 697). The majority of infants (69%) were born to mothers in the Medicaid payer group. Table 1 summarizes the descriptive measures for key maternal characteristics, infant gender, and delivery modality. Generally, mothers in the Medicaid group tended to be younger, single, and non-Caucasian compared to the privately insured group (all p-values < 0.0001). Additionally, mothers in the Medicaid group delivered slightly more female preterm infants (p=0.0014) over the span of seven years. With respect to delivery modalities, there exists an association between payer type and delivery mode (p<0.0001). In general, mothers in the privately insured group had a higher proportion of indicated relative to either PROM or spontaneous deliveries. On the other hand, spontaneous deliveries represented the most frequently occurring delivery modality in the Medicaid group.

Table 2 summarizes descriptive trends in gestational age, birth weight centile, complications, and anomalies by payer type across the discharge year. In this initial descriptive assessment, for simplicity, a composite sum for both complications and anomalies were used. In general, mothers in the Medicaid group tended to deliver a slightly higher percentage of very preterm infants (i.e., gestational age < 32 weeks) and infants in the lower birth weight centile (i.e., < 25th centile) compared to the privately insured mothers. Conversely, the privately insured mothers delivered preterm infants with marginally more complications. Both payer groups displayed an increase in the average number of complications over the duration of our study period.

The Kaplan-Meier mean LOS estimate for preterm infants in the Medicaid group was 9.6 (0.17) days and 9.1 (0.22) days for the privately insured group. The results based on the log-rank test indicated no statistical difference in mean LOS for this unadjusted model ($p=0.5005$). Next, an AFT model was used to investigate potential trends in LOS across the discharge years and between payer types while adjusting for some key maternal and infant covariates and censoring. Among the 5,842 preterm infants in the private payer group, ~10.5% (~1% due to death; ~8.8% due to transfer; and ~0.7% due to “assumed death/transfer”) were censored. Similarly, among the 12,870 preterm infants in the Medicaid group, ~12.9% (~0.9% due to death; ~10.4% due to transfer; and ~1.6% due to “assumed death/transfer”) were censored. Therefore, there does not appear to be any systematic differences between the private payer group and the Medicaid group with respect to the causes of censoring. Using the AIC, the log-normal distribution provided the best relative fit to our data. Therefore, only the parameter estimates from the log-normal AFT model are presented. The results using the base set of predictors are provided in Table 3. A positive (negative) regression coefficient implies a longer (shorter) time to hospital discharge. On average, infants from the Medicaid group had shorter LOS, adjusting for other covariates. More specifically, controlling for other covariates in the model, the expected time for infants to be discharged to go home among those in the Medicaid group was 3.2% ($p=0.0198$) shorter than that for those in the private payer group.

Additionally, during our study period between 2004 and 2010, each additional year is associated with a 1.6% ($p<0.0001$) increase in the expected LOS while holding all other predictors constant. Of the infant variables, gestational age and birth weight centile were highly significant. As expected, LOS decreases as gestational age increases (i.e., a 30% reduction in LOS for each week increase in gestational age). For the birth weight centile variable, the 50th percentile (median) was used as the reference group. The expected LOS for infants in the lower centile groups was longer than for those in the 50th centile. In contrast, infants in the upper centile groups had shorter expected LOS. Delivery modality was also statistically significant in the base AFT model. Both indicated and PROM deliveries were associated with approximately a 30% increase in LOS as compared to spontaneous deliveries. Infants of older mothers had longer lengths of stay than infants of mothers between ages 20 and 34, and infants of Caucasian mothers had longer lengths of stay than infants of non-Caucasian mothers.

Table 3 also provides the results from our log-normal AFT model with the inclusion of the complication/anomaly indicators. Ten anomaly and ten complication indicators were added to the model. Adjusting for these indicators, the model implied no differences in expected LOS between payer types ($p=0.3304$). While the increase in LOS over subsequent years remained statistically significant ($p=0.010$), the expected LOS percentage increase from year to year was only 0.59%.

To further investigate the non-significant payer type predictor with the inclusion of the risk indicators and the slightly increasing trend in complications found in the descriptive Table 2, individual logistic regression models were used where the congenital anomaly and complication indicators were the dependent variables. The set of predictor variables was the same as for the base AFT model. The complete tables of results based on the logistic

regression models are provided in Appendices 3 and 4. For congenital anomalies, the *eye*, *ear*, *gastrointestinal*, and *other* groupings had numerical problems with quasi-complete separation of data due to low event frequencies. Of the remaining six anomaly indicators, there were no statistical differences between payer types. However, the odds of having a congenital anomaly from the *cardiovascular* class increased by 34% (95% CI: 26%–43%) with each subsequent year between 2004 and 2010.

Of the ten complication class indicators, only the *birth trauma* grouping displayed quasi-complete separation of data points. Three of the complication indicators were statistically significant between payer types with the privately insured group having higher odds of a complication of the class *hypoxia/asphyxia/respiratory*, *hemorrhage/hemolysis/endocrine/jaundice/hematologic*, and *other ill-defined conditions originating in the perinatal period* as compared to the Medicaid group, controlling for gestational age, birth weight for age, and other factors. Only the *maternal causes of perinatal morbidity/mortality* and *other ill-defined conditions* indicator groupings did not display an increase in the odds of having that type of complication with each subsequent year. For example, the odds of having a complication from the *hypoxia/asphyxia/respiratory* class increased by 5.4% (95% CI: 3.6% – 7.2%) with each passing year.

The results from our complication/anomaly indicator analyses provide an insight as to why the association between payer type and LOS appears to be eliminated in the AFT model after adjusting for these factors. The association between payer type and LOS is explained by the fact that privately insured mothers deliver preterm infants with more complications. Preterm neonates with cardiovascular defects were an increasing portion of the pool of surviving infants over this time period, and the frequency of surviving neonates with all types of complications also increased over time.

DISCUSSION

This examination of trends in LOS for preterm infants delivered in Arkansas between 2004 and 2010 indicates a time trend towards longer lengths of stay across both infants with private insurance and those covered by Medicaid. Although neither gestational age nor birth weight for gestational age distributions changed appreciably over time in this preterm population, there were certain classes of complications and anomalies that did show an increase in occurrence.

Taking maternal demographics and infant gestational age and birth weight for gestational age into account, infants covered by Medicaid had on average slightly shorter LOS than infants covered by private insurance. At the same time, infants covered by Medicaid were more frequently delivered spontaneously or after maternal PROM, and less likely to have an indicated delivery. Controlling for other factors, infants covered by Medicaid had fewer complications recorded in the hospital discharge record than infants covered by private insurance. When complications and anomalies were taken into account, insurance coverage differences in neonatal LOS were not statistically significant. The reasons why preterm infants covered by Medicaid have fewer complications at the same gestational age, birth weight and delivery mode as privately insured infants is not clear, but it is possible that

factors associated with the lower socioeconomic status of the Medicaid covered population result in the early delivery of infants who would otherwise be carried to term in a less disadvantaged population. As noted, the portion of Medicaid-covered infants born before 37 weeks gestation was substantially higher than that of privately insured infants.

In general, for many classes of complications and for anomalies from the *cardiovascular* class, the frequencies increased between 2004 and 2010 in this surviving hospitalized neonatal population; this is the primary driver of the increase in LOS. It seems likely that the increase over time in neonatal morbidity is related to a decrease in mortality among preterm infants over this time period. In a recent report based on state vital records, the Arkansas Department of Health reported a 28.2% decline in mortality for infants born between 28 and 31 weeks gestation, from 203.2 per thousand to 145.9 per thousand between 2003 and 2009.²⁶ Although controlling for these measures of morbidity in the analysis reduced the predicted annual differences in LOS from 1.6% to **0.59%** annually, the trend of longer LOS over time remains statistically significant, and may be related to trends in neonatal management protocols.

In this study, LOS for a preterm infant was considered censored if he/she died prior to hospital discharge, transferred to another hospital, or was presumed to have died or been transferred. Some researchers might contend that infants who died should not have been censored and that there exists too much uncertainty in our presumed death or transferred mechanism. Therefore, as a sensitivity analysis, we also estimated our AFT survival model where only those preterm infants with a transfer indicator were deemed to be censored. The results using this censoring mechanism were consistent with the ones presented in Table 3. That is, after adjusting for complication and anomaly risk indicators, there was not a difference in LOS between payer types and the expected LOS percentage increased 0.46% per year. These results were not surprising since transferred infants accounted for much of the censoring in our original analyses.

LIMITATIONS

There are two important limitations to the data used in this analysis. First, we were unable to follow infants from their birth hospital to any transfer hospital; ideally days of stay in the transfer hospital would be added to days in the birth hospital to estimate a total length of stay from delivery. Instead in this survival analysis, we considered cases that ended in transfer to be censored, as in cases that ended in death. This enabled us to retain the cases in our analysis and to take into account the fact that we did not observe the entire length of stay for those infants.

A second limitation is that hospital identification was not included in the data, so that we could not take into account the impact that hospital characteristics might have on length of stay. Elsewhere we have shown a general increase in the portion of preterm infants delivered at hospitals with neonatology staffing over this period in Arkansas.²⁷ Increases in the portion of preterm infants treated in such facilities may account for improved survival rates, and may also help to explain that portion of the increase over time in LOS that is not accounted for by increased morbidity.

CONCLUSION

The substantial improvements in preterm infant mortality that occurred in Arkansas in the last decade were accompanied by a lengthening of about 1.6% annually in length of hospital stay of these newborns after delivery. Over half of this change is accounted for by measurable increases in morbidity in the neonatal population. The remaining portion of the change cannot be accounted for by the data available here, but may be due to changes in management protocols and/or an increase in the portion of preterm infants cared for in specialty settings. There is no evidence that neonatal hospital resources are being distributed differentially by insurance type, once differing characteristics of preterm infants in different insurance types are taken into account.

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Abbreviations

NICU	neonatal intensive care unit
LOS	length of stay
ADH	Arkansas Department of Health
PROM	premature rupture of membrane
KM	Kaplan-Meier
AFT	accelerated failure time
AIC	Akaike's information criterion

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Table 1

Bivariate analysis of maternal characteristics, infant gender, and delivery mode

	Medicaid		Privately Insured		p-value
	N	%	N	%	
Mother's age					<0.0001
< 18	880	6.8%	26	0.4%	
18–19	1936	15.0%	95	1.6%	
20–34	9318	72.4%	4793	82.0%	
35+	736	5.7%	928	15.9%	
Married	4703	36.6%	5170	88.5%	<0.0001
Caucasian	7503	58.3%	4862	83.2%	<0.0001
Infant gender					0.0014
Female	6294	48.9%	2710	46.4%	
Delivery mode					<0.0001
PROM	1111	8.6%	456	7.8%	
Indicated	5609	43.6%	3058	52.3%	
Spontaneous	6150	47.8%	2328	39.8%	

Note: PROM (premature rupture of membranes)

Table 2
Descriptive measures for gestational age group, birth weight centile, and composite complication and anomaly count

	Payer	2004	2005	2006	2007	2008	2009	2010
Gestational Age, N(%)								
24	Medicaid	10 (0.6%)	30 (1.7%)	17 (0.9%)	13 (0.7%)	13 (0.7%)	27 (1.4%)	10 (0.5%)
	Private	3 (0.3%)	10 (1.1%)	9 (1.0%)	8 (0.8%)	12 (1.4%)	3 (0.4%)	3 (0.5%)
25–28	Medicaid	84 (5.3%)	90 (5.0%)	90 (4.8%)	75 (4.0%)	92 (4.8%)	83 (4.3%)	93 (4.9%)
	Private	25 (2.9%)	31 (3.6%)	33 (3.6%)	36 (3.7%)	27 (3.1%)	29 (4.0%)	29 (4.6%)
29–32	Medicaid	162 (10.3%)	192 (10.6%)	213 (11.3%)	198 (10.6%)	206 (10.7%)	231 (12.1%)	209 (11.1%)
	Private	97 (11.2%)	67 (7.7%)	99 (10.8%)	90 (9.2%)	84 (9.7%)	54 (7.5%)	61 (9.8%)
33–34	Medicaid	267 (17.0%)	313 (17.2%)	333 (17.7%)	323 (17.3%)	344 (17.8%)	331 (17.3%)	356 (18.9%)
	Private	141 (16.3%)	124 (14.2%)	143 (15.6%)	189 (19.4%)	160 (18.4%)	109 (15.1%)	113 (18.1%)
35–36	Medicaid	1049 (66.7%)	1193 (65.6%)	1224 (65.2%)	1262 (67.5%)	1278 (66.1%)	1242 (64.9%)	1217 (64.6%)
	Private	598 (69.2%)	639 (73.4%)	633 (69.0%)	652 (66.9%)	585 (67.4%)	528 (73.0%)	418 (67.0%)
Centile, N(%)								
3 rd pct	Medicaid	32 (2.0%)	45 (2.5%)	55 (2.9%)	41 (2.2%)	44 (2.3%)	54 (2.8%)	55 (2.9%)
	Private	23 (2.7%)	20 (2.3%)	23 (2.5%)	17 (1.7%)	14 (1.6%)	14 (1.9%)	15 (2.4%)
10 th pct	Medicaid	72 (4.6%)	79 (4.4%)	83 (4.4%)	85 (4.5%)	77 (4.0%)	77 (4.0%)	107 (5.7%)
	Private	34 (3.9%)	38 (4.4%)	36 (3.9%)	26 (2.7%)	26 (3.0%)	31 (4.3%)	24 (3.9%)
25 th pct	Medicaid	176 (11.2%)	213 (11.7%)	218 (11.6%)	234 (12.5%)	210 (10.9%)	215 (11.2%)	203 (10.8%)
	Private	78 (9.0%)	80 (9.2%)	76 (8.3%)	83 (8.5%)	71 (8.2%)	76 (10.5%)	64 (10.3%)
50 th pct	Medicaid	419 (26.7%)	464 (25.5%)	514 (27.4%)	499 (26.7%)	503 (26.0%)	530 (27.7%)	518 (27.5%)
	Private	198 (22.9%)	188 (21.6%)	188 (20.5%)	231 (23.7%)	190 (21.9%)	159 (22.0%)	143 (22.9%)
75 th pct	Medicaid	409 (26.0%)	490 (27.0%)	477 (25.4%)	530 (28.3%)	553 (28.6%)	526 (27.5%)	533 (28.3%)
	Private	223 (25.8%)	268 (30.8%)	245 (26.7%)	283 (29.0%)	260 (30.0%)	185 (25.6%)	185 (29.7%)
90 th pct	Medicaid	243 (15.5%)	273 (15.0%)	285 (15.2%)	265 (14.2%)	291 (15.1%)	269 (14.1%)	252 (13.4%)
	Private	153 (17.7%)	146 (16.8%)	176 (19.2%)	159 (16.3%)	161 (18.6%)	146 (20.2%)	97 (15.5%)
97 th pct	Medicaid	120 (7.6%)	145 (8.0%)	124 (6.6%)	112 (6.0%)	136 (7.0%)	125 (6.5%)	119 (6.3%)
	Private	82 (9.5%)	78 (9.0%)	98 (10.7%)	93 (9.5%)	90 (10.4%)	58 (7.5%)	54 (8.7%)
> 97 th pct	Medicaid	101 (6.4%)	109 (6.0%)	121 (6.5%)	105 (5.6%)	119 (6.2%)	118 (6.2%)	98 (5.2%)
	Private	73 (8.5%)	53 (6.1%)	75 (8.2%)	83 (8.5%)	56 (6.5%)	54 (7.5%)	42 (6.7%)

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	Payer	2004	2005	2006	2007	2008	2009	2010
Complications, mean $\pm$ SD	Medicaid	1.21 (1.40)	1.35 (1.55)	1.36 (1.49)	1.27 (1.45)	1.46 (1.67)	1.52 (1.63)	1.40 (1.48)
	Private	1.29 (1.40)	1.47 (1.52)	1.47 (1.49)	1.47 (1.49)	1.55 (1.66)	1.54 (1.61)	1.56 (1.55)
Anomalies, mean $\pm$ SD	Medicaid	0.03 (0.19)	0.03 (0.20)	0.04 (0.22)	0.03 (0.19)	0.05 (0.23)	0.05 (0.26)	0.06 (0.29)
	Private	0.03 (0.21)	0.03 (0.18)	0.03 (0.20)	0.04 (0.22)	0.05 (0.24)	0.05 (0.26)	0.08 (0.33)

Note: PCT (percentile); SD (standard deviation)

Table 3

Log-normal accelerated failure time model results

	Base Set Model		Base Set + Risk Indicator Model ^a	
	Estimate	p-value	Estimate	p-value
Main predictors of interest				
Medicaid	−0.0321	0.0198	0.0109	0.3304
Year	0.0159	<0.0001	0.0059	0.0100
Maternal/Infant/delivery factors				
Female	−0.0208	0.0588	0.0125	0.1624
Gestational age	−0.3583	<0.0001	−0.2435	<0.0001
Birth weight centile (ref: 50 th)				
3 rd centile	0.9377	<0.0001	0.7670	<0.0001
10 th centile	0.5579	<0.0001	0.4311	<0.0001
25 th centile	0.2420	<0.0001	0.1798	<0.0001
75 th centile	−0.1249	<0.0001	−0.0842	<0.0001
90 th centile	−0.1964	<0.0001	−0.1475	<0.0001
97 th centile	−0.2806	<0.0001	−0.2246	<0.0001
> 97 th centile	−0.4169	<0.0001	−0.3232	<0.0001
Mother's age group (ref: 20 – 34)				
< 18	0.0152	0.5717	0.0129	0.5522
18 – 19	−0.0013	0.9435	−0.0079	0.5977
35	0.0412	0.0367	0.0343	0.0321
Married	0.0236	0.0773	0.0027	0.8051
Caucasian	0.0649	<0.0001	0.0008	0.9391
Delivery mode (ref: spontaneous)				
PROM	0.2985	<0.0001	0.1735	<0.0001
Indicated	0.2684	<0.0001	0.1748	<0.0001

Note: For simplicity, estimates for ten congenital anomaly and ten complication indicators were not included in the table. For binary variables such as payer type or infant gender, e^{β} provides the estimated ratio of the expected LOS for the two groups. For quantitative variables like year and gestational age, $100 \times (e^{\beta} - 1)$ gives the percent increase/decrease in the expected LOS for each unit increase in the variable.

Appendix 1

Congenital Anomaly Indicators, Rates, and ICD-9-CM Diagnosis Codes

	Rate (Number per 1,000 births)	ICD-9-CM Codes
Group 1: Central Nervous System (Anencephalus, Spina bifida without anencephalus, Hydrocephalus without Spina Bifida, Encephalocele, Microcephalus)	Private = 2.2 Medicaid = 4.4	740.0 – 740.1, 741.0, 741.9 w/o 740.0 – 740.10, 742.3 w/o 741.0, 741.9, 742.0, 742.1
Group 2: Eye (Anophthalmia/micropthalmia, Congenital cataract, Aniridia)	Private = 0 Medicaid = 0.70	743.0, 743.1, 743.30 – 743.34, 743.45
Group 3: Ear (Anotia/microtia)	Private = 0 Medicaid = 0.16	744.01, 744.23
Group 4: Cardiovascular (Common truncus, Transposition of great arteries <i>Tetralogy of Fallot</i> , Ventricular septal defect, Atrial septal defect, Atrioventricular septal defect, AVSD [endocardial cushion defect], Pulmonary valve atresia and stenosis, Tricuspid valve atresia and stenosis Ebstein's anomaly, Aortic valve stenosis, Hypoplastic left heart syndrome, Patent ductus arteriosus, Coarctation of aorta)	Private = 18.0 Medicaid = 16.4	745.0, 745.10, .11, .12, .19 745.2, 745.4, 745.5 745.60, .61, .69, 746.01, 746.02, 746.1, 746.2, 746.3, 746.7, 747.0, 747.10
Group 5: Orofacial (Cleft palate without cleft lip, Cleft lip with and without cleft palate, Choanal atresia)	Private = 1.7 Medicaid = 2.8	749.0, 749.1, 749.2, 748.0
Group 6: Gastrointestinal (Esophageal atresia/tracheoesophageal fistula, Rectal and large intestinal atresia/stenosis, Pyloric stenosis, Hirschsprung's disease (congenital megacolon), Biliary atresia)	Private = 3.6 Medicaid = 2.6	750.3, 751.2, 750.5, 751.3, 751.61
Group 7: Genitourinary (Renal agenesis/hypoplasia, Bladder exstrophy, Obstructive genitourinary defect, Hypospadias, Epispadias)	Private = 11.5 Medicaid = 8.5	753.0, 753.5, 753.2, 753.6, 752.61, 752.62
Group 8: Musculoskeletal (Reduction deformity, upper limbs, Reduction deformity, lower limbs, Gastroschisis, Omphalocele, Congenital hip dislocation, Diaphragmatic hernia)	Private = 2.9 Medicaid = 4.4	755.20 – 755.29, 755.30 – 755.39, 756.79, 756.79, 754.30, 754.31, 754.35, 756.6
Group 9: Chromosomal (Trisomy 13, Down syndrome, Trisomy 18)	Private = 3.8 Medicaid = 3.9	758.1, 758.0, 758.2
Group 10: Other and Unspecified Congenital Anomalies	Private = 0.17 Medicaid = 0.93	759

Note: Total sample size = 18,712 (Private = 5,842; Medicaid = 12,870)

Appendix 2

Complication Indicators, Rates, and ICD-9-CM Diagnosis Codes

Group Indicators	Rate (Number per 1,000 births)	ICD-9-CM Codes
Group 1: Maternal causes of perinatal morbidity and mortality	Private = 22.9 Medicaid = 24.1	760, 760.7, 760.71, 760.72, 760.75, 761, 761.1, 762, 762.5, 763
Group 2: Length of gestation and fetal growth	Private = 56.8 Medicaid = 58.4	764, 764.0, 765, 765.1, 766, 766.0, 766.21, 766.22
Group 3: Birth trauma	Private = 3.1 Medicaid = 3.8	767, 767.0, 767.1, 767.11, 767.2, 767.9
Group 4: Hypoxia/asphyxia/respiratory	Private = 414.2 Medicaid = 382.8	768, 768.3, 768.5, 768.9, 769, 770, 770.1
Group 5: Infections specific to the perinatal period	Private = 44.3 Medicaid = 47.0	771, 771.0 – 771.8, 771.81
Group 6: Hemorrhage/hemolysis/endocrine/jaundice/hematologic	Private = 453.8 Medicaid = 394.6	772, 772.0, 772.1, 772.10 – 772.14, 772.2 – 772.9, 773, 773.0 – 773.3, 775, 775.0 – 775.6, 776, 776.0 – 776.9
Group 7: Perinatal disorders of digestive system	Private = 2.4 Medicaid = 2.3	777, 777.3, 777.5
Group 8: Integument/temperature regulation	Private = 18.3 Medicaid = 18.9	778, 778.0 – 778.9
Group 9: Other ill-defined conditions originating in the perinatal period	Private = 140.4 Medicaid = 122.2	779, 779.0 – 779.3, 779.31 – 779.34, 779.4 – 779.8, 779.81 – 779.89, 779.9
Group 10: Persistent fetal circulation	Private = 4.6 Medicaid = 4.4	747.83

Note: Total sample size =18,712 (Private = 5,842; Medicaid = 12,870)

Appendix 3

Results of multivariable logistic regression analyses of the individual congenital anomaly indicators

	CNS		Cardiovascular		Orofacial		Genitourinary		Musculoskeletal		Chromosomal	
	OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)		OR (95% CI)	
Main predictors of interest												
Medicaid	1.90 (0.97 – 3.73)		1.09 (0.83 – 1.44)		1.52 (0.68 – 3.40)		0.88 (0.61 – 1.26)		1.31 (0.70 – 2.46)		1.45 (0.82 – 2.59)	
Year	1.02 (0.90 – 1.15)		1.34 (1.26 – 1.43)		0.85 (0.73 – 0.99)		1.01 (0.93 – 1.09)		1.03 (0.92 – 1.16)		1.03 (0.91 – 1.16)	
Maternal/Infant/delivery factors												
Female	0.80 (0.49 – 1.29)		1.00 (0.80 – 1.26)		0.77 (0.43 – 1.39)		0.12 (0.08 – 0.22)		1.32 (0.83 – 2.09)		1.18 (0.74 – 1.88)	
Gestational age	0.96 (0.89 – 1.03)		0.83 (0.80 – 0.85)		0.95 (0.86 – 1.05)		0.97 (0.92 – 1.03)		1.00 (0.91 – 1.09)		1.03 (0.94 – 1.14)	
Birth weight centile (ref: 50 th)												
3 rd centile	11.74 (4.99 – 27.7)		2.99 (1.87 – 4.80)		2.63 (0.71 – 9.74)		2.85 (1.49 – 5.44)		2.48 (0.91 – 6.77)		9.92 (4.06 – 24.2)	
10 th centile	3.66 (1.37 – 9.77)		1.63 (0.99 – 2.68)		1.56 (0.43 – 5.70)		1.89 (1.02 – 3.52)		2.94 (1.36 – 6.38)		4.44 (1.75 – 11.2)	
25 th centile	2.63 (1.13 – 9.76)		1.56 (1.07 – 2.29)		1.04 (0.36 – 3.01)		1.11 (0.65 – 1.88)		1.52 (0.75 – 3.05)		1.51 (0.58 – 3.91)	
75 th centile	0.68 (0.26 – 1.79)		0.87 (0.61 – 1.24)		1.12 (0.50 – 2.51)		0.69 (0.43 – 1.10)		0.52 (0.26 – 1.06)		1.15 (0.52 – 2.53)	
90 th centile	1.22 (0.46 – 3.20)		1.08 (0.73 – 1.59)		0.89 (0.33 – 2.42)		0.88 (0.53 – 1.45)		0.30 (0.10 – 0.88)		1.46 (0.62 – 3.45)	
97 th centile	1.44 (0.45 – 4.61)		0.88 (0.51 – 1.52)		0.92 (0.26 – 3.32)		1.01 (0.55 – 1.87)		0.48 (0.14 – 1.61)		1.44 (0.50 – 4.17)	
> 97 th centile	3.59 (1.45 – 8.91)		1.41 (0.88 – 2.25)		0.70 (0.15 – 3.19)		1.32 (0.74 – 2.38)		1.14 (0.46 – 2.85)		2.33 (0.89 – 6.06)	
Mother's age group (ref: 20 – 34)												
< 18	0.27 (0.04 – 1.95)		0.62 (0.31 – 1.24)		1.08 (0.32 – 3.62)		0.85 (0.37 – 1.97)		2.07 (0.90 – 4.76)		0.37 (0.05 – 2.70)	
18 – 19	1.32 (0.67 – 2.60)		0.85 (0.56 – 1.30)		0.97 (0.40 – 2.37)		1.14 (0.69 – 1.90)		1.51 (0.80 – 2.88)		0.93 (0.39 – 2.24)	
35	0.81 (0.32 – 2.07)		1.75 (1.26 – 2.42)		1.19 (0.42 – 3.42)		1.03 (0.63 – 1.71)		1.16 (0.49 – 2.76)		5.63 (3.34 – 9.48)	
Married	1.11 (0.64 – 1.94)		1.33 (1.01 – 1.74)		0.62 (0.31 – 1.25)		1.20 (0.83 – 1.74)		0.72 (0.42 – 1.25)		1.01 (0.58 – 1.74)	
Caucasian	0.76 (0.45 – 1.27)		1.53 (0.89 – 1.50)		1.91 (0.96 – 3.80)		1.27 (0.89 – 1.82)		3.05 (1.66 – 5.58)		1.11 (0.66 – 1.87)	
Delivery mode (ref: spontaneous)												
PROM	1.86 (0.81 – 4.31)		1.64 (1.12 – 2.40)		1.22 (0.44 – 3.34)		1.39 (0.81 – 2.38)		0.84 (0.32 – 2.21)		1.61 (0.71 – 3.66)	
Indicated	1.51 (0.87 – 2.63)		1.36 (1.05 – 1.77)		1.06 (0.56 – 2.00)		1.25 (0.90 – 1.74)		1.06 (0.65 – 1.75)		1.07 (0.63 – 1.81)	

Note: OR (odds ratio); The logistic regression models for eye, ear, gastrointestinal, and other unspecified congenital anomalies did not converge.

Appendix 4

Results of multivariable logistic regression analyses of the individual complication indicators

	Group 1	Group 2	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Main predictors of interest									
Medicaid	1.21 (0.95 – 1.53)	1.07 (0.91 – 1.26)	0.92 (0.85 – 1.00)	1.05 (0.88 – 1.26)	0.79 (0.73 – 0.85)	0.89 (0.42 – 1.87)	0.82 (0.62 – 1.08)	0.78 (0.70 – 0.87)	1.10 (0.64 – 1.86)
Year	0.95 (0.90 – 0.99)	1.04 (1.01 – 1.08)	1.05 (1.04 – 1.07)	1.05 (1.02 – 1.09)	1.07 (1.06 – 1.09)	0.88 (0.75 – 1.03)	1.09 (1.03 – 1.15)	0.94 (0.92 – 0.96)	1.32 (1.17 – 1.49)
Maternal/Infant/delivery factors									
Female	1.02 (0.84 – 1.23)	1.01 (0.89 – 1.15)	0.73 (0.69 – 0.78)	0.77 (0.67 – 0.89)	1.01 (0.95 – 1.08)	0.84 (0.46 – 1.54)	0.78 (0.63 – 0.97)	0.97 (0.89 – 1.06)	0.65 (0.42 – 1.02)
Gestational age	0.91 (0.88 – 0.93)	1.15 (1.11 – 1.18)	0.60 (0.59 – 0.61)	0.81 (0.80 – 0.83)	0.83 (0.81 – 0.84)	0.75 (0.70 – 0.81)	1.00 (0.96 – 1.04)	0.86 (0.84 – 0.87)	0.85 (0.80 – 0.90)
Birth weight centile (ref: 50 th)									
3 rd centile	1.54 (0.95 – 2.48)	20.39 (15.63 – 26.60)	1.37 (1.09 – 1.73)	1.29 (0.89 – 1.88)	1.47 (1.20 – 1.81)	2.29 (0.66 – 7.98)	0.87 (0.44 – 1.74)	1.52 (1.19 – 1.94)	2.40 (0.96 – 6.04)
10 th centile	0.59 (0.33 – 1.03)	9.70 (7.62 – 12.34)	1.37 (1.15 – 1.64)	1.26 (0.91 – 1.73)	1.42 (1.21 – 1.66)	2.25 (0.72 – 7.06)	1.26 (0.79 – 1.99)	1.47 (1.21 – 1.79)	0.79 (0.23 – 2.74)
25 th centile	1.06 (0.77 – 1.45)	2.69 (2.12 – 3.40)	1.06 (0.94 – 1.20)	1.03 (0.81 – 1.32)	1.22 (1.10 – 1.37)	1.03 (0.33 – 3.19)	1.46 (1.08 – 1.98)	1.36 (1.18 – 1.57)	1.16 (0.53 – 2.55)
75 th centile	0.77 (0.59 – 1.00)	0.40 (0.30 – 0.54)	0.90 (0.82 – 0.99)	0.86 (0.70 – 1.05)	0.87 (0.80 – 0.94)	0.85 (0.31 – 2.37)	0.60 (0.45 – 0.80)	0.77 (0.68 – 0.87)	1.09 (0.57 – 2.08)
90 th centile	0.63 (0.45 – 0.88)	1.04 (0.80 – 1.36)	0.84 (0.75 – 0.94)	0.95 (0.76 – 1.20)	0.88 (0.80 – 0.97)	2.28 (0.91 – 5.72)	0.44 (0.29 – 0.65)	0.72 (0.62 – 0.83)	1.31 (0.64 – 2.68)
97 th centile	1.07 (0.74 – 1.54)	2.19 (1.67 – 2.86)	0.91 (0.79 – 1.04)	0.76 (0.55 – 1.04)	0.78 (0.69 – 0.89)	0.88 (0.19 – 4.20)	0.32 (0.17 – 0.59)	0.67 (0.55 – 0.82)	0.58 (0.17 – 1.99)
> 97 th centile	0.95 (0.64 – 1.42)	6.51 (5.18 – 8.17)	0.80 (0.69 – 0.92)	0.98 (0.73 – 1.32)	0.73 (0.64 – 0.83)	0.81 (0.17 – 3.85)	0.42 (0.23 – 0.77)	0.55 (0.44 – 0.68)	1.79 (0.79 – 4.06)
Mother's age group (ref: 20 – 34)									
< 18	0.85 (0.52 – 1.38)	0.81 (0.57 – 1.14)	0.98 (0.83 – 1.16)	0.81 (0.58 – 1.15)	0.97 (0.83 – 1.12)	2.10 (0.76 – 5.79)	0.62 (0.34 – 1.12)	0.81 (0.65 – 1.01)	0.76 (0.23 – 2.51)
18 – 19	1.00 (0.73 – 1.38)	0.78 (0.62 – 0.98)	1.03 (0.92 – 1.15)	1.09 (0.87 – 1.36)	1.03 (0.93 – 1.14)	0.67 (0.20 – 2.26)	1.03 (0.73 – 1.44)	0.93 (0.80 – 1.08)	0.71 (0.30 – 1.68)
35	1.21 (0.88 – 1.65)	0.96 (0.76 – 1.20)	1.01 (0.90 – 1.14)	1.01 (0.79 – 1.30)	1.07 (0.96 – 1.19)	0.20 (0.03 – 1.47)	1.01 (0.68 – 1.48)	0.95 (0.81 – 1.11)	0.92 (0.43 – 1.94)

	Group 1	Group 2	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Married	1.17 (0.93 – 1.47)	0.91 (0.78 – 1.06)	1.17 (1.08 – 1.27)	0.99 (0.84 – 1.17)	1.09 (1.02 – 1.18)	1.35 (0.64 – 2.85)	0.81 (0.62 – 1.04)	0.87 (0.78 – 0.97)	1.29 (0.76 – 2.19)
Caucasian	1.19 (0.96 – 1.48)	1.17 (1.00 – 1.35)	1.40 (1.30 – 1.52)	1.39 (1.18 – 1.64)	1.18 (1.10 – 1.26)	0.68 (0.35 – 1.31)	0.98 (0.77 – 1.24)	1.10 (0.99 – 1.21)	1.21 (0.73 – 2.01)
Delivery mode (ref: spontaneous)									
PROM	4.04 (3.08 – 5.29)	0.72 (0.52 – 0.99)	1.55 (1.36 – 1.76)	2.34 (1.91 – 2.87)	1.76 (1.57 – 1.97)	2.61 (1.04 – 6.60)	1.39 (0.99 – 1.96)	1.44 (1.24 – 1.67)	1.66 (0.78 – 3.54)
Indicated	1.47 (1.17 – 1.85)	1.31 (1.14 – 1.51)	1.86 (1.73 – 2.00)	1.07 (0.91 – 1.26)	1.29 (1.21 – 1.37)	2.01 (0.94 – 4.30)	0.76 (0.60 – 0.96)	1.16 (1.06 – 1.28)	1.65 (1.00 – 2.74)

Note: The group labeling is found in appendix 2. The logistic regression model for birth trauma did not converge.