Descriptive epidemiology of birth trauma in the United States in 2003

Erin K. Sauber-Schatz[a], Nina Markovic[a], Harold B. Weiss[a], Lisa M. Bodnar[a], John W. Wilson[b] and Mark D. Pearlman[c]

Departments of [a]Epidemiology and [b]Biostatistics, University of Pittsburgh, Graduate School of Public Health, Pittsburgh, PA, and [c]Department of Obstetrics and Gynecology and Department of Surgery, University of Michigan, Ann Arbor, MI, USA

Summary

Correspondence:
Erin K. Sauber-Schatz, PhD, MPH, Florida Department of Health, Division of Family Health Services, MCH Practice and Analysis Unit, 4052 Bald Cypress Way Bin A13, Tallahassee, FL 32399-1721, USA.
E-mail:
Erin_Sauber-Schatz@doh.state.fl.us

Sauber-Schatz EK, Markovic N, Weiss HB, Bodnar LM, Wilson JW, Pearlman MD. Descriptive epidemiology of birth trauma in the United States in 2003. *Paediatric and Perinatal Epidemiology* 2010; **24**: 116–124.

The rate of birth trauma in the US has been reported to range between 0.2 and 37 birth traumas per 1000 births. Because of the minimal number of population-based studies and the inconsistencies among the published birth trauma rates, the rate of birth trauma in the US remains unclear. This is a cross-sectional study that was conducted using 890 582 in-hospital birth discharges from the 2003 Healthcare Cost and Utilization Project Kids' Inpatient Database. A neonate was defined as having birth trauma if their hospital discharge record contained an International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis code from 767.0 to 767.9. Weighted data were used to calculate rates for all birth traumas and specific types of birth traumas, and rates and odds ratios by demographic, hospital and clinical variables. Weighted data represented a national estimate of 3 920 787 in-hospital births.

Birth trauma was estimated to occur in 29 per 1000 births. The three most frequently diagnosed birth traumas were injuries to the scalp, other injuries to the skeleton and fracture of the clavicle. Significant univariable predictors for birth trauma included male gender, Asian or Pacific Islander race, living in urban or wealthy areas, being born in Western, urban and/or teaching hospital, a co-diagnosis of high birthweight, instrument delivery, malpresentation and other complications during labour and delivery. Birth trauma risk factors including those identified in this study may be useful to consider during labour and delivery. In conclusion, additional research is necessary to identify ways to reduce birth trauma and subsequent infant morbidity and mortality.

Keywords: *birth trauma, fractured clavicle, birth prevalence, birthweight, mode of delivery, ethnic origin, urban areas, neighbourhood income, teaching hospital.*

Introduction

Birth trauma is defined as an injury sustained by the neonate during the process of labour and delivery.[1–3] It usually results from trauma sustained during a difficult delivery or secondary to obstetric manipulation of the fetus to allow for delivery.[3,4] The incidence of birth trauma has reportedly decreased over time because of improvements in obstetric care and prenatal diagnosis;[5] however, it still occurs even in the presence of highly skilled obstetric and neonatal care.[3]

In studies conducted primarily at single hospitals, birth trauma has been estimated to occur in 2–7% of all deliveries and is associated with an increased risk of infant morbidity and mortality.[3,6,7] The few studies that provide population-based national birth trauma estimates report rates ranging from 0.2 to 37 birth traumas per 1000 births.[8–10] The various birth trauma definitions, study populations and methods used throughout the birth trauma literature make comparisons among or meta-analyses of studies difficult. Because of the minimal number of population-based studies and the inconsistencies among the published birth trauma rates, the rate of birth trauma in the US remains unclear.

The purpose of this study was to determine the rate of birth trauma in the US through the utilisation of a population-based sample of in-hospital births. The specific aims were: (i) to determine a national estimate of the rate of birth trauma, (ii) to determine the rates of specific types of birth trauma, and (iii) to report the rates and odds ratios (OR) of birth trauma stratified by demographic, hospital and various clinical variables.

Methods

The data source for this study was the 2003 Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database (KID). The KID is an ongoing part of HCUP sponsored by the Agency for Healthcare Research and Quality (AHRQ); it is the only database on children's hospital use, outcomes and charges in the US.[11] The 2003 KID collected hospital discharge data from 3438 community, non-rehabilitation hospitals in 36 states (AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, KY, MD, MA, MI, MN, MO, NC, NE, NH, NJ, NV, NY, OH, OR, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI and WV) for the year 2003.[11] Hospital discharges from federal hospitals (Veterans Administration, Department of Defense and Indian Health Service hospitals), long-term hospitals, psychiatric hospitals, alcohol/chemical dependency treatment facilities and hospital units within institutions (such as prisons) are excluded from the KID.[11] The KID is described in further detail elsewhere.[12]

Only births in hospital were included in this study. These births were identified in KID as a record with a principal or secondary diagnosis code ranging between V3000 and V3901 (with the last two digits of '00' or '01') and where the patient was not transferred from another facility.[11] After this exclusion, the study sample consisted of 890 582 in-hospital birth discharges from the 2003 KID. Discharge weights were applied to the study sample to adjust the data to represent nationwide birth discharges and obtain national estimates. The KID discharge weights were developed using the American Hospital Association universe as the standard and by post-stratification of hospitals on ownership/control, bed size, teaching status, rural/urban location, geographical region and hospital type (children's hospital or other).[11] After applying the weights, the data represented a weighted national estimate of 3 920 787 in-hospital birth discharges for 2003.

Birth trauma was defined in this study as an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis code from 767.0 to 767.9 in any one of the 15 diagnosis variables in the KID. The ICD-9-CM was 'the official system of assigning codes to diagnoses and procedures associated with hospital utilisation in the United States' in 2003.[13] Birth trauma was further classified by specific type of birth trauma, including subdural and cerebral haemorrhage (ICD-9-CM 767.0), injuries to the scalp (ICD-9-CM 767.1), fracture of the clavicle (ICD-9-CM 767.2), other injuries to the skeleton (ICD-9-CM 767.3),

Table 1. Number and rate per 1000 in-hospital births of reported birth trauma in the US, 2003 by type of birth trauma

Type of birth trauma (ICD-9 codes)	Un-weighted n	Weighted estimate	SD of weighted estimate	[a]Weighted rate per 1000 births
All birth trauma (767.0–767.9)	44 658	111 989	3227	28.56
Injuries to the scalp (767.1)	22 764	78 644	2487	20.06
Other injuries to the skeleton (767.3)	9525	14 499	1160	3.70
Fracture of the clavicle (767.2)	6353	9545	300.10	2.43
Other specified birth trauma (767.8)	3994	6136	289.94	1.56
Injury to the brachial plexus (767.6)	3302	5021	143.06	1.28
Subdural and cerebral haemorrhage (767.0)	1064	1599	77.49	0.41
Facial nerve injury (767.5)	661	1014	50.69	0.26
Birth trauma, unspecified (767.9)	218	339	32.25	0.09
Other cranial and peripheral nerve injuries (767.7)	124	192	18.39	0.05
Injury to the spine and spinal cord (767.4)	10	15	4.79	0.00
Total number of births	890 582	3 920 787	61 581	

[a]Birth trauma rate per 1000 in-hospital births.
ICD-9, International Classification of Diseases, Ninth Revision; SD, standard deviation.

Table 2. Univariable analysis of infants diagnosed with birth trauma by demographic variables (weighted), Kids' Inpatient Database 2003

Demographic variables	n_{WE}	n_{BT}	[a]Rate per 1000	OR	[95% CI]	*P*-value	% missing
Infant gender						<0.001	0.6
Female	1 900 219	47 439	24.97	1.00	Reference		
Male	1 997 286	63 996	32.04	1.29	[1.25, 1.34]		
Race						<0.001	28.4
White	1 486 381	41 877	28.17	1.00	Reference		
Hispanic	665 940	19 240	28.89	1.03	[0.93, 1.14]		
Black	354 448	8888	25.08	0.89	[0.81, 0.98]		
Other	169 286	4736	27.98	0.99	[0.88, 1.12]		
Asian or Pacific Islander	118 592	4692	39.56	1.42	[1.25, 1.62]		
Native American	13 178	249	18.90	0.67	[0.48, 0.92]		
Birthweight						<0.001	78.1
Low (<2500 g)	76 990	1300	16.89	0.54	[0.47, 0.62]		
Normal (2500–3999 g)	702 695	21 534	30.65	1.00	Reference		
High (≥4000 g)	78 952	3710	46.99	1.56	[1.41, 1.72]		
Short gestation; low birthweight; fetal growth retardation[b]						<0.001	0.0
Yes	448 673	10 486	23.37	0.80	[0.72, 0.88]		
No	3 472 114	101 504	29.23	1.00	Reference		
Location of the patient						<0.001	0.3
Large metropolitan	2 279 144	71 524	31.38	1.00	Reference		
Small metropolitan	1 070 318	26 750	24.99	0.79	[0.71, 0.88]		
Micropolitan	347 542	8778	25.30	0.80	[0.71, 0.90]		
Non-core	210 552	4571	21.71	0.69	[0.59, 0.79]		
Median household income for patient's zip code						<0.001	1.6
$60 000+	931 933	29 185	31.32	1.00	Reference		
$45 000–59 999	989 247	29 366	29.69	0.95	[0.88, 1.02]		
$36 000–44 999	977 151	26 550	27.17	0.86	[0.79, 0.94]		
$1–35 999	958 347	24 978	26.06	0.83	[0.75, 0.92]		
Payer information						<0.001	0.1
Private (including HMO)	2 092 341	60 531	28.93	1.00	Reference		
Medicaid	1 515 240	43 123	28.46	0.98	[0.92, 1.05]		
Self-pay	187 648	5074	27.04	0.93	[0.83, 1.05]		
Other	109 885	2853	25.96	0.90	[0.72, 1.12]		
No charge	5521	210	38.04	1.33	[0.88, 2.00]		
Medicare	4917	100	20.33	0.70	[0.49, 0.995]		

[a]Birth trauma rate per 1000 in-hospital births.
[b]Category from Clinical Classification Software.
CI, confidence interval; n_{BT}, weighted estimate of the number of infants with reported birth trauma; HMO, health maintenance organisation; n_{WE}, weighted estimate of the total number of births by stratum; OR, odds ratio.

injury to the spine and spinal cord (ICD-9-CM 767.4), facial nerve injury (ICD-9-CM 767.5), injury to the brachial plexus (ICD-9-CM 767.6), other cranial and peripheral nerve injuries (ICD-9-CM 767.7), other specified birth trauma (ICD-9-CM 767.8) and birth trauma, unspecified (ICD-9-CM 767.9). This study was approved by the University of Pittsburgh's Institutional Review Board.

All analyses were conducted on the weighted data using SPSS 15.0 (SPSS Inc., Chicago, IL, USA) and SAS version 9.1 (SAS Institute Inc., Cary, NC, USA). SAS's

PROC SURVEYFREQ[14] procedure was used to determine the national estimates of all birth trauma and specific types of birth trauma. These estimates were then used to calculate the rates of all birth trauma and specific types of birth trauma. SAS's PROC SURVEY-LOGISTIC[15,16] procedure with the total number of primary sampling units in the study population to compute a finite population correction for Taylor series variance estimation was used to calculate ORs, 95% confidence intervals [95% CI] and *P*-values for several demographic, hospital and clinical variables. The

Table 3. Univariable analyses of birth trauma by hospital variables (weighted), Kids' Inpatient Database 2003

Hospital variables	n_{WE}	n_{BT}	[a]Rate per 1000	OR	[95% CI]	P-value	% missing
Region of hospital						<0.001	0.0
South	1 446 837	39 283	27.15	1.00	Reference		
West	929 069	29 315	31.55	1.17	[1.02, 1.33]		
Midwest	870 745	24 924	28.62	1.06	[0.92, 1.21]		
Northeast	674 136	18 468	27.40	1.01	[0.87, 1.17]		
Hospital bed size						<0.001	0.6
Large	2 463 598	69 758	28.32	1.00	Reference		
Medium	1 031 358	30 418	29.49	1.04	[0.93, 1.17]		
Small	400 879	11 296	28.18	1.00	[0.86, 1.15]		
Location of hospital						<0.001	0.6
Rural	524 470	12 315	23.48	1.00	Reference		
Urban	3 371 364	99 157	29.41	1.26	[1.12, 1.42]		
Teaching status of hospital						0.002	0.6
Non-teaching	2 190 842	58 352	26.64	1.00	Reference		
Teaching	1 704 992	53 120	31.16	1.18	[1.06, 1.30]		
Location & teaching status of hospital						<0.001	0.6
Rural	524 470	12 315	23.48	1.00	Reference		
Urban non-teaching	1 711 037	47 273	27.63	1.18	[1.05, 1.33]		
Urban teaching	1 660 328	51 884	31.25	1.34	[1.17, 1.54]		

[a]Birth trauma rate per 1000 in-hospital births.
CI, confidence interval; n_{BT}, weighted estimate of the number of infants with reported birth trauma; n_{WE}, weighted estimate of the total number of births by stratum; OR, odds ratio.

STRATA, CLUSTER and WEIGHT statements were also used to specify sample design information in the PROC SURVEYLOGISTIC procedure and to take into account KID's sampling design.

Results

All of the following results are based on the weighted data. The rate of reported birth trauma was 28.6 or approximately 29 per 1000 in-hospital births (Table 1). This rate extrapolates to a birth trauma diagnosis in approximately 111 989 in-hospital births for the US in 2003. Injuries to the scalp were the primary type of birth trauma (20.06 per 1000 births) followed by other injuries to the skeleton (3.70 per 1000 births) and fracture of the clavicle (2.43 per 1000 births) (Table 1).

When the data were stratified by demographic variables (Table 2) it was clear that boys, Asian or Pacific Islanders and high-birthweight infants had higher rates and ORs of reported birth trauma. When the data were stratified by location of the mother (based on an urban to rural designation for the mother's county of residence) the rate and OR of birth trauma decreased as the location became more rural. Similarly the rate and OR of birth trauma decreased as the median

household income for the patient's zip code also decreased (Table 2). When the data were stratified by payer information, only those with Medicare had a significantly reduced OR of reported birth trauma compared with those with private payer (Table 2).

The 2003 KID includes 36 of the 50 states. The average rate of birth trauma was 27.2 per 1000 births across all 36 participating states, but the rate ranged from 15.3 cases of reported birth trauma in South Carolina to 57.5 cases of reported birth trauma in Maryland per 1000 in-hospital births. When the data were stratified by various hospital variables, it can be seen that hospitals in the Western United States as well as urban, teaching and urban teaching hospitals reported the highest rates and ORs of birth trauma (Table 3). There were no significant differences in the rates or ORs of birth trauma among hospitals with different bed sizes (Table 3).

Of the infants diagnosed with birth trauma 6.8% were also diagnosed with a complication of labour and delivery; only 0.9% of the infants not diagnosed with birth trauma were diagnosed with a complication of labour and delivery (data not shown). The corresponding OR for any complication of labour and delivery for all birth trauma was highly significant (OR = 7.93, 95%

Table 4. Univariable analyses of complications of labour and delivery by birth trauma type (weighted), Kids' Inpatient Database 2003

Complications of labour and delivery	All birth trauma		Injuries to scalp		Fracture of clavicle		Other injuries to skeleton		Facial nerve injury		Injury to brachial plexus		Other specified birth trauma	
	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]	OR	[95% CI]
Complications of labour and delivery (ICD-9 763.0–763.9)	7.93	[7.12, 8.83]	7.00	[6.19, 7.92]	6.14	[5.34, 7.05]	6.02	[5.03, 7.20]	9.65	[7.22, 12.90]	24.48	[21.39, 28.02]	8.98	[7.52, 10.72]
Breech delivery and extraction (763.0)	1.35	[1.07, 1.70]	0.17	[0.09, 0.32]	0.78	[0.32, 1.92]	3.30	[2.18, 4.99]	3.06	[0.76, 12.40]	1.23	[0.45, 3.31]	11.95	[8.68, 16.46]
Other malpresentation, malposition and disproportion (763.1)	13.74	[11.97, 15.77]	5.26	[4.31, 6.42]	25.31	[21.56, 29.72]	9.21	[7.46, 11.39]	8.21	[4.47, 15.06]	128.78	[112.08, 147.96]	9.42	[6.89, 12.88]
Forceps delivery (763.2)	16.34	[12.90, 20.70]	14.77	[11.15, 19.57]	4.72	[2.97, 7.49]	9.23	[6.45, 13.21]	76.07	[52.99, 109.21]	10.70	[7.10, 16.13]	34.50	[25.54, 46.59]
Delivery by vacuum extraction (763.3)	20.91	[17.67, 24.74]	25.42	[21.38, 30.21]	5.15	[3.87, 6.83]	9.81	[7.67, 12.55]	4.76	[2.25, 10.07]	6.03	[4.27, 8.52]	5.17	[3.63, 7.37]
Caesarean delivery (763.4)	3.74	[2.08, 6.72]	3.03	[1.66, 5.52]	a		3.08	[1.21, 7.85]	5.17	[0.80, 33.64]	a		22.98	[10.97, 48.14]
Maternal anaesthesia and analgesia (763.5)	2.02	[1.39, 2.95]	1.83	[1.04, 3.24]	2.50	[1.05, 5.92]	2.23	[0.98, 5.04]	a		3.01	[1.04, 8.70]	1.27	[0.31, 5.17]
Precipitate delivery (763.6)	2.22	[1.34, 3.68]	1.83	[0.87, 3.87]	1.88	[0.61, 5.82]	2.35	[0.70, 7.85]	a		2.94	[0.93, 9.24]	8.97	[4.73, 17.00]
Abnormal uterine contractions (763.7)	4.09	[2.75, 6.08]	4.72	[3.00, 7.43]	a		1.89	[0.57, 6.21]	a		13.26	[5.75, 30.61]	a	
Other specified complications of labour and delivery (763.8–763.84, 763.9)	3.16	[2.73, 3.66]	3.34	[2.78, 4.03]	1.03	[0.74, 1.44]	3.60	[2.64, 4.90]	2.53	[1.22, 5.26]	2.01	[1.31, 3.09]	3.82	[2.87, 5.08]
Unspecified complication of labour and delivery (763.9)	2.11	[0.88, 5.08]	0.78	[0.19, 3.17]	a		1.89	[0.27, 13.33]	a		22.54	[6.59, 77.12]	5.36	[0.72, 39.88]

a A cell in the two by two table contained a zero.
CI, confidence interval; ICD-9, International Classification of Diseases, Ninth Revision; OR, odds ratio.

Table 5. Birth trauma rate and univariable analysis of infants diagnosed with birth trauma by severity indicators (weighted), Kids' Inpatient Database 2003

Severity indicators	n_{EW}	n_{BT}	[a]Rate per 1000	OR	[95% CI]	P-value	% missing
Length of stay (days)						<0.001	0.0
0	50 024	801	16.01	0.50	[0.43, 0.57]		
1	695 598	15 750	22.64	0.71	[0.66, 0.76]		
2	2 010 960	63 801	31.73	1.00	Reference		
3	641 915	15 665	24.40	0.76	[0.72, 0.81]		
4	247 479	6985	28.23	0.89	[0.82, 0.96]		
5+	274 811	8988	32.71	1.03	[0.97, 1.10]		
Number of diagnoses						<0.001	0.0
1	1 577 566	0	0.00	[b]			
2	1 182 679	29 221	24.71	1.00	Reference		
3	562 739	34 060	60.53	2.54	[2.36, 2.74]		
4	252 729	22 292	88.21	3.82	[3.52, 4.15]		
5	122 926	11 602	94.38	4.11	[3.76, 4.51]		
6+	222 149	14 813	66.68	2.82	[2.56, 3.11]		
Number of procedures						<0.001	0.0
0	1 929 510	49 731	25.77	1.00	Reference		
1	1 418 424	43 101	30.39	1.19	[1.11, 1.26]		
2	403 266	13 446	33.34	1.30	[1.17, 1.45]		
3+	169 587	5712	33.68	1.32	[1.19, 1.46]		
Total charges						<0.001	3.3
$0–1093	949 224	22 433	23.63	1.00	Reference		
$1094–1602	948 272	26 352	27.79	1.18	[1.08, 1.29]		
$1603–2584	946 681	28 040	29.62	1.26	[1.14, 1.39]		
$2585+	947 877	32 077	33.84	1.45	[1.30, 1.61]		
Died during hospitalisation						<0.001	0.0
No	3 907 761	111 752	28.60	1.00	Reference		
Yes	12 306	210	17.07	0.59	[0.49, 0.70]		

[a]Birth trauma rate per 1000 in-hospital births.
[b]A cell in the two by two table contained a zero (a cell).
CI, confidence interval; n_{BT}, weighted estimate of the number of infants with reported birth trauma; n_{WE}, weighted estimate of the total number of births by stratum; OR, odds ratio.

CI [7.12, 8.83], Table 4). The most frequently diagnosed complications of labour and delivery for infants with reported birth trauma were delivery by vacuum extraction (2.6%) followed by other malpresentation, malposition and disproportion (2.0%) and forceps delivery (0.9%) (Table 4); in comparison, only 0.1% of infants without birth trauma were diagnosed with each of the above complications (data not shown). These three complications also had the highest unadjusted ORs for all the birth trauma categories (Table 4). The diagnosis of a complication of labour and delivery was also highly significant for each of the specific types of birth trauma (Table 4). However, the prevalence of each complication of labour and delivery varied to some degree by the type of birth trauma reported (Table 4).

When the data were stratified by various severity indicators (Table 5) it was found that the rate of reported birth trauma was highest in neonates with a length of stay ≥5 days, the rate and OR of reported birth trauma was highest in those with five diagnoses and three or more procedures, and as the total hospital charges increased so did the rate and OR of reported birth trauma (Table 5). Interestingly, the rate of birth trauma was higher in the infants that did not die during hospitalisation than in those who died during hospitalisation. Compared with neonates who did not die during hospitalisation, the ones who died were 41% less likely to have a reported birth trauma (Table 5).

Discussion

This study's reported birth trauma rate of 28.6 per 1000 births is higher than many other published rates, but is

similar to the rate reported in Tomashek *et al.* for the years 1999–2000,[8] which is one of the few studies in the literature that provided a recent national estimate of birth trauma. Their national estimates were derived from the National Hospital Discharge Survey and included 55 210 newborns in 1989–90 and 68 678 newborns in 1999–2000.[8] Tomashek *et al.* estimated that the rate of birth trauma in all newborns was 37.0 per 1000 newborns in 1989–90 and 29.2 per 1000 newborns in 1999–2000.[8] A 7-year study conducted in Finland and published in 1990 reported the rate of major birth trauma as 31.6 per 1000 livebirths.[17]

Other studies have reported much lower rates of birth trauma. For instance, Hankins *et al.* in 2006, through an Ovid Medline literature review restricted to the previous 10 years of literature using the search term 'fetal trauma', estimated that the incidence of significant birth trauma varied from 0.2 to 2 per 1000 births.[9] At a single hospital in Saudi Arabia, Awari *et al.* in 2003 determined that birth injuries had an incidence of 6.7 per 1000 livebirths through a retrospective review of the medical records of 31 028 consecutive deliveries from January 1986 to December 1996.[10] The reported rate in the study by Awari *et al.* is higher than Hankins *et al.*, but much lower than the rate reported in the current study and by Tomashek *et al.*

Interestingly, this study showed that Asian or Pacific Islanders were more likely to experience birth trauma; however, there were no clear reasons for the increased risk. For instance, only 1.3% of the Asian or Pacific Islander infants experienced any complications of labour and delivery compared with 1% in all births. Furthermore, of the Asian or Pacific Islander infants with a reported birthweight, 85.9% were of normal weight and only 5.7% had a high birthweight compared with a high birthweight in 9.2% of all births. Some of the increased risk could be as a result of the fact that Asian or Pacific Islander neonates primarily lived in the wealthiest neighbourhoods (41.8%) and were born in urban (95.6%) and Western hospitals (50%). Another possibility for the increased risk could be anatomical, including pelvic differences among Asian or Pacific Islander women; however, further research is needed.

It is important to point out that neonates with birth trauma have a reduced rate and OR of death during their hospitalisation. We speculate that in some cases, choices are made or procedures are performed during labour and delivery to protect the health and lives of both the pregnant woman and fetus, even if they increase the risk of birth trauma. For instance, if a fetus is known to be experiencing hypoxia or birth asphyxia, a physician may make the decision to use vacuum extraction or forceps delivery to reduce the risk of potential adverse health effects resulting from a lack of oxygen. Although the instrument delivery may cause birth trauma [the OR for birth trauma in infants diagnosed with intrauterine hypoxia and birth asphyxia was OR = 2.35, 95% CI [2.14, 2.58] in this study (data not shown)], the benefits of using the instrument to resolve hypoxia/asphyxia will likely outweigh the risks of birth trauma.

Also of interest, the birth trauma rate in 'normal newborns' with uncomplicated in-hospital births was 17.5 birth traumas per 1000 in-hospital births (data not shown). This rate is approximately only 11 fewer cases per 1000 in-hospital births than the overall rate of 29 cases of birth trauma per 1000 in-hospital births. This raises the question of what is an acceptable or normal rate of birth trauma. Even during an uncomplicated natural vaginal delivery the neonate is exposed to several forces as it passes through the birth canal that can cause birth trauma. Therefore, it is not unreasonable to believe that the birth trauma rate will never be zero and that a specific rate, perhaps approximately 18 per 1000 in-hospital births, should be considered an acceptable and normal baseline for birth trauma.

This study has several strengths. Specifically, the KID provides current, quality controlled and reliable national data with a much larger sample size and more recent data than any previously published birth trauma study. The large sample size also allowed for rate calculations of specific types of birth trauma as well as stratification of the data by key variables.

Our study was limited by the fact that not all data elements in the KID are provided by each state.[11] Therefore, some of the analyses used incomplete data. This has the potential to bias some of the results, but with such a large sample size and through the use of advanced statistical procedures, any resulting biases would be very limited. Another limitation is the possible variation among hospital coding practices. The data in the KID rely solely on hospital discharge data and are therefore only as complete and accurate as the hospital reports allow.

However, the use of hospital discharge data is also a strength of this study. Lydon-Rochelle *et al.* quantified the accuracy of administrative data (birth certificate data, hospital discharge data and combined birth certificate and hospital discharge data) for reflecting

actual maternal diagnoses and intrapartum procedural status.[18] They determined that perinatal epidemiological studies should not rely exclusively on birth certificate data.[18] This study used hospital discharge data that were shown by Lydon-Rochelle *et al.* to have generally high true positive fractions or accuracy for detecting maternal diagnoses and intrapartum procedures.[18] Another potential limitation is that it is unknown whether it is the hospital, the population it serves, or a combination thereof, that is driving the increased risk of birth trauma. Further research is needed to explore this issue.

A final limitation is the possibility of confounding. Only diagnoses of birth trauma were taken into account for analyses and, although a majority of birth trauma cases had the same average number of diagnoses as in-hospital births without birth trauma, the potential for confounding because of other diagnoses should be kept in mind when interpreting results.

There are several clinical and public health implications of this study. Through a population-based national estimate it was determined that the rate of birth trauma in the US is higher than a majority of studies have previously reported. Health professionals may have the ability to decrease the number and rate of infants diagnosed with birth trauma by recognising perinatal risk factors for birth trauma and using technological advancements (such as ultrasonography and fetal monitoring) before attempting a vaginal delivery.[19] In addition, further birth trauma research, including more in-depth classification (such as an expansion of the work done by Pressler[19]) and follow-up of infants who are diagnosed with birth trauma, will better quantify the morbidity and mortality of birth trauma by type and among infants and women with various birth trauma risk factors. Prevention of birth trauma will also reduce the number of stresses that it places on the health care system because neonates with birth trauma were shown in this study to have higher costs, greater lengths of stay, and have more medical procedures than neonates not diagnosed with birth trauma. Simply stated, preventing birth trauma will reduce infant morbidity and mortality and reduce the stresses it places on the health care system.

Acknowledgements

References

1 Becerra JE, Fry YW, Rowley DL. Morbidity estimates of conditions originating in the perinatal period: United States, 1986 through 1987. *Pediatrics* 1991; **88**:553–559.

2 Towner D, Castro MA, Eby-Wilkens E, Gilbert WM. Effect of mode of delivery in nulliparous women on neonatal intracranial injury. *New England Journal of Medicine* 1999; **341**:1709–1714.

3 Parker LA. Part 1: early recognition and treatment of birth trauma: injuries to the head and face. *Advances in Neonatal Care* 2005; **5**:288–297; quiz 298–300.

4 Gherman RB, Goodwin TM, Ouzounian JG, Miller DA, Paul RH. Brachial plexus palsy associated with cesarean section: an in utero injury? *American Journal of Obstetrics and Gynecology* 1997; **177**:1162–1164.

5 Uhing MR. Management of birth injuries. *Pediatric Clinics of North America* 2004; **51**:1169–1186, xii.

6 Welch K, Strand R. Traumatic parturitional intracranial hemorrhage. *Developmental Medicine and Child Neurology* 1986; **28**:156–164.

7 Menticoglou SM, Perlman M, Manning FA. High cervical spinal cord injury in neonates delivered with forceps: report of 15 cases. *Obstetrics and Gynecology* 1995; **86**(4 Pt 1): 589–594.

8 Tomashek KM, Crouse CJ, Iyasu S, Johnson CH, Flowers LM. A comparison of morbidity rates attributable to conditions originating in the perinatal period among newborns discharged from United States hospitals, 1989–90 and 1999–2000. *Paediatric and Perinatal Epidemiology* 2006; **20**:24–34.

9 Hankins GD, Clark SM, Munn MB. Cesarean section on request at 39 weeks: impact on shoulder dystocia, fetal trauma, neonatal encephalopathy, and intrauterine fetal demise. *Seminars in Perinatology* 2006; **30**:276–287.

10 Awari BH, Al-Habdan I, Sadat-Ali M, Al-Mulhim A. Birth associated trauma. *Saudi Medical Journal* 2003; **24**:672–674.

11 Agency for Healthcare Research and Quality. *Introduction to the HCUP KIDs' Inpatient Database (KID) 2003*. Rockville, MD: HCUP Central Distributor, 2007.

12 HCUP. *KID Database Documentation*. Rockville, MD: AHRQ, 2008.

13 National Center for Health Statistics. *Classification of Diseases and Functioning, and Disability*. Hyattsville, MD: NCHS, 2008. http://www.cdc.gov/nchs/icd9cm.htm [last accessed 18 November 2009].

14 An AB, Watts D. *New SAS Procedures for Analysis of Sample Survey Data*. Cary, NC: SAS, 2007.

15 An AB. *Performing Logistic Regression on Survey Data with the New SURVEYLOGISTIC Procedure*. Advanced tutorials. Paper 258. Orlando, FL: SUGI 27 2002.

16 SAS Institute Inc. *SAS/STAT 9.2 User's Guide: The SURVEYLOGISTIC Procedure*. Cary, NC: SAS Institute Inc., 2008.

17 Salonen IS, Uusitalo R. Birth injuries: incidence and predisposing factors. *Zeitschrift Für Kinderchirurgie* 1990; **45**:133–135.

18 Lydon-Rochelle MT, Holt VL, Nelson JC, Cárdena V, Gardella C, Easterling TR, *et al.* Accuracy of reporting maternal in-hospital diagnoses and intrapartum procedures in Washington State linked birth records. *Paediatric and Perinatal Epidemiology* 2005; **19**:460–471.

19 Pressler JL. Classification of major newborn birth injuries. *Journal of Perinatal and Neonatal Nursing* 2008; **22**:60–67.