

Children hospitalized early and increased risk for future serious injury

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Abstract

Objective—To determine if infants hospitalized for any reason before 90 days of age are at increased risk for future serious injury.

Setting—Washington State.

Methods—A population based retrospective cohort study, using data from Washington State birth and death certificates linked to a statewide hospital discharge database for the years 1989 through 1997. Participants included healthy full term infants born in Washington State between 1989 and 1995. A total of 29 466 infants hospitalized <90 days of age (early hospitalization) were compared to 29 750 randomly selected infants not hospitalized early. The primary outcome was an injury resulting in hospitalization or death between 3–24 months.

Results—Among infants hospitalized early, 76/10 000 had a subsequent serious injury before age 2, compared with 47/10 000 infants without an early hospitalization (relative risk (RR) 1.6; 95% confidence interval (CI) 1.3 to 2.0). In a multivariate model including maternal age and parity, the adjusted RR for serious injury associated with early hospitalization was 1.5 (95% CI 1.2 to 1.8). Infants hospitalized early were three times as likely to be hospitalized between 3–24 months of age for intentional injury compared with infants not hospitalized early (RR 3.3; 95% CI 1.1 to 10.1).

Conclusions—Infants hospitalized in the first three months of life for any reason were 50% more likely to have a subsequent serious injury compared with infants not hospitalized early and were also at increased risk of intentional injury. This identifiable group of infants might be suitable for targeted childhood injury prevention programs including those involving prenatal and postnatal visits.

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Risk factors for dying from an injury in early childhood include low birth weight, young maternal age, less than 12 years of maternal education, higher parity, and low household income.^{1 2} The same sociodemographic characteristics are found in children at high risk for abuse.^{3 4} Interventions have been proven effective in reducing medical visits and hospital days due to injury in children living in very high risk families.^{5 6} However, over 20% of infants in the

United States have two or more socio-demographic risk factors for dying from an injury.⁷ Targeting resource intensive injury prevention interventions to such a large high risk group is not feasible in many communities. If health care providers were better able to predict which children are at highest risk for injury, resources to prevent these injuries could be used more effectively.

Most serious injuries in early childhood fall somewhere on a continuum between those resulting from inadequate parental supervision or inadequate use of safety devices to neglect or outright abuse. Evidence exists that abused children are hospitalized more frequently for medical illness apparently unrelated to abuse than non-abused children, in some cases even before any abuse had been reported or suspected.^{8–10}

This study was designed to determine if infants hospitalized in the first three months of life are at increased risk of serious injury in early childhood, and would therefore be an important population to target for prevention measures.

Methods

We conducted a population based retrospective cohort study of healthy full term infants born in Washington State between 1989 and 1995. The study cohort was identified by linking birth certificates to the Comprehensive Hospital Abstract Reporting System (CHARS) database for the years 1989 to 1997. CHARS was created by the Washington State Department of Health and contains hospital discharge information for all hospitalizations in the state except those that occur in federal hospitals. Information available in the linked hospitalization record included date of admission and discharge, nine discharge diagnoses (*International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) N codes), and one cause of injury code (ICD9-CM E code). Information on deaths due to injury, which included date and cause of death (ICD9-CM E code), was obtained by linking the birth certificates to death certificates for the years 1989 to 1997.

Infants were included in the study if they were ≥ 37 weeks gestational age, had a birth weight ≥ 2000 g, and had a birth hospitalization lasting ≤ 7 days. Infants were excluded from the study if they died before 90 days of age. Approximately 590 000 infants were born in Washington State between 1989 and 1995. Our study sample included all 29 466 healthy full term infants who met our inclusion criteria and who had a hospitalization for any reason before 90 days of age. We then randomly

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selected 29 750 healthy full term infants from the birth cohort (frequency matched by birth year) who also met our inclusion criteria but who did not have an early hospitalization. We excluded premature infants because they are known to be at high risk for injury,⁷ are likely to be in the hospital for much of their first 90 days of life, and are also more likely to have professional follow up after hospital discharge.

MATERNAL/CHILD CHARACTERISTICS

We obtained other information regarding infant and maternal characteristics from the birth certificate and birth hospitalization discharge record that might confound or modify the association between early hospitalization and injury risk. Each characteristic was examined for confounding or effect modification by stratified analysis. Infant characteristics examined included the presence of birth defects, gender, and birth weight. Maternal characteristics examined were age at time of delivery, race, county of residence, marital status, parity before delivery of study infant, trimester prenatal care began, and smoking during pregnancy. Paternal characteristics examined were age and whether or not a father was listed on the birth certificate.

As maternal education was only available on birth certificates after 1991, we limited the analysis to infants born 1992–95 when examining maternal education as a potential confounder or effect modifier. The Washington State birth certificate also has employment information about the mother and father at the time of delivery. This information was combined into three mutually exclusive categories: employed, teen, or unemployed. Maternal and paternal employment were examined for confounding or effect modification by stratified analysis, although 9.2% of the data for maternal occupation and 22% of the data for paternal occupation were missing.

REASON FOR FIRST ADMISSION

We examined the first diagnosis on the hospital discharge record of the first hospitalization at less than 90 days of age to determine if the diagnosis was related to the risk of subsequent injury hospitalizations or death due to injury. Due to limitations in sample size, we grouped the early diagnoses into the following broad categories based on ICD-9-CM codes: non-respiratory infection, pneumonia/bronchiolitis, jaundice, and perinatal conditions. All other reasons for the first admission were grouped as “other” such as diseases due to non-infectious gastrointestinal diseases, nutritional deficiencies, anemia, or malignancy.

OUTCOMES

The primary study outcome was death or hospitalization due to injury between 3 and 24 months of age. The first four hospitalizations occurring between 3 and 24 months of age were assessed, accounting for 98% of hospitalizations in both groups. In children with more than one hospitalization between 3 and 24 months, only the first injury hospitalization was counted.

As a secondary analysis, the risk of hospitalization or death by whether the injury was intentional or not was also assessed.

ANALYSIS

In the univariate and stratified analysis, we used the Mantel-Haenszel relative risk estimate and test based methods to obtain the 95% confidence interval (CI) for the risk of hospitalization or death due to injury among those infants hospitalized before 90 days compared with those who were not hospitalized during this time. On stratified analysis, significant confounding was defined by a change in the relative risk (RR) of $\geq 10\%$ and effect modification was defined by a Breslow-Day test of homogeneity p value < 0.05 . Binomial regression with the log link function was conducted using the `binreg` command under Stata 6.0. This form of analysis yielded adjusted relative risks, which could be compared to unadjusted relative risks calculated from the bivariate analyses. All injury hospitalizations (intentional, unintentional, and those of undetermined intent) were included as a single dichotomous outcome variable in the final binomial regression model.

Results

Of infants who were hospitalized early, 225 (76/10 000) had a subsequent injury hospitalization or death due to injury, compared with 141 (47/10 000) of those who were not hospitalized early (RR 1.6; 95% CI 1.3 to 2.0). Burns, ingestions, foreign bodies, and falls accounted for over 70% of all injury hospitalizations in both groups (table 1).

Over the seven year study period, six children in the early hospitalization group and eight in the control group died from injury related causes. The children who had an early hospitalization subsequently died from an ingestion, a drowning, suffocation, electrocution, and abuse (2). Those not hospitalized early died from a motor vehicle accident, a fall, an animal attack, drowning (3), and suffocation (2).

Infants who were hospitalized before 90 days of age (early hospitalization) differed from those who did not have an early hospitalization in many ways (table 2). Infants hospitalized early were more likely to be male, have a birth weight between 2000 and 2499 g, and were more likely to have a malformation. Mothers of infants hospitalized early were younger, more likely to be unmarried, unemployed, have less than a high school education, be on Medicaid, begin prenatal care late, have smoked during pregnancy, and were less likely to live in urban areas and to be white, non-Hispanic.

There was no evidence that any of the infant, maternal, or paternal characteristics that were examined importantly confounded or modified the relationship between early hospitalization and subsequent injury hospitalization or death. In multiple binomial regression, maternal age and parity were also found to be significant predictors of subsequent serious injury and were included in the final regression model

Table 1 Selected newborn and maternal characteristics of healthy full term infants with a hospitalization in the first 90 days and comparison infants, Washington State 1989–1996

	Early hospitalization (n=29 466)		No early hospitalization (n=29 750)		Stratum specific RR (95% CI)
	No	Injury rate*	No	Injury rate*	
All children	29 466	76	29 750	47	1.6 (1.3 to 2.0)
Infant gender					1.6 (1.3 to 2.0)†
Male	16 821	84	15 098	52	1.6 (1.2 to 2.1)
Female	12 645	70	14 652	43	1.6 (1.2 to 2.3)
Birth weight (g)					1.6 (1.3 to 2.0)†
2000–2499	996	80	559	54	1.5 (0.4 to 5.6)
2500–4000	24 708	78	24 768	50	1.5 (1.2 to 1.9)
>4000	3 752	77	4 414	32	2.4 (1.3 to 4.6)
Any malformation at birth	2 202	77	1 383	72	1.1 (0.5 to 2.3)
<i>Maternal characteristics</i>					
Age (years)					1.5 (1.2 to 1.9)†
<20	4 192	112	3 039	79	1.4 (0.9 to 2.3)
20–24	8 411	101	7 492	63	1.6 (1.1 to 2.3)
25–34	14 212	60	16 113	39	1.5 (1.1 to 2.1)
35+	2 633	30	3 084	23	1.3 (0.5 to 3.7)
Race					1.6 (1.3 to 2.0)†
White, non-Hispanic	22 916	76	23 683	46	1.6 (1.3 to 2.1)
White, Hispanic	2 678	49	2 150	42	1.2 (0.5 to 2.7)
African American	902	122	1 027	58	2.1 (0.8 to 5.6)
Marital status					1.6 (1.3 to 2.0)†
Not married	8 659	98	6 890	58	1.7 (1.2 to 2.5)
Married	20 763	70	22 821	45	1.6 (1.2 to 2.0)
Education‡					1.5 (1.0 to 2.1)†
Less than high school	1 768	79	1 295	61	1.3 (0.7 to 2.5)
High school	3 683	69	3 824	56	1.2 (0.7 to 2.1)
> High school	4 569	45	5 689	20	2.3 (1.1 to 4.6)
Employment					1.7 (1.4 to 2.1)†
Teen	1 320	129	937	75	2.3 (1.1 to 4.6)
Unemployed	11 751	90	11 313	55	1.6 (1.2 to 2.2)
Employed	13 496	62	14 944	36	1.7 (1.2 to 2.4)
Source of insurance					1.5 (1.2 to 1.9)†
Medicaid	11 268	93	8 293	58	1.6 (1.1 to 2.3)
Other	16 406	69	18 336	46	1.5 (1.1 to 2.0)
County of residence					1.6 (1.3 to 2.0)†
Rural	3 799	97	3 543	54	1.8 (1.0 to 3.2)
Suburban/small urban	8 451	64	7 128	52	1.2 (0.8 to 1.9)
Metropolitan	16 948	78	18 748	45	1.7 (1.3 to 2.3)
No of prior deliveries					1.6 (1.3 to 2.0)†
2+	7 996	96	7 694	55	1.8 (1.2 to 2.6)
1	9 522	83	9 755	48	1.7 (1.2 to 2.5)
0	11 579	60	11 975	42	1.4 (1.0 to 2.1)
Month prenatal care began					1.6 (1.3 to 2.0)†
7–10	1 095	146	913	33	4.4 (1.3 to 15.2)
4–6	4 934	99	4 681	62	1.6 (1.0 to 2.5)
0–3	22 055	67	22 874	45	1.5 (1.2 to 1.9)

Columns may not add up to total No because of missing data.

*Cumulative injury rate/10 000 children ages 3–24 months.

†Estimate of common relative risk (Mantel-Haenszel).

‡Maternal education was available on the birth certificate beginning in 1992. From 1992–95 11% of the data were missing.

with early hospitalization (table 3). In the final model, healthy full term infants who had a hospitalization for any reason before 90 days of age were 50% more likely to have a subsequent injury hospitalization between 3–24 months of

Table 2 Type of injury hospitalization between 3 and 24 months of age by cause (ICD-9-CM E code) in infants with and without hospitalization for any reason before 90 days of age

Type of injury	Prior early hospitalization (n=29 466)		No prior early hospitalization (n=29 750)	
	No	Rate*	No	Rate*
Burn	38	12.8	27	9.1
Ingestion	38	12.8	19	6.4
Foreign body	32	10.8	15	5.0
Fall	28	9.4	22	7.4
Vehicle accident	13	4.4	13	4.4
Child abuse	13	4.4	4	1.3
Submersion	5	1.7	5	1.7
Other	24	8.1	11	3.7
No E code	34	11.5	25	8.4
All injuries	225	76	141	47

*Cumulative incidence of injury hospitalizations, per 10 000.

Table 3 Final multiple binomial regression model: independent predictors of increased risk of injury hospitalization or death due to injury between 3 and 24 months of age

Predictor of injury	Adjusted RR	95% CI
Hospitalized <90 days old		
Yes	1.5	1.2 to 1.8
No	Referent	
Maternal age		
11–19	5.4	3.0 to 9.5
20–24	3.7	2.2 to 6.4
25–34	2.0	1.2 to 3.4
35+	Referent	
Parity		
2+	2.1	1.2 to 2.1
1	1.6	1.6 to 2.8
0	Referent	

age than infants not hospitalized early (adjusted RR 1.5; 95% CI 1.2 to 1.8). Infants hospitalized early who also had young mothers were at highest risk of serious injury, at least eight times the risk of the lowest risk group of infants, those without an early hospitalization with a nulliparous mother age 35 or older. The mother's occupation, level of education, insurance status, and race were not important confounders or independent predictors of a child's injury risk in this dataset and were therefore not included in the final regression model.

We also examined the association between hospitalization before 90 days of age and subsequent risk of injury by intent of injury (table 4). Full term infants who were hospitalized before 90 days of age for any reason were more than three times as likely to have a subsequent hospitalization for intentional injury than infants not hospitalized early (RR 3.3; 95% CI 1.1 to 10.1). The rates of hospitalization for intentional injury were 4.4/10 000 in the early hospitalized group and 1.3/10 000 in the infants not hospitalized early.

Finally, we examined the association between the diagnosis of the first hospitalization at less than 90 days of age on the risk of subsequent injury, again compared to those infants who did not have an early hospitalization (table 5). Infants hospitalized in the first three months for bronchiolitis or pneumonia had more than a twofold increased risk of subsequent serious injury when compared with those not hospitalized early (RR 2.3; 95% CI 1.7 to 3.1). The risk of subsequent injury for infants hospitalized for non-respiratory infectious diseases was nearly twice that of infants without an early hospitalization (RR 1.8; 95% CI 1.2 to 2.5). Few infants were hospitalized before 90 days of age with an injury diagnosis and were therefore included in the group "other". When infants hospitalized with jaundice were excluded from the early hospitalized group, the relative risk of subsequent serious injury with early hospitalization for any reason other than jaundice increased to 1.9 (95% CI 1.5 to 2.3). There were not enough intentional injuries to determine if the reason for the first admission influenced the risk associated with intentional injury in this dataset. Of the 13 intentional injuries in the early hospitalized group, five were initially hospitalized for an infection, four had bronchiolitis, two had

Table 4 Risk of injury hospitalization or death by mechanism of injury among healthy full term infants hospitalized in the first three months of life relative to infants not hospitalized early

Outcome	Early hospitalization (29 466 children) n (n/10 000)	No early hospitalization (29 750 children) n (n/10 000)	RR (95% CI)
Intentional injury	13 (4.4)	4 (1.3)	3.3 (1.1 to 10.1)
Unintentional injury	177 (59.7)	111 (37.3)	1.6 (1.3 to 2.0)
Undetermined/no E code	35 (11.8)	26 (8.7)	1.4 (0.8 to 2.3)

Table 5 Effect of reason for first admission on risk of subsequent serious injury between 3 and 24 months of age

Reason for hospitalization	No with diagnosis	% Of early admissions	No of injuries	RR (95% CI)
Any diagnosis	29 466	100	225	1.6 (1.3 to 2.0)
Pneumonia/bronchiolitis	5 792	19.5	63	2.3 (1.7 to 3.1)
Other infectious disease	4 452	15.0	37	1.8 (1.2 to 2.5)
Perinatal conditions	5 625	19.0	38	1.4 (1.0 to 2.0)
Jaundice	6 657	22.4	25	0.8 (0.5 to 1.2)
Other	6 940	23.6	62	1.8 (1.4 to 2.5)
No initial hospitalization	29 750		141	1.0 (referent)

χ^2 test for differences in injury rates between diagnosis groups in the early hospitalized cohort $p < 0.001$.

Table 6 Age of injury, length of stay and total charges by exposure status

	Prior early hospitalization Median	No prior early hospitalization Median	p Value*
Age of injury	14.7 months	14.8 months	0.20
Length of stay	2.0 days	2.0 days	0.22
Total charges	\$2314	\$2146	0.82

*Wilcoxon rank sum test.

gastroenteritis, one was burned, and one had jaundice.

The median age at admission for the injury hospitalization, the length of the injury hospitalization, and the total charges for the injury hospitalization were similar between the group of infants hospitalized before 90 days of age and infants not hospitalized early (table 6).

Discussion

Although hospitalization or death due to injury in early childhood is relatively rare, nearly 20% of children visit an emergency department or clinic for injuries in this age group.¹¹ This makes early childhood injuries an important and costly public health problem. In our study, full term infants hospitalized before 90 days of age had a 50% increased risk of future serious injury in early childhood. Infants hospitalized early were also three times more likely to be hospitalized for abuse before 24 months of age. This risk appears to be independent of known, measurable risk factors for early childhood injury mortality such as male gender, young maternal age, low socioeconomic markers, and high parity. Although previous studies have demonstrated that abused children are more likely to be hospitalized for medical conditions unrelated to abuse,^{8,9} no population based study has shown an association between early hospitalization and future increased risk of unintentional injury as well.

The reason for the first admission affected the risk of future injury. Most importantly, infants hospitalized for jaundice were at no increased risk of subsequent serious injury, whereas those hospitalized with a respiratory

Key points

- Full term infants hospitalized before 90 days of age for any reason other than jaundice are at increased risk for serious injury in early childhood.
- Health professionals should incorporate injury prevention anticipatory guidance into their discharge instructions for these infants.
- Hospitalized infants are easily identifiable for injury prevention interventions, and public health interventions could be specifically developed for this group of infants.

condition were more than twice as likely to have a serious injury before 24 months of age. If we excluded infants hospitalized early for jaundice, the risk of future serious injury associated with early hospitalization for any other reason increased to nearly twofold that of infants not hospitalized early.

Early hospitalization was unlikely to be a direct cause of increased risk of injury. Instead it may be a surrogate marker for family characteristics including parenting skills, household income, adequacy of social support, and other factors that place children at higher risk for both hospitalization in early infancy for certain conditions and for subsequent serious injury. Alternatively, underlying chronic illness that predisposes to both early hospitalization and to subsequent injury may account for the increased risk.

Young maternal age and high parity have been shown to be markers for increased risk of death due to injury in early childhood.^{1,2,12} We have demonstrated that these are also important risk factors for injury hospitalization in early childhood. Infants born to mothers younger than age 20 were at high risk of injury, independent of early hospitalization. Injury prevention efforts, such as home visits by trained staff, should continue to be focused on young mothers during their pregnancies and after delivery.

The limitations of studies that rely on secondary datasets, such as birth and death certificate data and hospital discharge records, have been well described.^{1,2} Although we were able to demonstrate a significant increase in risk of hospitalization for documented intentional injury in infants hospitalized for any reason before 90 days of age, the rate of intentional injury in both groups was low. Furthermore, the number of injury hospitalizations where there was no determined mechanism was more than three times that of documented intentional injuries, and intentional injury in this age group is often underdiagnosed or underreported. Therefore, the increased risk of hospitalization for intentional injury after an early hospitalization in this cohort of infants should be interpreted with caution.

Several potential confounders such as access to care and provider characteristics were not in

this dataset. Furthermore, determining socioeconomic status may be subject to considerable measurement error. Infants of higher socioeconomic status or with better access to care may be less likely to be hospitalized in the first three months of life for common childhood illnesses. These infants may or may not be less likely to be hospitalized for subsequent injury. However, the injury hospitalizations for the infants hospitalized early did not differ substantially from that of infants not hospitalized early, at least not in terms of length of stay, age at admission, and hospital charges accrued. We examined only the first four hospitalizations for infants between 3 and 24 months of age, thereby missing hospitalizations that may have occurred subsequently. This likely resulted in a slight underestimate of the true risk of injury in the first 24 months of life in both groups. Finally, the data were limited to hospitalizations that occurred in Washington State.

Implications for prevention

Infants hospitalized before 90 days of age are an easily identified and potentially targetable group of infants for injury prevention interventions. Home visits by nurses has been shown to be effective in reducing injury hospitalizations in other high risk groups of infants, and may be an effective intervention in infants discharged from the hospital in early infancy, particularly if lack of community resources prohibits intensive home visit programs for all infants with high risk environments.⁵ In addition, interventions such as home nurse visitation may have many other benefits including reductions in emergency department visits for injuries, reductions in crime, and time on welfare for socially disadvantaged families.^{13 14}

Providers and public health professionals who care for infants who are hospitalized early, particularly infants of young mothers, should be aware of the increased risk for serious injury in this group of infants. Providers may wish to

incorporate injury prevention counseling in their discharge instructions or at follow up outpatient visits. Future studies may determine the mechanism responsible for this increased risk of both intentional and unintentional injury in infants hospitalized early. In addition, public health interventions could be specifically developed to reduce injuries in this “captive” group of infants.

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