Fall-Related Pediatric Brain Injuries: The Role of Race, Age, and Sex

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Background: Falls remain a major cause of childhood morbidity and mortality. To improve effectiveness of our prevention program, we used our electronic injury surveillance database to analyze patient variables and the incidence of fall-related brain injury.

Methods: The database was queried for all injuries treated in the pediatric emergency department for which the word "fall" was listed as part of the chief complaint. Age, sex, and mechanism variables were cross tabulated for analysis with traumatic brain injury (TBI) codes.

Results: Between June 2005 and June 2008, the electronic surveillance system reported 39,718 injury-related visits to the pediatric emergency department. Falls were reported in 3,436 patients (2,107 males, 1,329 females). TBI occurred from falls in 171 patients. Although black children had a higher fall rate (69.24%) than white children (23.75%) and non-black, non-white children (7.01%), white children had the highest TBI rate from falls (9.47%). TBI from falls occurred at a lower mean age for females (5.40 ± 4.45) than males (6.6 ± 5.15) and for non-whites (5.98 ± 4.88) than whites (6.21 ± 4.93). Multiple logistic regression demonstrated a significant influence of age, race, and sex on the likelihood that a fall results in TBI. Females have a higher risk of TBI from falls than males from ages 0 to 11.5. This runs contrary to previous studies suggesting that toddler males are at highest risk for TBI.

Conclusion: A disproportionate number of infants, toddlers, and adolescents sustain brain injury from falls. Race and sex group differences mandate enhanced focus on environmental safety and risk-taking behaviors.

Key Words: Fall related, Traumatic brain injury, Pediatric falls, Pediatric traumatic brain injury, Traumatic brain injury from falls.

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Falls remain a major cause of childhood morbidity and mortality. Falls and fall-related injury results in an estimated 7,946,000 Emergency Department visits and 10,000,000 primary care visits annually.[1,2] Approximately, 200,000 children per year require hospitalization due to traumatic brain injury (TBI). Approximately10 per 100,000 of these children die from their head injury.[3] More than 1 billion dollars in total hospital charges are spent annually for pediatric TBI patients, placing a tremendous strain on the US healthcare system.[4] The Shands Jacksonville Electronic Surveillance Database is a unique tool, which allows tracking of all visits to the Pediatric Emergency Department. Each entry, de-identified for patient privacy, includes patient demographic data, admission, and discharge diagnoses. We used our electronic surveillance database to analyze patient variables and the incidence of fall-related brain injury. This analysis is part of an ongoing effort to improve the effectiveness of our injury prevention program.

METHODS

The Shands Jacksonville Electronic Surveillance Database was queried using Microsoft Access for all injuries treated in the pediatric emergency department in which the word "fall" was listed as part of the chief complaint. Age, sex, and mechanism E-codes were cross tabulated by ICD-9-CM diagnosis and disposition entered at discharge with special focus on discharge diagnosis of brain injury. TBI was defined by ICD-9 diagnosis codes 800–804, 850–854 (Table 1).

Statistical analysis was done using SAS 9.1. Chi-square tests were used to perform table tests on categorical variables. *T* tests and analysis of variance *F* tests were used to compare means. Multiple logistic regression was used to model the relationship between the likelihood of a TBI from a fall and age controlling for sex and race. Summary statistics are reported in (mean ± SD format). The level of significance for multiple comparisons was determined by appropriate methods.

RESULTS

The Shands Jacksonville Hospital Electronic Surveillance Database reported 39,718 injury-related visits to the pediatric emergency department between June 2005 and June 2008. Falls were reported in 3,436 patients (2,107 males, 1,329 females). The database for falls is summarized in Table 2. Note that NWF indicates non-white female and the other three race–sex combinations are defined analogously. A total of 74.19% of falls were sustained by non-white children, whereas 25.81% of falls were sustained by white children. Analysis of variance showed significant differences between the average ages at which falls occurred for the four race–sex combinations described in Table 2 ($F = 3.69$, $p = 0.0115$). The mean age of falls for females (6.30 ± 4.48) was significantly lower ($t = 2.91$, $p = 0.0036$) than the mean age for males (6.82 ± 4.57). A comparison of non-white to white children showed no significant difference in mean age for falls ($t = 0.54$, $p = 0.5874$); however, among non-white children, females were ~1 year younger than males.

TBI occurred from falls in 171 patients (4.97%, 72 females, 99 males). When the effect of age was not taken into

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account, there was no significant difference between the TBI rates from falls for males and females ($\chi^2 = 0.89, p = 0.345$). However, there were significant differences in the rates of TBIs from falls between the four race–sex combination groups described in Table 2 ($\chi^2 = 53.9, p < 0.0001$). Aggregating across all ages, the TBI rate is significantly higher for whites (9.47%) than for non-whites (3.41%; $\chi^2 = 51.04, p < 0.0001$). The risk of TBI from falls was 2.77 times greater for whites than non-whites (95% confidence interval [CI] 2.08–3.71).

Observed TBI rates from falls by year of age (0–14) are in Table 3. Infants and toddlers 0 to 3 years had an elevated risk of TBI from falls when compared with children in older age groups ($\chi^2 = 6.55, p = 0.0105$). Children <1 year of age had the highest rate of TBI from falls (8.96%, 95% CI 4.48–13.64), with the risk of TBI 1.9 times higher than that for the older children ($\chi^2 = 7.59$, $p = 0.0059$, 95% CI 1.20–3.00).

A statistical model using multiple logistic regression was created to evaluate the relationship among the likelihood of TBI from a fall and sex, race, and age. Our model demonstrates that age, sex, and race are all significant predictors of the likelihood that a fall results in a TBI (Table 4). The odds of TBI from a fall are 2.89 times greater for whites compared with non-whites (95% CI 2.11–3.94).

Figure 1 shows the relationship between age and TBI risk for the four possible combinations of race and sex. Note that for males the curve has a U-shape, indicating that the TBI rate falls until approximately age 7 and then increases; and for females the curve falls over time, indicating a lower risk of TBI as a percentage of falls as females get older. For example, at age of 2, the probability of TBI from falls is ~12.5% for a white female, 9.5% for a white male, 5% for a non-white female, and 3.5% for a non-white male, respectively.

Figure 1 suggests that girls have a higher risk of TBI from falls than boys from ages 0 to 11.5. This runs contrary to previous studies suggesting that toddler males are at highest risk for TBI.[5]

DISCUSSION

A disproportionate number of infants, toddlers, and adolescents sustain brain injury from routine falls.[6] Previous literature has suggested that male toddlers are more likely to sustain TBI from falls.[5,7] The AAP Committee on Injury and

TABLE 1. From World Health Organization, International Statistical Classification of Diseases and Related Health Problems, Ninth Revision; 1977

ICD-9 classifications of TBI
- 800–804—Fracture of skull
  - with unspecified state of consciousness
  - with loss of consciousness
  - with concussion
- 850–854—Intracranial injury, excluding skull fracture
  - with unspecified state of consciousness
  - with loss of consciousness
  - with concussion

TABLE 4. Multiple Logistic Regression Model Used to Predict the TBI Risk From Falls

Logistic Regression Model With TBI as a Response Variable					
Parameter	DF	Estimate	Standard Error	Wald χ^2	$p > \chi^2$
Intercept	1	−2.3083	0.1707	182.7726	<.0001
Race (white)	1	0.5301	0.0794	44.5936	<.0001
Age	1	−0.1970	0.0691	8.1280	0.0044
Age squared	1	0.0121	0.00494	5.9977	0.0143
Age × sex (F)	1	0.0859	0.0431	3.9813	0.0460
(Age squared) × sex (F)	1	−0.00744	0.00373	3.9780	0.0461

TABLE 2. TBI Status From Falls by Race and Sex Along With Age Statistics for Events

Race and Sex	Number of TBI (% of Total)	Number of Falls (% of Total)	% TBI From Falls	Percentage of TBI From Falls by Race (%)	Age for Falls		Age for TBI	
					Mean	SD	Mean	SD
NWF	34 (20)	984 (29)	3.46	3.41 (87/2,549)	6.33	4.49	5.65	4.64
NWM	53 (31)	1,565 (46)	3.39		6.84	4.50	6.21	5.06
WF	38 (22)	345 (10)	11.01	9.47 (84/887)	6.21	4.48	5.18	4.32
WM	46 (27)	542 (16)	8.49		6.76	4.77	7.07	5.29
Total	171	3436	4.98					

NWF, non-white female; NWM, non-white male; WF, white female; WM, white male.

TABLE 3. TBI Rates From Falls by Age

Age (yr)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
TBI rates	8.96	6.20	6.34	4.32	2.93	5.16	4.26	1.18	4.55	2.55	6.08	4.69	4.48	4.38	6.12
Falls	212	355	331	278	205	213	188	169	176	196	181	213	223	251	245

0, age corresponds to ≤11 months; 1, ≥12 months and <24 months, and so on.

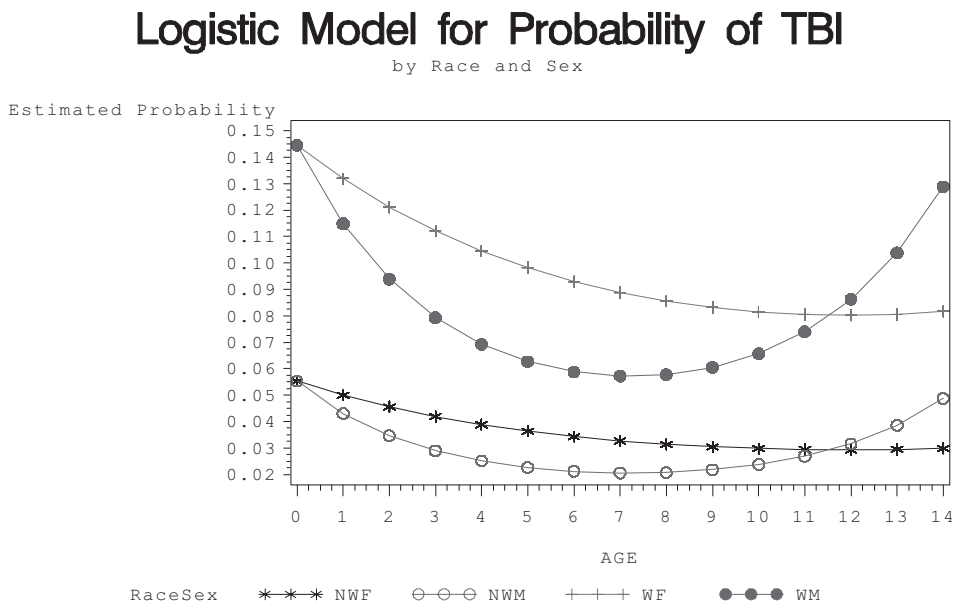

Figure 1. Risk of TBI from falls as a function of age, by age and sex.

Poison Prevention has determined that fall-related injuries to boys outnumber those of girls by ~1.5:1 to 2:1, as with most other injuries.[7] Several studies have suggested that males fall with higher frequency.[5,6] Multiple reasons have been theorized, including greater male risk taking behaviors and differences in male socialization. However, our results suggest that both male and female children, ages 0 to 36 months are at risk of severe injury. Additionally, our analysis shows that girls are at a statistically significantly higher risk than boys for TBI from falls not only as toddlers, but through approximately age 11.

Children at ages 12 to 24 months learn to ambulate, which may account for the large number of falls in this toddler group. However, what is more difficult to explain is the large number of falls (Table 3) sustained in the youngest age group (0–11 months, 6.2% of falls) as well as the large number of TBIs from falls in this group (8.6% of falls resulted in TBI). It is unclear whether this younger group is more susceptible to greater injury due to social factors (e.g., nonaccidental trauma) or physiologic factors (e.g., anatomic characteristics).

Several studies have examined anatomic or physiologic susceptibility of young children to TBI. Goldstein et al.[8] suggested that increased skull elasticity makes toddlers less susceptible to fractures. Berney et al.,[9] however, found that infants and toddlers may be more susceptible to skull fracture and intracranial injury from routine low-energy accidents. Previous studies have suggested that a proportionally greater cephalic mass of toddlers increases their likelihood of cranial impact after a fall.[10–12] However, most of this literature has focused on toddlers, not infants. More research is indicated to explore any possible anatomic differences between male and female infants and toddlers with regards to TBI.

A limitation of this study is the inability to attain more specific information about each patient from a surveillance database whose purpose is to contain only basic registration and discharge data. In addition, as the information in the database has been de-identified, it is not possible to match details of each patient's admission (e.g., chart data) with a corresponding entry in the database. Therefore, specific information regarding medical, social, and developmental history could not be obtained. Additionally, as children may begin to ambulate as early as 9 months, it is possible that this group (ages 9–11 months) may be contributing to the large number of TBIs from falls during the first year. As the dataset is not broken down by months for the first year, the exact age of each patient entered could not be ascertained. The results of this study of surveillance data suggest that a prospective study is warranted to provide a more detailed description of this population.

CONCLUSION

This report demonstrates the usefulness of an emergency department surveillance database in identifying injury trends. Analysis from our database suggests that both male and female infants and toddlers carry an elevated risk for TBI from falls and girls from birth to 11 years have a significantly higher risk of TBI. In this regard, the surveillance database has accomplished its goal. A prospective study is now warranted to confirm these findings and to facilitate development of effective strategies for injury prevention and control.

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