



Variation in patterns of hospitalization and associated resource use among children with spinal cord injury in the U.S.



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ABSTRACT

Introduction: Trauma is a leading cause of mortality and morbidity among children in the U.S. There is paucity of data on the triage of children with spinal cord injury (SCI) to definitive trauma care, and it is unknown if clinical outcomes and resource utilization for children hospitalized with SCI vary according to the settings where trauma care is provided. The study was conducted to describe recent patterns of emergency department (ED) evaluation for paediatric SCI in the U.S., and to characterize outcomes and resource use for children hospitalized at non-trauma centres versus trauma centres.

Materials and methods: Secondary analysis of a national database on injured children 0–20 years evaluated at U.S. EDs and either hospitalized or released, in 2009–2012. In-hospital mortality, duration of stay, and overall charges, were compared according to trauma centre status of the treating hospital.

Results: Of an estimated 67 million annual paediatric visits to the ED for trauma evaluation nationally in 2009–2012, 2317 had SCI. Majority (87%) of children evaluated for SCI were under 6 years of age, and boys comprised 73% of the visits. Injuries were caused mainly by motor vehicle accidents, falls, non-transport-related accidents, and firearms. The South census region had the most ED visits and hospitalizations. Majority (92%) of the most severely injured was evaluated at trauma centres, and more visits to trauma centres (81% vs. 18%, $p = 0.022$) resulted in hospitalization. Among an estimated 1570 hospitalizations of children with SCI from the ED nationally, children at trauma centres were more likely to have major injuries (67% vs. 44%, $p = 0.001$), similar mortality, longer average hospital stay, and higher charges, compared with children hospitalized at non-trauma centres.

Conclusion: Significant demographic and geographical variation exists in national patterns of hospital care for paediatric SCI. Higher severity of patient injury was associated with concomitantly higher hospital resource use at trauma centres.

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Introduction

Trauma is a leading cause of mortality and morbidity among children in the U.S. [1]. Substantial costs [2,3] and tangible psychological and emotional burdens [4] are also borne by survivors and their caregivers. In areas without specialized paediatric emergency and trauma care services, outcomes of paediatric injury are adversely affected [5]; and deleterious outcomes have been reported for injured children without proper triage to a paediatric trauma centre [6–8]. Although there is paucity of data on the triage

of children with spinal cord injury (SCI) to definitive trauma care, a recent study reported better outcomes of direct transfer of children with cervical spine injury to paediatric trauma centre care versus a local hospital [9].

Importantly, due to the complexity of the management of the child with spinal injuries, reports of gradual onset of neurological deficits among some children with SCI, and the higher likelihood of better outcomes in paediatric versus adult SCI; definitive care for paediatric SCI is ideally best undertaken at trauma centres with expertise in paediatric SCI [9]. To optimize the delivery of care to children with SCI, it is important to determine the recent epidemiology of paediatric SCI, and investigate for any variation in clinical outcomes and resource use by setting of definitive trauma care. Dated prior reports on the epidemiology of SCI in U.S. children suggest they comprise up to 10% of all injuries [10–12],

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while more recent data suggest an incidence of 2 cases occur per 100,000 children [13]. This study was performed to determine the recent prevalence of SCI among children evaluated at U.S. emergency departments (ED), and among those hospitalized thereafter. Clinical outcomes and hospital resource use were determined and compared according to the trauma centre status of the treating hospital. It was hypothesized that in-hospital mortality will be higher, and hospital stay longer, for children with SCI admitted to non-trauma versus trauma centres.

Materials and methods

Study design

We conducted secondary analysis of data on injured children 0–20 years old, using the 2009–2012 versions of the Nationwide Emergency Department Sample (NEDS) [14]. Developed by the Agency for Healthcare Research and Quality, NEDS is the largest all-payer ED database in the U.S., with information on ED visits that either result in hospitalization or not. It includes information on patient and hospital characteristics, diagnosis and procedure codes, ED discharge status, type of payer, and ED charges. For hospitalized patients, duration of hospitalization and total hospital charges were also available. The 2012 NEDS, the most recent version, includes 31 million ED visits at 950 hospital-based EDs in 30 U.S. states, that approximates a 20-percent stratified sample of U.S. hospital-based EDs [14]. Each record in the database includes a sample weight for generation of nationally representative estimates. As a result of pooling data from four NEDS years, we divided the sampling weights provided in each year by four to obtain annualized estimates [15].

Study sample and variable identification

Children with trauma diagnoses evaluated in the ED in 2009–2012 were identified using International Classification of Diseases, ninth revision, clinical modification (ICD-9-CM) primary or secondary diagnosis codes indicative of trauma (800–959), as described in prior studies [16,17]. Among these children, diagnosis of SCI was ascertained using specific ICD-9-CM codes for SCI including 806.xx and 952.xx. We excluded SCI from birth trauma (767.4) which would be more appropriately categorized as a complication of the perinatal period. To ascertain injury severity, each record was coded for injury severity scores (ISS). ISS values range from 1 to 75, with higher values signifying higher severity [18]. ISS was used to categorize patient injuries into major (ISS > 15) and minor injuries (ISS ≤ 15), as previously reported in the literature [19]. Records with missing ISS values, missing age, or age > 20 years, were excluded. Anatomical sites of patient injury were identified via the creation of a Barell Injury Diagnosis Matrix [20], while mechanisms of injury were identified via a methodical approach described in the NEDS documentation [14]. These mechanisms included motor vehicle accidents, falls, non-transport-related accidents (cuts, strike, and machinery), firearms, drowning, suffocation, fire, and natural/environmental causes.

Patient characteristics of study interest included age, gender, anatomical sites of injury, ISS, use of invasive medical devices, payer type, mechanisms of injury, ED survival status, and destinations after ED discharge. The use of invasive medical devices was investigated as a proxy for injury severity and potential for hospitalization. Invasive medical devices were identified using ICD-9-CM procedure codes. The devices (ICD-9-CM codes) included mechanical ventilators (96.7), arterial catheters (38.91), central venous catheters (89.62, 38.93, 38.95, 38.94), and intracranial pressure monitors (01.10).

Hospital characteristics of study interest included trauma centre status, geographical characteristics (census region, and metropolitan versus non-metropolitan location) and hospital ownership. Metropolitan status was determined using urban influence codes to signify the urban-rural designation of the county where the hospital was located [21]. Trauma centre designation was based on information from the Trauma Information Exchange Program database, a national inventory of U.S. trauma centres [22].

Study outcomes:

- (1) Among all patients evaluated in the ED: Use of invasive medical devices, mortality, and discharge destination.
- (2) Among hospitalized children: In-hospital mortality, length of hospital stay, and total hospital charges.

Statistical analysis

Using data pooled across the years 2009–2012, the analysis was conducted in two steps:

- i. National incidence of ED visits for SCI at U.S. hospitals was determined. Subsequently, patient and hospital characteristics for the visits, and use of invasive medical devices were compared according to the trauma centre status of the hospital, using Chi-square tests.
- ii. Among hospitalizations from the EDs, patient and hospital characteristics were described and compared according to trauma centre status of the hospital using Chi-square tests. Thereafter, in-hospital mortality, mean length of hospital stay, and total hospital charges were compared according to the trauma centre status of the treating hospital, using Student *t* test.

The number of hospitalizations in the results was presented as unweighted data with accompanying nationally representative annualized estimates, while all effect estimates and the accompanying 95% confidence intervals (CI) were calculated using sample weights to account for the complex survey design, using Stata version 10 for Windows (Stata Corp.; College Station, Texas). In keeping with the statutes guiding the use of the data, information within cells smaller than 10 observations were suppressed [22].

Multivariable logistic regression, multiple linear regression, and Poisson regression models for complex survey data were fit to assess differences in mortality, total charges, and LOS, respectively, by trauma centre status. Because of skewness in the distribution of data for hospital charges, models for hospital charges were fit after logarithmic transformation of the variable. Predicted charges were determined after exponentiation of the estimate and applying Duan's smearing estimator [23]. All the charge data were adjusted with the appropriate inflation factor to calculate 2012 US dollar estimates. Variance estimates accounted for clustering of data at the hospital level by using hospital identifiers as the primary sampling units. Potential confounders adjusted for in the multivariable regression models included injury severity score, mechanisms of injury, age, and gender. The institutional review board at the University of Michigan School of Medicine granted exempt status to the study.

Results

Characteristics of paediatric SCI visits in U.S. EDs

In 2009–2012, of 30 million visits (67 million estimated nationally) to the ED for trauma evaluation, 1973 (2317 estimated

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