Epidemiological Trends of Traumatic Brain and Spinal Cord Injury in Puerto Rico from November 10th, 2006, through May 24th, 2011

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Objective: According to the Centers for Disease Control and Prevention (CDC), injury to the central nervous system (CNS) continues to be a leading cause of injury-related morbidity and mortality in the US today.

Methods: A prospective cohort study was performed to determine the incidence of all traumatic CNS injuries. Descriptive variables were presented as frequencies and percentages. Quantitative variables were expressed as means and averages (plus/minus standard deviation); bivariate cross-tabulation and multiple regression analyses were employed to identify risk factors and compare epidemiological patterns of injury-related variables.

Results: Information from 3,202 patients with confirmed CNS injuries was collected and analyzed. Traumatic brain injuries (TBIs) had occurred in 2,524 of the cases (78.8%). Spine injuries had occurred in 831 cases (25.9%), and 197 cases (6.2%) had suffered spinal cord injuries. Overall, most of the cases were male (75.0%) and with a median age of 40 years. Of the total number of cases, newborns and infants (≤ 4 years of age) comprised 7.8% and elderly individuals (>65 years of age), 27.4%. Nearly half of the injuries were due to falls (47.5%), followed by motor vehicle and other transport accidents (35.2%). Loss of consciousness occurred in 61.3% of the traumas. The Glasgow Coma Scale (GCS) was used to categorize TBI severity and showed that the majority of TBIs were mild (70.0%). Over 90% of all cases had been injured either at home (42.8%) or on the street (49.1%).

Conclusion: These results are evidence that additional collaborative efforts that focus on trauma are needed to increase knowledge, public health awareness, and preventive measures. [*P R Health Sci J 2018;37:67-77*]

Key words: Neurological injuries, Traumatic brain injuries, Spinal cord injuries, Epidemiology, Incidence

Neurological injuries are a major cause of death and disability throughout the world (1, 2, 3, 4, 5, 6, 7, 8). Neurological injuries are divided into peripheral and central nervous system (CNS) injuries; CNS injuries are further subdivided into traumatic brain injuries (TBIs) and spinal cord injuries (SCIs). According to recently available data in the United States (US), published by the Centers for Disease Control and Prevention (CDC), the incidence of TBI has continued to climb, reaching a rate of 823.7 per 100,000 in 2010 (1, 2). TBI is a contributing factor to a third (30%) of all injury-related deaths in the US (1,2). In 2010 approximately 2.5 million people in the US sustained a TBI, and every day, 138 people die from injuries that include TBI (3). TBI contributed to the deaths of more than 50,000 people and was a diagnosis in more than 280,000 hospitalizations and 2.2 million emergency department (ED) visits (2). The CDC estimated that the annual incidence rate for TBI-related ED visits was 91.7 per 100,000 in 2010 (4). Information about TBI from the European Union is limited; however the available epidemiological data shows the yearly aggregate incidence of hospitalized and fatal TBI of approximately 235 per 100,000 population, similar to what has been reported in Australia (6). In the US, the rate for the same was 108.8 per 100,000 in 2010 (5).

TBIs are also a major cause of long-term disability (5, 6). Approximately 10 to 15% of patients with TBI have moderate to severe head injuries, many of them with residual sequelae. The annual economic cost of TBI in the US, including direct medical and rehabilitation costs and indirect societal economic costs, is

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estimated to be $ $76.5 billion (7). TBI is frequently referred to as the "silent epidemic" because the long-term complications of TBI, such as changes in motor function, affect, thinking, sensation, language, emotions, and/or epilepsy, may not be readily apparent, and limited awareness about this condition exists within the general public.

According to the National Spinal Cord Injury Statistical Center, Birmingham, Alabama, SCIs affect around 12,000 Americans every year (9). It has been estimated that 282,000 American citizens are currently living with SCI-related disabilities, and 55% of these injuries occur in people from 16 to 30 years old. The cost of the management care of SCI patients approaches $10 billion each year. The World Health Organization (WHO) indicated in 2013 that every year, worldwide, as many as 500,000 people suffer an SCI (10). People with SCIs are 2 to 5 times more likely to die prematurely, with the worst survival rates being in low- and middle-income countries (10).

The main purpose of this study was to describe the occurrence and prevalence of CNS trauma in patients evaluated by the neurosurgery service at the Puerto Rico Medical Center's ED from November 2006 through May 2011. The authors are not aware of any comprehensive study describing the epidemiological trends of TBI and SCI in Puerto Rico (PR).

Methods

In 2005, Victor G. Coronado, MD, MPH, a member of the National Center for Injury Prevention and Control, Division of Injury Response, at the CDC, provided the senior author with a questionnaire designed to gather epidemiological information from patients with neurological injuries evaluated in the ED. This form was modified with respect to the pertinent Puerto Rican profiles (See Appendix). The study protocol was reviewed and approved by the University of Puerto Rico, Medical Sciences Campus, Institutional Review Board.

The present cohort study gathered data prospectively from November 10, 2006, to May 24, 2011, to determine the prevalence of all CNS injuries (TBI, SCI, and combined TBI/SCI) in patients receiving medical evaluation due to trauma by the neurosurgery division of the UPR Medical School, located at the Puerto Rico Medical Center. The modified version of the CDC questionnaire form for CNS trauma was used to collect the data. The statistical analysis was performed at the Puerto Rico Clinical and Translational Research Consortium. Descriptive variables were presented as frequencies and percentage. Quantitative variables were expressed as mean (plus/minus standard deviation); bivariate cross-tabulation and multiple regression analyses were employed to identify risk factors and compare epidemiological patterns of injury-related variables.

The Puerto Rico Medical Center (PRMC) is the main health facility in PR, with an available neurosurgery service in the emergency room, 24 hours a day, 365 days per year. The emergency room of the PRMC serves the Trauma Hospital, the University Adult Hospital, and the University Pediatric Hospital. It is believed that almost all the major neurological traumas in PR are referred to the ED of the PRMC. The severity of a TBI may range from "mild," described as a brief change in mental status or consciousness, to "severe," characterized by an extended period of unconsciousness. Spinal injury (SI) is defined as a traumatic event affecting the vertebral bones, the vertebral supporting ligaments, and/or the spinal cord. An SCI is characterized as an insult to the spinal cord resulting in a change, either temporary or permanent, in its normal motor, sensory, or autonomic function.

Results

Data were gathered prospectively from 3,285 traumatized patients evaluated by the neurological surgery at the ED of the "Administración de Servicios Médicos" (ASEM; in English, the Medical Services Administration) of the Puerto Rico Medical Center from November 10, 2006, through May 24, 2011, and subsequently examined for the distribution of socio-demographic and injury-related characteristics as defined by the study questionnaire. Eighty-three (83) cases were eliminated from the study due to their lack of neurological injuries; therefore, 3,202 cases were finally analyzed. Although efforts were made to obtain all the information requested in the questionnaire, there was information missing for several of the parameters evaluated. In some cases, the specifics for a number of the variables was not available or recorded.

Table 1 summarizes the distribution of sex, age, and the place where the injured person lived. Table 2 contains the event information. Table 3 depicts the injury circumstances, which include the mechanism of the injury, the activity that the injured person was involved in at the time of the accident, whether the trauma was intentional or not, and whether the injured person experienced a loss of consciousness. Table 4 contains multiple details about transportation injuries. Table 5 summarizes the medical findings of the traumatized individuals and includes neurologic findings, Glasgow Coma Scale scores, CT scan results, details regarding associated non-CNS injuries, SI-related radiographic findings (detailing location and severity), the various dispositions of the injured patients, and whether alcohol or illegal drugs were being consumed during the accidents from which the different traumas resulted.

The occurrence of TBIs and/or spine injuries was documented in all 3,202 cases. Head injuries occurred in 2,975 cases (92.9%). TBIs occurred in 2,524 cases (78.8%). TBI alone (without SI) occurred in 2,361 cases (73.7%). SIs occurred in 831 cases (25.9%), SIs combined with head trauma, 712 cases (22.2%), and SCIs, 197 cases (6.2%). There were 119 cases (3.7%) of SI without accompanying head injury. The radiographic findings of SI were documented in 513 cases. Injury to the spine was diagnosed as fracture in 421 (82.1%) cases, as subluxation in 65

Table 1. Registration and sociodemographic information of the injured

Variables	N Total =3,202	Value
Gender, n (%)	3,088	
Male		2318 (75.0)
Female		770 (25.0)
Age, years	3,150	
Mean (SD)		42.9 (27.2)
Median (min-max)		40.0 (0.014-102.0)
0 – 4		246 (7.8)
5 – 14		260 (8.3)
15 – 24		508 (16.1)
25 – 44		651 (20.7)
45 – 64		621 (19.7)
65 +		864 (27.4)
Residence municipality, n (%)	2904	
Arecibo		336 (11.6)
Bayamón		351 (12.1)
Carolina		333 (11.5)
Guayama		384 (13.2)
Humacao		395 (13.6)
Mayaguez		291 (10.0)
Ponce		262 (9.0)
San Juan		515 (17.7)
Other PR (Homeless)		1 (0.03)
Other outside PR		36 (1.24)
Town (for non-PR residents), n (%)	36	
USA		21 (58.3)
Francia		2 (5.6)
St. Croix		7 (19.4)
St. Thomas		5 (13.9)
Tortola		1 (2.8)

SD: standard deviation; min: minimum; max: maximum

(12.7%) cases, and as soft tissue injuries in 84 (16.4%) cases. (See Table 5).

The age was recorded in 3,150 cases, yielding an average age of 42.9 years and a median age of 40 years (range 0.01–102) (st. dev. = +/- 27.1). Age was further subdivided into the following age groups: 0 to 4 years (246 patients, 7.8%), 5 to 14 years (260 patients, 8.3%), 15 to 24 years (508 patients, 16.1%), 25 to 44 years (651 patients, 20.7%), 45 to 64 years (621 patients, 19.7%), and 65 years old or older (864 patients, 27.4%).

The patient's district of residence was recorded for 2,904 patients. Overall, the patients resided in the municipalities in which their injuries occurred. A significant number of the patients (45.2%) were referred from outside the San Juan metropolitan area. As expected, most of the injuries (54.8%) occurred in the metropolitan area where most of the patients lived and worked. According to the US census (11), over half of the Puerto Rican population lives in the San Juan metropolitan area. Moreover, it was not a surprise that most of the injuries occurred during weekend days, in the afternoons and evenings. Most motor vehicle accidents tend to take place at these times. The monthly distribution of TBI-related occurrences is fairly homogeneous, except for in the month of July, when there was a slight decrease in the number of such events.

Table 2. Event information

Variables	N	Value
Injury week day, n (%)	2,881	
Monday		427 (14.8)
Tuesday		385 (13.4)
Wednesday		327 (11.4)
Thursday		300 (10.4)
Friday		356 (12.4)
Saturday		498 (17.3)
Sunday		588 (20.4)
Injury time n (%)	1,336	
12:00 am – 5:59 am		183 (13.7)
6:00 am – 11:59 am		262 (19.6)
12:00 pm – 5:59 pm		503 (37.6)
6:00 pm – 12:00 am		388 (29.0)
Injury month n (%)	2,773	
Jan		257 (9.3)
Feb		252 (9.1)
Mar		260 (9.4)
Apr		258 (9.3)
May		262 (9.4)
Jun		236 (8.5)
Jul		163 (5.9)
Aug		248 (8.9)
Sep		183 (6.6)
Oct		202 (7.3)
Nov		181 (6.5)
Dec		272 (9.8)
Injury year n (%)	2,980	
2006		42 (1.4)
2007		894 (30.0)
2008		741 (24.9)
2009		526 (17.7)
2010		569 (19.1)
2011		208 (7.0)
Place of occurrence, n (%)	2,505	
Home		1,072 (42.8)
School		21 (0.8)
Work		38 (1.5)
Street		1,231 (49.1)
Other		143 (5.7)
Occurance municipality, n (%)	2,266	
Arecibo		285 (12.6)
Bayamón		270 (9.6)
Carolina		253 (11.2)
Guayama		300 (13.2)
Humacao		308 (13.6)
Mayaguez		227 (10.0)
Ponce		203 (9.0)
San Juan		406 (17.9)
Other PR (Homeless)		-
Other outside PR		14 (0.6)

The place of injury occurrence was identified in 2,510 cases. The injury occurred at home in 1,148 (45.7%) cases, at school in 23 (0.9%) cases, at work in 37 (1.5%) cases, and on the street in 1,302 (51.9%) cases. With regard to this distribution, it is important to mention the fact that work-related injuries are evaluated by the Fondo del Seguro del Estado (FSE) (PR's equivalent to the Office of Workers' Compensation Programs, US Department of Labor) and therefore were not seen by the neurological surgery service at the ED of PRMC, explaining

Table 4. Transport injuries

Variables	N	Value
Type of users, n (%)	1,038	
Pedestrian		199 (19.2)
Passenger		222 (21.4)
Driver		464 (44.7)
Cyclist		110 (10.6)
Other		43 (4.1)
Type of accident, n (%)	843	
Run over		148 (17.5)
Collision between vehicles		315 (37.3)
Collision with fixed object		164 (19.5)
Collision with animal		4 (0.5)
Tipped, rolled over		60 (7.1)
Fall / Ejected from vehicle		137 (16.3)
Other		15 (1.8)
Type of vehicle, n (%)	912	
Car		362 (39.7)
Pick up		39 (4.3)
Bus		7 (0.8)
Truck		6 (0.6)
Bicycle		77 (8.4)
Motorcycle		212 (23.2)
ATV (4-track)		59 (6.5)
Water cycle (jet-sky)		1 (0.1)
Skateboard, skates, scooter		10 (1.1)
Train		
Cart		1 (0.1)
Animal traction		20 (2.2)
Other		118 (12.9)
Type of second vehicle or counterparts, n (%)	630	
Car		359 (57.0)
Pick up		19 (3.0)
Bus		11 (1.7)
Truck		16 (2.5)
Vehicle		8 (1.3)
Motorcycle		13 (2.1)
ATV (4-track)		
Water cycle (jet-sky)		
Skateboard, skates, scooter		
Train		
Cart		2 (0.3)
Animal traction		3 (0.5)
Other		199 (31.6)
Safety equipment use, n (%)	680	
Seatbelt		246 (36.2)
Helmet		117 (17.2)
Helmet (w/o strap)		
Car seat (children)		16 (2.4)
Vehicle with airbag		2 (0.3)
Airbags activated		5 (0.7)
No protective gear		272 (40.0)
Other		22 (3.2)

the low incidence of job-related trauma. It is not surprising that there is an almost equal distribution of injuries at home and in the street, where besides their jobs most of the people spend their time.

Loss of consciousness is considered to be an indicator of brain injury. The incidence of loss of consciousness was recorded in 2,908 cases. Loss of consciousness was documented in 1,922 (66.1%) cases. The duration of the loss of consciousness was documented in 1,763 cases; 1,288 (44.8%) had a loss of consciousness of less than 1 hour, and 475 (16.5%) had a loss of consciousness of 1 hour or more. Although a prognosis of each of the patients was out of the scope of this study, there has been great interest in the literature correlating multiple concussions and Chronic Post-traumatic Encephalopathy (4,7). Chronic Post-traumatic Encephalopathy is a degenerative condition linked to repeated head injuries.

The dispositions of the patients after their evaluations in the emergency room were registered for 2,937 cases. There were 1,313 (44.7%) patients that were admitted to the hospital and 1,624 (55.3%) that were not. Of the patients not admitted to the hospital, 135 (8.3%) were discharged without observation and referred to the outpatient facilities for follow-up, 100 (6.2%) were kept under observation at the trauma unit, 1,231 (75.8%) were kept under observation at the emergency room, and 158 (9.7%) were transferred to another service.

Discussion

The goal of this study was to provide descriptive information on multiple characteristics of neurological injuries and the patterns associated with them. The study did not evaluate medical management strategies or results. The true incidence rate of CNS injuries in PR cannot be estimated from this study because the total population of patients with neurological trauma is unknown; it is unknown, as well, how many patients were evaluated or treated at facilities outside the PRMC during the period of the study.

Age–Gender

Data gathered from 3,202 patients evaluated for CNS traumatic injuries showed that 75% were males and 25% were females. This finding is different from what has been revealed in the US data (as reported by the CDC in 2010); these data show that 56% of the emergency room evaluations for TBI were done on males (4). The Puerto Rican Trauma Center Group reported an incidence of 16.36% for females that were admitted to the center from 2002 to 2011 with general body injuries (12). In 1980, Annegers et al reported that the incidence of males with TBI in Minnesota was 70% (13); in 1983, Cooper et al reported a TBI incidence of 73% for males in New York (14); in their 1984 study, Kraus et al (15) claimed a TBI incidence of 69% for males in California; Cadotte et al, in their 2011 (16) Canadian study, indicated having found a male TBI incidence of 69.6%. There is no obvious explanation for this disparity between our age-related findings and those reported by the CDC.

The National Spinal Cord Injury Statistical Center reported that 80% of the new SCIs in 2016 were in males (9). More in accordance with the national data, in our study, 75.8% of patients with SIs were male. WHO studies have reported male-to-female ratios of at least 2:1, among adults (10).

In population-based studies that include all ages, a tri-modal age-specific TBI incidence has generally been reported;

Table 5. Medical exam

Variables	N	Value
Brain trauma, n (%)	2,564	
Mild (GCS 13-15)		1898 (70.0)
Moderate (GCS 9-12)		321 (12.5)
Severe (GCS 3-8)		305 (11.9)
Brain dead		40 (1.6)
Neurological findings*, n (%)	2,478	
Not recorded		303 (12.2)
No CT available		16 (0.6)
A-SDH		587 (23.7)
C-SDH		286 (11.5)
SAH		380 (15.3)
DAI		64 (2.6)
EDH		229 (9.2)
Penetrating injury		40 (1.6)
Edema		165 (6.7)
Concussion		1763(71.1)
Contussion		895 (36.1)
ICH/IVH		119 (4.8)
Fracture		774 (31.2)
Laceration		59 (2.4)
Spine*, n (%)	513	
Fracture		421 (82.1)
Subluxation		65 (12.7)
Soft tissue		84 (16.4)
Trauma level*, n (%)	400	
Cervical		239 (59.8)
Thoracic		79 (19.8)
Lumbar		98 (24.5)
Sacral		4 (1.0)
Spinal cord trauma, n (%)	197	
Complete spinal cord injury		73 (37.0)
Incomplete: sensory but no motor function below neurological level		26 (13.2)
Incomplete: motor function preserved below level; muscle grade<3		39 (19.8)
Incomplete: motor function preserved below level; muscle grade>3		59 (29.9)
Associated injury Non-CNS*, n (%)	2,823	
Wound, cut, laceration		1127 (39.9)
Superficial trauma/Hematoma		626 (22.2)
Excoriation (scratch)		199 (7.0)
Crushing trauma		16 (0.6)
Fracture (not skull, not spine)		337 (11.9)
Foreign body effect		9 (0.3)
Traumatic amputation		2 (0.07)
Blood vessel trauma		5 (0.2)
Nerve trauma		22 (0.8)
Organ trauma		166 (5.9)
Muscle and tendon trauma		20 (0.7)
Multiple trauma		151 (5.3)
None		948 (33.6)
Unspecified		19 (0.7)
Other		64 (2.3)
Disposition, n (%)	2,937	
Ambulatory treatment		61 (2.1)
Observation in trauma unit		100 (3.4)
Observation in emergency room		1231 (41.9)
Transferred/Sign off		158 (5.4)
Admission to	1,387	
Neurointermediate care unit		55 (1.9)
Neurointensive care unit		42 (1.4)
Trauma intensive care unit		236 (8.0)
Trauma intermediate care unit		371 (12.6)
Pediatric hospital ward		68 (2.3)
Pediatric intensive care unit		26 (0.9)
Medicine		15 (0.5)
Operating room		445 (15.2)
Voluntary discharge		2 (0.07)
Death		18 (0.6)
Organ donation		21 (0.7)
Discharged		74 (2.5)
Other		14 (0.5)
Clinical evidence of drug or alcohol abuse, n (%)		
Alcohol	2,446	
Yes		467 (19.1)
No		1979 (80.9)
Ilegal Drugs	2,415	
Yes		150 (6.2)
No		2265 (93.8)

*More than one finding per subject

incidence peaks in early childhood and late adolescence–early adulthood and in the elderly (17). A comparison between studies of specifics regarding age is often difficult because of the non-uniformity of age categorization, differences in case ascertainment methods, the influences of socioeconomic status, race, the location (urban or rural) of a given trauma event, and the various mechanisms of injury; however, age-incidence trends can be identified. This study does not capture the data of all the children with head injuries, specifically; it does not capture information about very young children (0–4 years) because they are usually evaluated at the ED of the University Pediatric Hospital of Puerto Rico (UPH). A study published in 2010 by Fernandez, et al (18) reported on the evaluation and management (in the ED of the UPH, 2004 to 2006) of 136 children, 0 to 2 years old, with minor head injuries. This study indicates that 34% of the cases were not evaluated by a neurosurgeon; hence, the information of the cases with neurological trauma that were not seen by the neurosurgical service was not captured in the present study, clearly indicating that the occurrences of neurological injuries (specifically in children) are much larger than our data indicate. This is also true for minor head injuries in adults who were evaluated and managed in other hospital EDs around the island and who were never referred to the PRMC.

Injury circumstances: Mechanism of injury

The main mechanisms of injury were falls, which were responsible for 1,379 cases (47.5%), and transportation accidents (TAs), which accounted for 1,021 cases (35.2%). Furthermore, TAs were responsible for 31.7% of the patients with TBI and 24.8% of those with spinal trauma. These results compare with the most common causes of TBI in the US (as reported by the CDC) (4,7); the CDC reports listed TAs as being the third leading cause of TBI.

TBI incidence related to TAs in PR is higher than what was reported by the CDC (4,7), which organization revealed that motor vehicle–related traffic events accounted for 14.3% of all TBIs, indicating that the PR incidence was 2.5 times higher that the US incidence was. The Puerto Rican Trauma Center Group (19,20) examined 14,874 patients admitted to the Puerto Rico Trauma Hospital from 2002 to 2011 and concluded that TAs were the most frequent mechanism of injury, accounting for 36.1% of all the admissions (regardless of the presence of TBI or not). Although the variables related to transport accidents are innumerable, our study suggests a worrisome situation with regard to Puerto Rican driving risks.

Our analysis showed that 30.6% of the TAs occurred in the 15 to 24 age group, 30.4% occurred in the 25 to 44 age group, and 16.8% occurred in the 45 to 64 age group. Of the TBI cases, the very young (<1 year), young (1–4 yrs.), and elderly (≥ 65 years) had significantly more TBIs due to falls than the members of any other age group did ($p<0.001$) (See Figure 1).

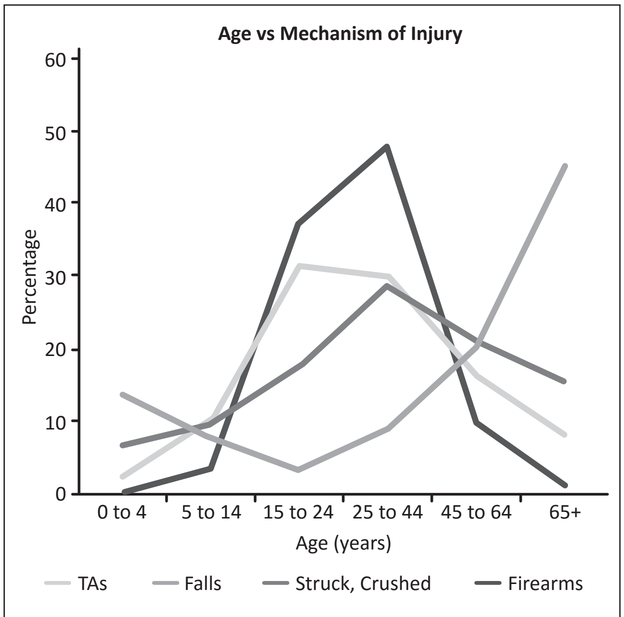

Figure 1. The main mechanisms of injury were falls and transportation accidents (TAs). Falls are very frequent in children and the elderly. TAs, firearm-related injuries, and injuries produced by being struck or crushed tend to occur in the middle-aged.

The CDC (4,7) reported that motor vehicle crashes were the leading cause of hospitalization for persons from 15 to 44 years of age; among all age groups, motor vehicle crashes were the third overall leading cause of TBI (14%). Looking just at TBI-related deaths (2006–2010), motor vehicle crashes were the second leading cause of such deaths (26%), which correlates with our own observations. In Canada (2007), motor vehicle accidents were responsible for 60.3% of all TBIs (16), in China (1983), for 32% (17,21), and in France (1986), for 60% (17), indicating a great variability around the world.

Every year in the US, more than one third of the adults over the age of 65 years fall. Among older adults, falls are the leading cause of injury-related death (22,23). Falls are the etiology of 47.5% and 40.5% of all the TBIs in PR and the US, respectively (4,7). Falls are very frequent in children and the elderly. Among infants, head injuries occur due to falls from a caregiver's arms or from furniture (17,24); in toddlers, falls occur while they are learning to walk; in older children, falls are most likely to occur while they are running, jumping, riding bicycles/skateboards, playing sports, or engaging in other skills-learning activities. Falls in the elderly usually occur at home.

Our study identified falls as the etiology of TBI in 12.8% of the members of the 0 to 4 age group, 7.6% of the members of the 5 to 14 age group, 9.1% of the members of the 25 to 44 age group, 21.5% of the members of the 45 to 64 age group, and 44.4% of the members of the 65 and older age group; in 1.4% of the cases, the age was not reported. As previously stated, our data are not very robust in terms of the child population. The CDC (4) reports that falls are the primary mechanisms of TBI-related ED visits in the members of the youngest (0–4 years) and oldest (65 years and older) age groups, accounting for 72.8% and 81.8%, respectively, of TBI-related ED visits. (See Figure 1).

In our study, transport accidents were responsible for 43.6% of all the SIs, and falls for 39.1% of them. The National Spinal Cord Injury Statistical Center (8) reported an incidence of 38% for vehicular crashes and 30.5% for falls, following a similar pattern of distribution as was observed in our study. In Canada (25), motor vehicle accidents were the etiology for 65.5% of the SIs, and falls for 12.9% of them. The age distribution of the SIs was 0.5% for the 0 to 4 age group, 3.0% for the 5 to 14 age group, 17.4% for the 15 to 24 age group, 28.9% for the 25 to 44 age group, 27.8% for the 45 to 64 age group, and 20.5% for those aged 65 years or older; in 1.9% of the cases, the age was not reported. Piatt (26) reported that for Hispanic children, motor vehicle accidents were responsible for 68.5% and falls for 12.5% of all the SIs. There is a peak distribution in the age groups of 25 to 64. This tendency toward a higher rate of patients with SIs in the middle-aged group was also observed in a Canadian study (25).

Each year in the US, 2.8 million elderly people are treated in EDs for fall injuries, which represent the most common mechanism of TBI (27,28) and account for a 46% fatality rate (29,30). These injuries can limit independent living in the elderly and increase the risk of early death (31,32). Many people who fall, even those who are not injured, develop a fear of falling. This fear may cause them to limit their activities, leading to reduced mobility and physical fitness and increasing their actual risk of falling (33).

The percentage of patients with TBIs that presented with SIs was 32.9% (831/2,975), and 85.7% (712/831) of the patients with an SI had suffered a TBI. Macciocchi et al (34) reported that

60% of their sample members who had experienced a traumatic SCI had also sustained a TBI. The co-occurrence of TBI with SCI has been estimated to be 40 to 60%, in earlier studies (25). Tolonen et al (35) stated that TBI is underdiagnosed in patients with SCIs.

The incidence of SCI in this cohort was 6.1%. According to the National Spinal Cord Injury Statistical Center (9), SCI has an incidence of 54 per 1 million inhabitants and TBI of 807.5 per million; SCI represents 6.7% of the CNS injury cases, which is similar to what we found in our study.

Severity of head injuries

The Glasgow Coma Scale (GCS) was used to classify the severity of each case's TBI. A GCS score of 13 to 15 was considered mild, a score of 9 to 12, moderate, and a score of 3 to 8, severe. There were 1,898 (75.2%) cases with mild TBI, 321 (12.7%) cases with moderate head injuries, and 305 (12.1%) cases with severe TBI; 40 (1.6%) of the cases that presented to the emergency room were brain dead (GCS = 3).

The Puerto Rican Trauma Center Group reported an incidence of a GCS score lower than or equal to 9 in 12% of the male and 10.22% of the female patients with general body injuries (12). The CDC has indicated that most of the TBIs in the US are mild (4,7). Bruns and Hauser (17) summarized the TBI severity index for a cohort from South Africa, reporting the incidence of mild TBI to be 87.5%, with moderate head injuries occurring in 7.9% of the cases, and severe TBI occurring in 4.6%; in a cohort in France, mild TBI was reported in 80% of the cases, moderate head injuries in 11%, and severe TBI in 9%. Bruns and Hauser (17) estimated the average head injury severity score to be mild for 80% of their sample, moderate for 10%, and severe for 10%. In a cohort from Germany (36), the GCS status was documented in 6,683 cases; 90.2% were classified as mild, 3.9% as moderate, and 5.2% as severe. Haavde Strand (37) et al from Norway documented the incidence of mild head injuries at 91.4%, moderate injuries at 7.2%, and severe ones at 1.3%. In a compressive sports-related TBI study, Winkler et al (38) reported that in their cohort, mild TBI constituted 80.6% of the injuries. Macciocchi et al (34) reported that TBIs related to SCIs were mild (34%), moderate (6%), and severe TBI (10%). These patterns of distribution are aligned with those observed in our cohort; however, great variability exists within the trauma centers.

In 2014, Quayle (39) reported the GCS scores of 43,904 children who had suffered from head trauma, were 17 years of age or younger, and who lived in the US; the distribution was 98% for mild, 1% for moderate, and 1% for severe head injuries, indicating that children tend to experience minor head injuries more often than they do any of the others. Fernandez (18) et al reported a similar experience in children less than 2 years of age.

Computed tomography findings

Computed tomography (CT) findings are important for the diagnosis, management, and prognosis of TBI patients. The TBI patients were further subdivided according to their CT scan imaging results. This variable was registered in 2,478 cases. In our study the number of patients in which data for the CT were recorded was 77.4%, and of these patients, 12.2% had a normal CT. Eighty-four percent (84%) had 1 or more neurosurgical cranial findings, such as brain contusions (36.1%), a cranial fracture (31.2%), or an acute subdural hematoma (23.7%) (the percentage adds up to more than 100% because some patients had more than 1 CT scan finding) (See Table 5). In a Norwegian (37) study of 1,325 cases, 73.2% had a normal CT finding, and of the patients with a positive CT, 49.4% were determined to have a brain contusion, 45.8%, a skull fracture, 37.4%, a subdural hematoma, and 24.1%, a subarachnoid hemorrhage/intraventricular hemorrhage. A cohort from Africa (40) was reported to have abnormal CT findings after head injuries in 54.5% of the cases, with a 30% incidence of brain contusion, a 23.3% incidence of subdural hematoma, a 6.7% incidence of epidural hematoma, and a 27.7% incidence of skull fracture. Haydel (41) reported on 93 patients with positive head CTs after minor head injuries, with 47% showing brain contusion, 38%, subdural hematomas, 14%, subarachnoid hemorrhage, 10%, epidural hematomas, and 11%, depressed skull fractures. Obviously, the incidence of CT findings will depend on the population evaluated in the ED and the referral patterns and selection criteria. Our study results suggest the existence of a very selective referral pattern, in which patients with radiographically documented pathology are referred to our ED, despite their being in a good neurological state (as reflected by their Glasgow Coma Scale scores).

Spinal injuries

SIs occurred in 831 cases (25.9%), of which 712 cases (85.7%) had both injuries to the spine and head trauma, and 197 cases (23.7%; 197/831) had SCIs. The incidence of SCI within the cohort was 6.2% (197/3,202). There were 119 cases (14.3%) with SIs but without head injuries. In the Canadian spine and spinal cord epidemiological study (25), the overall SI incidence was 23.2%, and the incidence of SCI was 5.4%.

The level of the SI was registered in 400 patients. The cervical spine was traumatized in 239 (59.8%) cases, the thoracic spine, in 79 (19.8%), the lumbar spine, in 98 (24.5%), and the sacral region. in 4 (1.0%). In the Canadian study (25), the incidence of cervical injuries was 29%, of thoracic injuries, 21%, of lumbo-sacral injuries, 50%, and of multiple levels, 20%. A Chinese cohort (42) reported an incidence of 20.5% for injuries to the spine occurring in the cervical area, of 30.5% for such injuries in the thoracic region, of 47.8% for such injuries in the lumbar spine, and of 1.2% for such injuries in the sacral region. The National Spinal Cord Injury Statistical Center (9) reported that 54.0% of patients had cervical lesions, 35.1% had thoracic lesions, 10.5% had lumbar lesions, and 0.4% had sacral lesions. These study findings are not dissimilar to those of our study.

Trauma to the spinal cord was recorded in 197 patients. Complete neurologic deficit was identified in 73 (37.1%) cases, incomplete SCI with motor function preserved below level but with strength above 3 was observed in 59 (29.9%) cases, incomplete SCI with motor function preserved below level and with strength below 3 was seen in 39 (19.8%) cases, and incomplete SCI without motor function below the lesion but preserved sensation was seen in 26 (13.2%) cases. In the Chinese study (42), complete injuries were present in 34.4% of the cases, complete motor deficits with remaining sensory function in 7.3%, inefficient motor function in 13.5%, and useful residual motor function in 44.8%. The National Spinal Cord Injury Statistical Center (9) reported an incidence of complete neurologic deficit in 45.4% of cases, motor functional in 18.8%, motor non-functional in 13.8%, and sensory incomplete in 12.3%. This suggests that the severity of our SCIs was slightly lower than that of the SCIs in the US, as a whole.

Limitations of study

This study was based on data collection that was accomplished using a questionnaire. The parameters and information may not include all the relevant variables. For example, no outcome parameters were evaluated, and for some patients, not all the requested data were available or else were not recorded. The study data were gathered prospectively, but the analysis was done after all the data were collected, creating a possibility of bias. The results could be skewed by inaccurate or missing data. The study analyzed variables at only 1 institution, making generalization difficult or imprecise.

Conclusion

As is the case in the US, CNS trauma is a major cause of morbidity and mortality in PR. The data compiled in this study corroborated with that of the US showing that head trauma is more common than spinal trauma. The major causes of head trauma are falls (mainly in children and the elderly) followed closely by transportation accidents; furthermore, spinal trauma is mostly caused by transport accidents. One of the essential benefits of this project is that it can serve as a reference study with which future studies can be compared. It can help in the monitoring of prevention efforts and of the changing patterns of neurological injuries as time evolves and society changes.

Currently, PR does not have widespread CNS injury–prevention initiatives. We hope that this study might lead to the creation, improvement, or amplification of preventive educational programs, such as Piénsalo Primero (Think First, PR chapter), a program that focuses on CNS injury prevention. Preventive educational programs could lead to a decline in the amount of CNS trauma, given that both falls and transport accidents are preventable. Finally, although the information is not available, it can be speculated that, given the resemblance of the patterns of both TBI and spinal trauma in the US and PR, the economic burdens are similar in both countries. Understanding the characteristics of neurological injuries in term of the occurrences of their multiple related parameters could help improve the focus of the Department of Health, of health insurance providers, of private and public institutions, and of the general public, leading all interested parties toward an all-inclusive effort to reduce the incidence of these incapacitating injuries.

Resumen

Trasfondo: De acuerdo a los Centros de Control de Enfermedades y Prevención (CDC, por sus siglas en inglés), trauma al sistema nervioso central (SNC) continúa siendo una de las causas principales de morbilidad y mortalidad. Método: Se hizo un estudio prospectivo para determinar la incidencia de trauma al SNC. Las variables descriptivas fueron presentadas como frecuencias y promedios. Las variables cuantitativas fueron expresadas como mediana, promedios (más/menos la desviación estándar). El análisis de regresión múltiple se usó para identificar factores de riesgo y comparar patrones y variables epidemiológicas de riesgo. Resultados: Durante el periodo del estudio se recolectó información de 3,202 pacientes con trauma al SNC. Un total de 2,524 (78.8%) pacientes sufrió trauma encefálico. Trauma a la columna espinal ocurrió en 831 casos (25.9%) y 197 (6.2%) sostuvo trauma a la médula espinal. La mayoría de los casos fue de varones (75.0%) con una edad mediana de 40 años. Los recién nacidos e infantes (≤ 4 años) comprendían el 7.8% y los ancianos (>65 años) el 27.4% de todos los casos. Cerca de la mitad de los traumas fueron resultado de caídas (47.5%), seguidos de accidentes automovilísticos (35.2%). En 61.3% de las injurias hubo una pérdida de conocimiento. La escala de Coma de Glasgow se usó para clasificar la severidad del trauma encefálico; la mayoría fue leve (70.0%). Más de 90% de las injurias ocurrieron en la casa (42.8%) o en la calle (49.1%). Conclusión: Estos resultados son evidencia de que se necesitan estudios colaborativos adicionales para aumentar el conocimiento y concientizar al público sobre medidas previsoras.

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Appendix

NEUROSURGICAL INJURIES REGISTRATION FORM

Neuro Surgery Section
School of Medicine
University Of Puerto Rico

Case Definition: "Every patient reffered to the Neurosurgery service due to an evident or suspected injury to the nervious system"

GENERAL INSTRUCTIONS

Fill one form per patient consulted due to trauma.
1- When an option is preceded by a number, choose only one option.
2- Please fill the specify blank every time **Other**, is selected.
3- Every field should be filled with the information requested.

A REGISTRATION AND SOCIODEMOGRAPHIC INFORMATION OF THE INJURED

Record Number: | Initials: | ☐ Unknown ☐ No response

Gender: 1.☐ Male 2.☐ Female 3.☐ Unknown | Age: _____ 1. ☐ Days 2.☐ Months 3.☐ Years | Birthdate: MONTH / DAY / YEAR

Municipality: | FOR NON PUERTO RICO RESIDENTS ONLY Town of Residence:: Country of Residence:

B EVENT INFORMATION

Injury date: MONTH / DAY / YEAR Date unknown ☐ | Time of the injury: Unknown time ☐

Injury weekday 1. ☐ Monday 2.☐ Tuesday 3.☐ Wednesday 4. ☐ Thursday 5. ☐ Friday 6. ☐ Saturday 7.☐ Sunday 8. ☐ Unknown

For MINORS: Person in charge 1.☐ Father 2. ☐ Mother 3. ☐ Both parents 4. ☐ Other>= 18 5. ☐ Other < 18 6.☐ No one 7.☐ Unknown

Place of occurrence: 1.☐Home 2.☐School 3.☐Work 4.☐Street 5.☐ Unknown 6.☐ Other ____________ | Municipality:

C INJURY CIRCUMSTANCES

1 Mechanism of injury

1. ☐ Transport accident
2. ☐ Crushed, trapped, stucked, jammed, pinched between objects
3. ☐ Struck (by objets, by persons)
4. ☐ Fall , same level
5. ☐ Fall from one level to another, Feet__________
6. ☐ Diving
7. ☐ Trauma by cutting and / or piercing instrument
8. ☐ Firearm (GSW)
9. ☐ Contact with heat source / hot substances
10. ☐ Electrical Exposure
11. ☐ Injury caused by animal or plant
12. ☐ Exposure to forces of nature
13. ☐ Other, specify: ______________
14. ☐ Unknown
15. ☐ No response

2 What (ACTIVITY) were you doing when you were injured? (IMPORTANT: if the activity required the use of **safety equipment please fill section 5.e**)

1. ☐ Working
2. ☐ Transport
3. ☐ House work
4. ☐ Sports / Recreation
5. ☐ Leisure
6. ☐ Unknown
7. ☐ Other, specify:______________________

3 Intentionality

1. ☐ Intentional
   - 1. 1. ☐ Quarrel / Fight
   - 1. 2. ☐ Burglary or robbery
   - 1. 3. ☐ Self inflicted (Suicide attempt, Suicide)
   - 1. 4. ☐ Gang activity
   - 1. 5. ☐ Family / Domestic Violence
   - 1. 6. ☐ Lost bullet / Celebratory gunfire
   - 1. 7. ☐ Unknown / Other ___________________
2. ☐ Non intentional
3. ☐ Legal intervention
4. ☐ Intention undetermined
5. ☐ Other, specify: ________________________________
6. ☐ Unknown
7. ☐ No response

4 Loss of Consciousness

1.☐ Yes, less than 1 hour 2.☐ No 3.☐ Yes, more than 1 hour 4.☐ Unknown 5. ☐ No response

Official Use Only 031808
☐ Null

D COMPLETE FOR TRANSPORT INJURIES ONLY

5 About the injured

5.a. Type of user
1. ☐ Pedestrian
2. ☐ Passenger
3. ☐ Driver
4. ☐ Cyclist
5. ☐ Other,specify____________________
6. ☐ Unknown
7. ☐ No response

5.b. Type of accident
1. ☐ Run over
2. ☐ Collision between vehicles
3. ☐ Collision with fixed object
4. ☐ Collision with animal
5. ☐ Tipped , rolled over
6. ☐ Fall / ejected from vehicle
7. ☐ Other, specify ____________________
8. ☐ Unknown
9. ☐ No response

5.c. Type of vehicle
1. ☐ Car
2. ☐ Pick -up
3. ☐ Bus
4. ☐ Truck
5. ☐ Bicycle
6. ☐ Motorcycle
7. ☐ ATV (4-track)
8. ☐ Water cycle (Jetski)
9. ☐ Skateboard, skates, scooter
10. ☐ Train
11. ☐ Cart
12. ☐ Animal traction
13. ☐ Other, specify ____________________
14. ☐ Unknown
15. ☐ No response

5.d. Type of second vehicle or counterpart
1. ☐ Car
2. ☐ Pick - up
3. ☐ Bus
4. ☐ Truck
5. ☐ Bicycle
6. ☐ Motorcycle
7. ☐ Train
8. ☐ Cart
9. ☐ Animal traction
10. ☐ Other, specify: ____________________
11. ☐ Unknown
12. ☐ No response

5.e. Was safety equipment used at the time of the injury?

☐ Seatbelt ☐ Car seat (children) ☐ Aibags activated ☐ Other, specify____________________

☐ Helmet (______w/o strap) ☐ Vehicle with airbag ☐ No protective gear ☐ Unknown ☐ No response

E MEDICAL EXAM

6 Neurosurgical Findings

6. a Cranial ☐ **None** ☐ **No CT available**

☐ A - SDH ☐ EDH ☐ Contussion
☐ C - SDH ☐ Penetrating Injury ☐ ICH / IVH
☐ SAH ☐ Edema ☐ Fracture
☐ DAI ☐ Concussion ☐ Laceration

6.b. Spine ☐ **None**

☐ Fracture
☐ Subluxation
☐ Soft tissue

6.c. Trauma level

☐ Cervical
☐ Thoracic
☐ Lumbar
☐ Sacral

7 Injury Severity

7.a. Brain Trauma ☐ **None**
1. ☐ Mild GCS 13 -15
2. ☐ Moderate GCS 9 -12
3. ☐ Severe GCS 3- 8
4. ☐ Brain dead

7.b. Spinal Trauma ☐ **None**
1. ☐ A. Complete
2. ☐ B. Incomplete: Sensory, but no motor function below neurological level
3. ☐ C. Incomplete: Motor function preserved below level; muscle grade <3
4. ☐ D. Inc:Motor function preserved below level; muscle grade>3
5. ☐ E. Normal

8 Associated Injury Non-CNS(check all that apply)

☐ Wound, cut, laceration ☐ Fracture (not skull, not spine) ☐ Nerve Trauma ☐ None
☐ Superficial Trauma / Hematoma ☐ Foreign Body Effect ☐ Organ Trauma ☐ Unspecified
☐ Excoriation (scratch) ☐ Traumatic Amputation ☐ Muscle and Tendon Trauma ☐ Other, specify________________
☐ Crushing Trauma ☐ Blood Vessel Trauma ☐ Multiple Trauma

9 Disposition
1. ☐ Ambulatory treatment
2. ☐ Observation in Trauma Unit
3. ☐ Observation in Emergency Room
4. ☐ Transferred / Sign off
5. ☐ Admission to
   - 5. 1. ☐ Neurointermediate care Unit
   - 5. 2. ☐ Neurointensive care Unit
   - 5. 3. ☐ Trauma Intensive care unit
   - 5. 4. ☐ Trauma Intermediate care Uni t
   - 5. 5. ☐ Pediatric Hospital Ward
   - 5. 6. ☐ Pediatric Intensive Care Unit
   - 5. 7. ☐ Medicine
6. ☐ Operating room
7. ☐ Voluntary discharge
8. ☐ Escape
9. ☐ Death
10. ☐ Organ donation
11. ☐ Discharged
12. ☐ Other, specify ____________________

10 Clinical evidence of drug or alcohol use

Alcohol:	1. ☐ Yes	2. ☐ No	3. ☐ Unknown	4. ☐ Not Evaluated
Drugs:	1. ☐ Yes	2. ☐ No	3. ☐ Unknown	4. ☐ Not Evaluated

Resident Name :

____
Print Name

DATE OF EVALUATION : MONTH / DAY / YEAR

Comments / Observations: