Review Article

Epidemiology of Traumatic Brain Injury over the World: A Systematic Review

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Abstract

We identified 60 reports from 29 countries with data on Traumatic brain injury (TBI) epidemiology in the published literature. Men were at higher risk of TBI than women. The average age at the time of TBI ranged from 27 to 59.67 years while the median age ranged from 29 to 45 years. The incidence of TBI in Sweden, Italy and Norway was decreased while the incidence of TBI in Spain and Taiwan was increased. The countries with the incidence of TBI from high to low were New Zealand, United States, Spain, Sweden, South Africa, Austria, France, Italy, Germany, Canada, Norway, Australia, Portugal, Finland, China, Iran, Switzerland and Belgium. The overall mild: moderate: severe ratio was 55: 27.7: 17.3 based on Glasgow Coma Scale (GCS). In patients with moderate and severe TBI, death was the most common outcome. In TBI patients with all severities, good recovery was the major clinical outcome. Motor vehicle collision (MVC) was the leading cause of TBI in China, Pakistan, Japan, Australia, France, Spain, Austria, England, Croatia, Slovakia, Bosnia, Macedonia, Netherland and Italy, whereas fall was the leading cause in The United States, Canada, New Zealand, Sweden, Scotland, Norway and Finland. The MVC-related TBIs were the most common causes in developing countries, whereas the fall-related TBIs were the most common causes in developed countries. The percentage of MVC-related TBIs were the highest in Asia. Europe had the highest percentage of fall-related TBIs and work-related TBIs. North America, followed by Oceania, had the highest percentage of sport-related TBIs.

Keywords: Head injury; Traumatic brain injury; Epidemiology; Incidence; Injury prevention

Introduction

TBI is one of the most devastating types of injury, and it results in varying degrees of paralysis, loss of consciousness, amnesia and even death. Head trauma accounts for the majority of trauma deaths [1]. The effects of TBI are not limited to an individual's health; it also creates a financial burden for families and societies. There was a widespread agreement that the fundamental aim of managing TBI is to avoid brain injury. Studying the epidemiology of TBI is challenging for a number of reasons, including various inclusion criteria and different methods for classifying TBI severity. Advances in understanding the mechanisms of TBI have yielded to effective prevention. Numerous articles on TBI epidemiology have come out of Europe and North America due to their TBI registries or databases [1-3]. Although most Asian countries do not have TBI registries, the number of studies from Asian countries has increased in recent years [4-7].

The knowledge of the epidemiology of TBI worldwide was required; however, a systematic review on TBI epidemiology worldwide has not been performed or published. The aim of this review was to compile epidemiological characteristics of TBI in order to improve the effectiveness of TBI prevention.

Methods

Search strategy: Pub Med, EBSCO, MEDLINE, EMBASE, and Google Scholar™ databases were searched for TBI articles published from January 1980 through May 2014 with the following key indexing and MeSH terms: "head injury", "traumatic brain injury",

Figure 1: The flow diagram of study selection.

"epidemiology", and "incidence". These terms were linked using combinations of "epidemiology" or "incidence" plus "head injury" or "traumatic brain injury". No language restrictions were used. References from the retrieved reports were reviewed to find additional relevant articles that may have been omitted from the database search (Figure 1).

Two independent reviewers assessed the titles and abstracts of the publications produced by the initial search strategy. To be eligible for inclusion, studies had to meet the following criteria: (1) human subjects; (2) original studies involving TBI; (3) epidemiological data available. General population studies were eligible for inclusion. The exclusion criteria were as below: (1) studies only included children and adolescence; (2) studies only included older adults; (3) studies involving military subjects or prisoners.

Data extraction: Available methodological information and data were extracted from the articles, including country (region), year of publication, and number of patients, source population, case criteria, incidence period, gender features, age features, incidence, and causes of TBI, mortality, severity and clinical outcome. Aggregated data were calculated based on data provided by each study and its study population.

Results

7639 articles were identified by the primary literature search. However, after screening the titles and abstracts, 7571 studies were excluded due to duplicates, laboratory studies, review articles, or the irrelevancies to the current study. 68 potentially relevant manuscripts were retrieved for detailed review. 4 of these studies only included children and adolescence, 2 studies only included older adults, 2 studies included military subjects or prisoners.

Consequently, we identified 60 reports from 29 countries (regions) with data on TBI epidemiology in the published literature. Of those, 9 reports were from the United States of America, 5 from Italy, 4 from China, 3 from Australia, 3 from Finland, 3 from France, 3 from Norway, 4 from Sweden, 3 from Austria, 2 from New Zealand, 2 from Germany, 2 from Spain, 2 from Denmark, 2 from Scotland and 2 from Iran, 1 from Ireland, 1 from Britain, 1 from Canada, 1 from Belgium, 1 from Portugal, 1 from Switzerland, 1 from Pakistan, 1 from South Africa, 1 from Croatia, Slovakia, Bosnia and Macedonia, 1from Netherland, 1 from Japan.

Study characteristics, including country (region), authors, year of publication, source population, case source, case criteria, gender features and age features are listed in (Table 1). The epidemiologic data, including incidence, mortality, and severity and Glasgow Outcome Score (GOS) outcome are summarized in (Table 2). The etiology of TBI is summarized in (Table 3).

Gender and age: As demonstrated in Table 1, we found that men were at a higher risk of TBI than women. The gender ratio ranged considerably, from 1.18:1 in South East Finland to 4.81:1 in South Africa. The average age at the time of TBI ranged from 27 to 59.67 years while the median age ranged from 29 to 45 years.

Incidence and prevalence: TBI incidence was only mentioned in 34 reports. The studies included in this review employed different case sources and case criteria. Therefore, we found that incidence rates ranged from the highest value of 811/100,000/year in New Zealand to the lowest value of 7.3/100,000/year in Western Europe. The incidence changed over time in many countries. The incidence of TBI in Sweden, Italy, France and Norway decreased over time markedly while the incidence of TBI in Spain and Taiwan increased over time. However, the incidence of TBI in the United States remained unchanged.

The incidence of TBI differs in countries. Based on aggregated data, the countries with an incidence of TBI from high to low were New Zealand, United States, Spain, Sweden, South Africa, Austria, France, Italy, Germany, Canada, Norway, Australia, Portugal, Finland, China, Iran, Switzerland and Belgium.

Prevalence is defined epidemiologically as the measure of the total amount of TBI at a time point or period interval in a certain population. Few studies utilized prevalence level of TBI in a community or nation. Only three included studies [8-10] mentioned the prevalence of TBI.

Mortality: The mortality rates were given in Table 2. Of the 60 studies included in this current report, 24 studies provided data on mortality. Mortality was expressed as annual death per 100,000 population or percentage of deaths among TBI patients. The annual mortality rate ranged from 80.73/100,000/year in South Africa to a rate as low as 5.2/100,000/year in France. The Percentage of deaths were assessed at discharge or the end of follow-up. The mortality rate in several studies included death before admission. Therefore, it was difficult to compare mortality from different regions.

Severity: The TBI severity is usually measured by GCS. One study [11] used Injury Severity Score (ISS), one study [12] used posttraumatic amnesia (PTA) score and two studies [13,14] used The Abbreviated Injury Score (AIS). The distribution over all three severity levels of TBI injuries indicated the pattern of patients received by hospitals for treatments. Two studies [15,16] only enrolled patients with moderate and severe TBI, 7 studies [8,14,17-21] only enrolled patients with severe TBI. Apart from the above, 20 studies reported all three severity levels of TBI, 3 studies only reported the percentage of mild TBI and 1 study only reported the percentage of severe TBI (Table 2). The proportion of mild TBI varied between 15.1% and 97%, and that of moderate and severe TBI ranged from 6% to 46% and 2% to 68.6% respectively. In studies which enrolled patients with GCS motor score≤8 or≤12, there were more moderate or severe TBI, according to initial GCS. In studies that enrolled patients with all severity levels, the overall mild: moderate: severe ratio was 55: 27.7: 17.3 based on the GCS.

General outcome: Outcome, as measured by the GOS score, was reported in 16 studies (Table 2) of 16 studies provided by GOS score, 4 reports gave GOS data at the time of discharge, 4 reports gave GOS data at six months, 3 reports gave GOS data at one year, 1 report gave GOS data at three months. The proportion of good recovery (a GOS of 5) varied between 18% and 97% and that of moderate disability (a GOS of 4) varied between 2% and 30%. The severe disability (a GOS of 3) ranged from 0.5% to 25% and vegetative state (a GOS of 2) ranged from 0.7% to 10%. Death accounts for 3%-52% of the total outcome. In studies which enrolled patients with a GCS motor score ≤8 or ≤12, death was the most common outcome. In studies which

Table 1: Characteristics of the included studies of traumatic brain injury worldwide.

	Study author(s) (year) [ref.]	Country (region)	Incidence period	Study population	Case ascertainment	Case criteria	Gender features	Age features
North America	**Sugerman et al (2012)[14]**	United States	2007-2009	321,013	Data from the American College of Surgeons National Trauma Databank National Sample Population	Head AIS score of 3 or greater and TBI using a ICD-9-CM definition. Infants and children younger than 18 years, those with a total ISS of less than 16, those with GCS motor score of 6 were excluded	Male: female= 1.97:1 in transferred patients; male: female= 2.76:1 in direct admitted patients	The mean age was 59.67 yrs in transferred patients; 50.39 yrs in direct admitted patients
	Colantonio et al (2010)[2]	province of Ontario, Canada	2002-2007	84,042	Hospitalization records from the Canadian Institute for Heath Information Discharge Abstract Database, records of EDs were from the National Ambulatory Care Resource System database.	ICD-10 codes: S02 and T90	Male: female ratio=1.85:1	The rate of hospitalization was highest for elderly over 75 yrs; episodes of care were greatest in youth under the age of 14 yrs and elderly over the age of 85 yrs.
	Selassie et al (2008)[30]	South Carolina, United States	1999-2002	288,009	Data from the South Carolina Traumatic Brain Injury and Follow-up Registry	ICD-9-CM: 800.0-801.9, 803.0-804.9, 850.0-854.1 and 959.01	Male: female ratio=1.63:1	NA
	Rutland-Brown et al (2006)[31]	United States	1998-2003	1,565,000	Patients with TBI admitted to the hospitals and ED	ICD-9-CM codes and ICD-10 codes	NA	NA
	Day et al (2006)[32]	Minnesota, United States	2002-2003	1,854	TBI patients admitted to the ED	ICD-9-CM codes	NA	NA
	Gerberding et al (2006)[33]	United States	2002	74,517	Patients related to TBI admitted to hospitals in 12 States	ICD-9 and/or ICD-10 codes	Male: female ratio=1.79:1	NA
	Tieves et al (2005)[3]	Wisconsin, United States	2001	5,065	The medical records on TBI injuries from National Center for Vital Statistics and the Wisconsin Bureau for Health Information	ICD-9-CM and ICD-10	NA	NA
	Wagner et al (2000)[7]	Carolinas, United States	1994-1998	2,637	Patients sustaining TBI admitted to Carolinas Medical Center Trauma Registry	ICD-9-CM code ranging from E950 to E976	1930 male patients (73.2%),707 female patients(26.8%); male: female ratio=2.73:1	NA
	Harmon et al (1996)[34]	Wisconsin, United States	1989-1992	2,764 (1989); 2,626 (1990); 2,446 (1991); 2,349 (1992)	TBI patients admitted to Wisconsin Hospital	ICD-9-CM codes: 800.1- 800.4, 800.6-800.9, 801.1- 801.4, 801.6-801.9, 801.1-803.4, 803.6-803.9, 851.0, 851.2- 851.9, 852.0- 852.5, 853.0-853.1, 854.0-854.1,	NA	NA
	Annegers et al (1980)[35]	Olmsted County, Minnesota, United States	1935-1974	3,587	Data from the medical records linkage system of the Rochester Project at the Mayo Clinic	A head injury with evidence of presumed brain involvement: concussion with LOC, PTA, neurologic signs of brain injury and skull fractures.	NA	NA
Oceania	**Feigin et al (2013)[36]**	Urban area of Hamilton and rural area of Waikato District, New Zealand	2010-2011	1,369	Patients with head trauma admitted and not admitted to hospital	ICD-10 S00-S09	Male: female ratio=1.67:1	The mean age was 28.1 yrs
	Myburgh et al (2008)[37]	Australia and New Zealand	2000	635	Adult patients with TBI admitted to the ICUs of major trauma centers	NA	Male: female ratio=2.87:1	The mean age was 41.6 ±19.6 yrs

	Tate *et al* (1998) [38]	Australia	1988	413	Patients admitted to regional hospitals	ICD 9th code: 310, 800, 801, 803, 804, 850, 851, 852, 853, 854, 905.0, 907.0	Male: female ratio=2.6:1	NA
	Hillier *et al* (1997)[39]	South Australia	1987	177	Data from all recognized public and private hospitals	ICD-9 codes: 348, 800 to 804, 840, 851, 852 and 854	Male: female ratio=2.3:1	NA
Europe	**Shivaji *et al* (2014)[40]**	Scotland	1998-2009	208,195	The records relating to TBI contained in the Scottish Morbidity Record data-set.	ICD-10 codes	Male: female ratio=2.33:1	The hospitalisation was highest in people aged less than 35 yrs with a further peak in people aged over 65 yrs
	Mauritz *et al* (2013)[41]	Austria	2009-2011	25,456	Patients with head trauma at hospital emergency rooms	ICD-10 codes S06.0– S06.9, T68, or T07.	Male: female ratio= 1.4:1	The mean age was 44.5 yrs
	Perez *et al* (2012)[11]	Spain	2000–2009	206,503	Patients with head trauma at the public and private hospitals	ICD9-CM codes: 800, 801, 803, 804,850, 851, 852, 853 and 854	Male: female ratio=1.92:1	NA
	Stocchetti *et al* (2011)[42]	Milan and Monza, Italy	1997–2007	1,478	Patients admitted consecutively to 3 neurosurgical ICUs	(1) admission because of head trauma, with or without extracranial injuries; (2) brain injury severity requiring admission to an ICU; (3) time from trauma to arrival at the ICU < 24 h; and (4) age over 18 years	NA	The median age was 45 yrs ranged from 19–94 yrs, 44% were 50 yrs old or older
	Numminen (2011)[43]	South East Finland	2002-2004	370	Patients with symptoms of brain injury after a head trauma at health centres and the South Karelia Central Hospital	ICD-10 codes S06	Male: female ratio=1.18:1	The mean age was 54.3 yrs
	Andriessen *et al* (2011)[15]	Netherland	2008–2009	508	5 out of 11 specialized trauma centers in the Netherlands.	All patients with TBI and an ED admission of GCS score ≤13; exclusion criteria were age < 16 years and hospital admission > 72 h after injury	Male: female ratio=2.3:1	The mean age was 47.3 yrs
	Andelic *et al* (2008)[44]	Oslo, Norway	2005-2006	445	TBI patients admitted to Ulleval University Hospital	ICD-10 codes: S02.0– S02.9, S06.0–S06.9, S07.0, S07.1, S07.8, S07.9, S09.7–S09.9, T04 and T06	Male: female ratio=1.8:1	The median age was 29 yrs
	Koskinen & Alaranta (2008) [45]	Finland	1991–2005	77,959	Patients of hospitalized and fatal TBI collected from the national registers of Finland	1991–1995 are based ICD 9 and from 1996–2005 on ICD 10	male: female ratio=1.45:1 ranged from 1.42–1.49	The highest incidence of TBI among both genders was in the age of 0–9, 50–59 and 60–69 yrs
	Mauritz *et al* (2008)[17]	Austria, Bosnia, Croatia, Macedonia and Slovakia	January 2001- June 2005	1,172	The data were collected in 13 tertiary care level centres located in Austria, Bosnia, Croatia, Macedonia and Slovakia	Inclusion criteria defined by the US National Traumatic Coma Database such as a GCS score of 8 or less following resuscitation or a GCS score deteriorating to 8 or less within 48 h of injury.	Male: female ratio=2.57:1 in Austria; male: female ratio=4.56:1 in Crotia and Slovakia; male: female ratio=3.55:1 in Bosnia and Macedonia.	The mean age was 49 yrs (55 yrs for males and 47 yrs for females) in Austria, 45 yrs (49 yrs for males and 44 yrs for females) 29 yrs in Crotia and Slovakia, (26 yrs for males and 30 yrs for females) in Bosnia and Macedonia.

Styrke *et al* (2007)[46]	Sweden	2001	449	The data from the Umea University Hospital's injury register	Injured person that arrived alive at the hospital within 24h after a brain trauma causing any degree of disturbed consciousness, amnesia, neurological deficit, severe headache, nausea, or vomiting	Male: female ratio= 1.22:1	Median age was 23 years ranged from 0–91 yrs
Maegele *et al* (2007)[47]	Western Europe	1990–1999	650	Patients admitted to general hospitals with relevant TBI	NA	Male: female ratio=2.67:1	The mean age was 40.3 yrs
Rosso *et al* (2007)[21]	Austria	NA	492	The data for this study were collected in five centers.	Severe TBI defined by the US National Traumatic Coma Database: GCS score of 8 or less following resuscitation or GCS score deteriorating to 8 or less within 48 hours of injury.	Male: female ratio=2.57:1	The mean age was 48 yrs
Steudel *et al* (2005)[48]	Germany	1972-2002	NA	Data collected from Federal Bureau of Statistics, hospital admissions register and mortality register	ICD 9 and ICD 10	NA	NA
Lannoo *et al* (2004)[49]	Flanders, Belgium	NA	72	Cases with the history of acquired brain injury	NA	Male: female ratio=3.8:1	The mean age was 38 yrs
Andersson *et al* (2003)[50]	western Sweden	1992-1993	489	Patients with TBI admitted to the Central Hospital Boraˇs and the registers at the Regional Department of Neurosurgery and at the Department of Forensic Medicine	ICD no. 850–854 and 800–804	Male: female ratio=1.42:1	The mean age was 27 yrs
Baldo *et al* (2003)[13]	Italy	1996-2000	55,368	Hospital discharge records in Veneto Region	ICD-9-CM 800.0–801.9, 803.0–804.9, 850.0–854.1	Male: female ratio=1.55:1	The mean age of males was 37.7 yrs; the mean age of female was 45.6 yrs
Kleiven *et al* (2003)[51]	Sweden	1987-2000	NA	Swedish Hospital Discharge Register at National Board for Health and Welfare	Public hospital in-patients discharged with ICD-9 800–804, 850–854 (1987–1996); ICD-10 S2.0–S2.9, S6.0–S6.9 (1997–2000)	Male: female ratio=2.1:1	Among males, the highest rates were for ages 15–19 and over 85 yrs; among females, the highest rates were for ages 0–4 and over age 85 yrs
Masson *et al* (2003)[19]	France	1996	248	Patients of 19 public hospitals with prolonged coma	Persons with significant intra-cranial injury with coma >24 hrs or GCS of 8 or less before sedation	Male: female ratio= 3:1	The median age was 41 yrs, 27.0% of patients over 60 yrs
Santos *et al* (2003)[52]	Portugal	1994, 1996 and 1997	NA	NA	ICD-9: 800, 801, 803, 804, 850, 851, 852, 853, 854 and 907.0	Male: female ratio=1.8:1 in hospital admissions and 3.4:1 in mortality	The highest risk was in age 20-29 yrs and after 80 yrs
Servadei *et al* (2002)[53]	Romagna, Italy	1998	2,430	Patients admitted to region hospitals following a head injury	ICD-9-CM codes of 800.0 to 800.3, 801.0 to 801.3, 803.0 to 804.3, 850, 851, 851.1, 852.0, 852.1, 853.0, 853.1, 854.0, 854.1	Male: female ratio=2.74:1	NA
Servadei *et al* (2002)[54]	Romagna and Trentino, Italy	1998	4,442	Medical records of 4442 hospital admissions for head injury	ICD-9 codes 800.0–800.3, 801.0–801.3, 803.0–803.3, 850, 851.0–851.1, 852.0–852.1, 853.0–853.1, 854.0–854.1	Male: female ratio=1.65:1	NA

Engberg & Teasdale (2001) [55]	Denmark	1979-1996	166,443	Patients with TBI diagnoses in Danish National Hospital Register	For TBI patients from 1979 to 1993: ICD 800,801,803,851-854; For fatal cases from 1994 to 1996: ICD 10 of S01.0-S09.9	NA	NA
Masson *et al* (2001)[18]	France	1996	497	Persons admitted to hospital via an emergency service with diagnosis of severe brain injury	AIS score of 4 or 5 to head region	Male: female ratio= 2.5:1	The median age was 44 yrs, with a quarter of patients more than 70 yrs
Firsching & Woischneck (2001)[56]	Germany	1996	279,029	Data from death certificates and Federal Board of Statistics	ICD-9 codes for hospital admitted persons	Male: female ratio= 2.45:1	NA
Alaranta *et al* (2000)[57]	Finland	1991-1995	NA	Hospital Discharge Register of the Finnish National Research Development Center for Welfare and Health	First time admissions with ICD-9 codes of 800–801, 803, 850–854	Male: female ratio=1.5:1,	The highest age specific rates for males at ages 0–9 yrs, 10–19yrs, and 40–49yrs; for females at ages 0–9yrs, and over age 70 yrs
Thornhill *et al* (2000)[58]	Glasgow, Scotland	February 1995-February 1996	769	Patients with acute head injuries admitted to five general hospitals	ICD9 codes 800804 and 850854	Male: female ratio=3.93:1	The median age was 38 yrs ranged from 14-98 yrs
Murray *et al* (1999)[20]	Britain	1986-1988	988	Patients admitted to one of four British neurosurgical units within 3 days of a severe head injury	severe head injury defined as no eye opening, no comprehensible verbal response, and not obeying commands	NA	NA
Murray *et al* (1999)[16]	12 European countries	February 1995-April 1995	1,005	Patients admitted to 67 centers in twelve countries	Patients were to be included if their GCS was 12 or less	Male: female ratio=2.85:1	The median age was 38 yrs
Ingebrigtsen *et al* (1998)[59]	Norway	1993	247	Patients referred first to University Hospital, or admitted to any hospital department plus ED treated and discharged	Head injury defined as physical damage to the brain or skull by external force and GCS and head ISS	Male: female ratio=1.7:1	The highest age specific rates for males was 10–24 yrs and above 80 yrs; for females was 0–10 yrs and 20–24 yrs
O'Brien & Phillips (1996) [60]	Ireland	July1992–June 1993	NA	All head injury admissions to neurosurgical unit	NA	Male: female ratio =3:1.	The mean age was 28.3 yrs
Engberg (1995) [8]	Fredericksburg County, Denmark	1988	NA	ED and ICU in 4 hospitals, hospital records, search of National Board of Health causes of death	Severe head trauma defined as PTA posttraumatic amnesia 24 hrs to 7 days. Very severe≥7 days PTA. Diagnoses included ICD-9th 851–854, 800, 801, 803	Male: female average rate ratio: 2.1:1	The highest rates for both genders were 65 yrs older
Vazquez-Barquero *et al* (1992)[61]	Spain	1988	477	Persons of head injury admitted to the University Hospital	Hospital contact <24 hours from injury with LOC, skull fracture, objective neurologic findings attributed to head injury including in-hospital deaths	Male: female ratio=2.7:1	The highest rates were in ages<15 and 15–24 yrs for both genders
Annoni *et al* (1992)[62]	St Gallen, Switzerland	1987	80	Data from patients who had been treated neurosurgically for brain injuries in neurosurgical units in Cantons, Zurich and Chur and patients who were living at the time of the accident in Canton	Patients who showed intracranial lesions on the admission CT scan were included in the study.	Ma1e:female ratio=3: 1	The mean age of the patients was 44.6 yr ranged from 4-91

	Johansson *et al* (1991)[63]	Northern Sweden	April 1984–October 1985	NA	All hospital admissions with ICD diagnoses of 850–854 plus deaths in files of department of forensic medicine	Those with ICD codes 850–854 8th were surveyed 1.5–3 yrs post-injury by mail	Male: female ratio=1.5:1	NA
	Tiret *et al* (1990) [64]	France	1986	8,940	Sample from admissions of all public and private hospitals and death certificates	Head trauma defined as contusions, lacerations, skull fractures, or brain injuries and/or LOC after a relevant injury	Male: female ratio=2.1:1	Peak rates at<5 yrs, 15–24 yrs, and over 75 yrs
	Nestvold *et al* (1988)[12]	Norway	1974-1975	488	All head injured patients referred to the county hospital	Trauma to face, head or neck with any of unconsciousness, retrograde amnesia, PTA, skull or neck fracture or trauma with headache, nausea or vomiting during 1st day of event	NA	The mean age of male was 29.8 yrs and the mean age of female was 29.7 yrs
	Servadei *et al* (1988)[65]	Italy	April 1984–March 1985	644	Cases presenting at Ravenna City Hospital emergency room and admitted to hospital	LOC, DOA, or death in ED if confirmed brain injury on autopsy	Male: female ratio= 1.63:1	The mean age was 38 yrs
Asian	**Aghakhani *et al* (2013)[66]**	West Azarbaijan province, Iran	2005-2006	1,796	The medical records based on the ICD items, TBI-related death based on the death certificate and demographic data	NA	Male: female ratio= 3.45:1	The most common age group was 20-29 yrs; mean age of dead persons was 31.9 yrs
	Rahimi-Movaghar *et al* (2013)[67]	Tehran, Iran	2007-2008	21	History of TBI from the samples, medical records and radiographs	NA	Male: female ratio=4.25:1	The mean age was 28.7 yrs
	Wu *et al* (2008) [4]	Eastern China	2004	14,948	TBI patients admitted to 77 hospitals in eastern China	NA	Male: female ratio=3.27:1	The mean age was 39.49 yrs
	Chiu *et al* (2007) [5]	Taipei City and Hualien County, Taiwan, China	2001	7,228	Patients admitted to the large medical centers and the medium-sized to small medical facilities	ICD-9-CM	NA	NA
	Nakamura *et al* (2002)[68]	Japan	NA	202	Records from Data Bank Program for Traumatic Brain Injury in Nine Advanced Life-saving Emergency Centers	NA	Male: female ratio=1.65:1	The mean age was 47.7 yrs ranged from 6-94 yrs
	Zhao *et al* (2001)[10]	China	1983-1985	63,195 (1983) 246,812 (1985)	The data from two large-scale epidemiological investigations in 1983 and 1985	The following diagnostic criteria were used: (1) clear history of head trauma, with primary coma and retrograde amnesia; (2) residual neurological deficit, and/or abnormality in CT or x-ray exam; (3) formal diagnostic certification issued by neurologists or neurosurgeons; (4) confirmation by at least two neurological specialists if the diagnosis was uncertain.	Male: female ratio=1.7:1 (six-city); male: female ratio=2.5:1 (rural areas)	The peak incidence was in ages from 20 to 30 yrs.
	Raja *et al* (2001) [6]	Pakistan	July 1, 1995 to June 30, 1999	260,000	The patients of head injury admitted to various neurosurgical centers in Pakistan	NA	Male: female ratio= 3:1.	The most common age group was 21-30 yrs
	Wang *et al* (1986)[9]	China	1983	63,195	TBI patients in six cities of the People's Republic of China	Patients with history of head trauma together with any of the following: (1) LOC; (2) posttraumatic amnesia; or (3) clinical evidence of subsequent focal brain dysfunction.	Male: female ratio=1.6:1	NA

| Africa | Nell & Brown (1991)[69] | Johannesburg, South Africa | 1986 | 5,106 | Trauma cases at all hospitals in Johannesburg. | Persons with cerebral contusion or laceration, with or without the LOC, or trauma related unconsciousness or amnesia of whatever duration | Male: female ratio=4.81:1 | NA |

NA= not available, TBI= traumatic brain injury, yrs= years, AIS=Abbreviated Injury Score, ISS=Injury Severity Score, GCS=Glasgow Coma Scale, ICU=intensive care unit, ED=emergency department, PTA=posttraumatic amnesia, LOC= loss of consciousness, DOA= dead on arrival.

Table 2: Incidence, mortality, severity and GOS outcome in selected studies.

	Study author(s) (year) [ref.]	Incidence	Mortality	Mild[1] (%)	Moderate[2] (%)	Severe[3] (%)	GOS outcome
North America	Sugarman *et al* (2012)[14]	NA	NA	0%[4]	0.6%[5]	99.4%[6]	NA
	Colantonio *et al* (2010)[2]	Male: 270/100,000/year Females: 116/100,000/year	NA	NA	NA	NA	NA
	Rutland-Brown *et al* (2006)[31]	1998: 538.4/100,000/year 1999: 549.9/100,000/year 2000: 555.8/100,000/year 2001: 517.3/100,000/year 2002: 538.9/100,000/year 2003: 538.2/100,000/year	1998: 18.1/100,000/year 1999: 17.7/100,000/year 2000: 17.2/100,000/year 2001: 17.7/100,000/year 2002: 17.4/100,000/year 2003: 17.5/100,000/year	NA	NA	NA	NA
	Gerberding *et al* (2006)[33]	79/100,000/year	NA	NA	NA	NA	NA
	Tieves *et al* (2005)[3]	94.4/100,000/year	19.7/100,000/year	NA	NA	NA	NA
Oceania	Feigin *et al* (2013)[36]	811/100,000/year	NA	94.8%	NA	NA	NA
	Myburgh *et al* (2008) [37]	NA	NA	24.7%	18.1%	57.2%	NA
	Hillier *et al* (1997)[39]	322/100,000/year	NA	75%	9%	16%	NA
	Tate *et al* (1998)[38]	100/100,000/year	NA	62.2%	20.3%	13.6%	NA
Europe	Mauritz *et al* (2013) [41]	303/100,000/year	11/100,000/year	NA	NA	NA	NA
	Perez *et al* (2012)[11]	472.6/100,000/year	NA	41.1%[7]	26.8%[8]	32.2%[9]	NA
	Stocchetti *et al* (2012)[42]	NA	NA	NA	NA	NA	GOS was assessed six months later with 33% good recovery, 17% moderate disability, 14% severe disability, 3% PVS and 33% death
	Numminen (2011)[43]	221/100,000/year	7.6%[10]	71.4%	11.9%	16.8%	GOS was assessed three months later with 70.5% good recovery, 9.8% moderate disability, 3.1% severe disability and 16.5% death
	Andriessen *et al* (2011)[15]	NA	Moderate[2]: 22%[11] Severe[3]: 46%[11]	0%	25.4%	74.6%	GOS was assessed six months later with 20% good recovery, 18% moderate disability, 13% severe disability, 0.7% PVS and 46% death.
	Andelic *et al* (2008) [44]	83.3/100,000/year	NA	86%	7.9%	6.1%	NA
	Koskinen & Alaranta (2008)[45]	101/100 000/year	18.3/100 000/year	NA	NA	NA	NA
	Mauritz *et al* (2008) [17]	NA	42%[12] in Austria 48%[12] in Crotia and Slovakia 55%[12] in Bosnia and Macedonia	0%	0%	100%	34% favorable outcome[13] in Austria, 28% favorable outcome in Crotia and Slovakia, 34% favorable outcome Bosnia and Macedonia
	Styrke *et al* (2007) [46]	354 /100,000/year	NA	97%	1%	2%	
	Maegele *et al* (2007) [47]	7.3/100,000/year	24.8%[14]	NA	NA	NA	GOS was assessed at the time of discharge with 32.52% good recovery, 16.8% moderate disability, 3.7% severe disability, 1% PVS and 45.8% death
	Rosso *et al* (2007) [21]	NA	31.7%[15]	82.8%	11.4%	5.7%	NA
	Lannoo *et al* (2004) [49]	11/100,000/year	72/100,000/year	NA	NA	NA	NA

	Andersson *et al* (2003)[50]	546/100,000/year	NA	NA	NA	NA	NA
	Baldo *et al* (2003)[13]	1996: 301/100,000/year 1997: 270/100,000/year 1998: 249/100,000/year 1999: 207/100,000/year 2000: 212/100,000/year	1996: 7.4/100,000/year 1997: 7.7/100,000/year 1998: 6.8/100,000/year 1999: 6.8/100,000/year 2000: 6.1/100,000/year	64%[4]	23%[5]	13%[6]	NA
	Kleiven *et al* (2003) [51]	259/100,000/year	NA	NA	NA	NA	NA
	Masson *et al* (2003) [19]	8.5/100,000/year	52%[14]	15.1%	16.3%	68.6%	GOS was assessed at the time of discharge with 18% good recovery, 9% moderate disability, 16% severe disability, 3% PVS and 52% death
	Santos *et al* (2003) [52]	1994: 151/100,000/year; 1996 and 1997: 137/100,000/year	NA	NA	NA	NA	NA
	Servadei *et al* (2002) [53]	250/100,000/year	18.3/100,000/year	NA	NA	NA	NA
	Servadei *et al* (2002) [54]	297/100,000/year[16] 332/100,000/year[17]	7.7/100,000/year[16] 2.1/100,000/year[17]	NA NA	NA NA	NA NA	NA
	Masson *et al* (2001) [18]	17.3/100,000/year	5.2/100,000/year	0%	0%	100%[6]	NA
	Firsching & Woischneck (2001) [56]	247 /100,000/year	11.5 /100,000/year	73%	NA	NA	NA
	Thornhill *et al* (2000) [58]	NA	NA	56%	17%	13%	GOS was assessed one year later with 45% good recovery, 30% moderate disability, 25% severe disability, 10% PVS and death
	Murray *et al* (1999) [20]	NA	NA	NA	NA	54.7%	GOS was assessed six months later with 41.9% favorable outcome[13], 16.6% severe disability, 40.6% unfavorable outcome[18]
	Murray *et al* (1999) [16]	NA	NA	16.1%	18.2%	60.4%	GOS was assessed six months later with 31% good recovery, 20% moderate disability, 16% severe disability, 3% PVS and 31% death
	Ingebrigtsen *et al* (1998)[59]	229/100,000/year	NA	NA	NA	NA	NA
	O'Brien & Phillips (1996)[60]	NA	NA	NA	NA	NA	GOS was assessed at the time of discharge with 54% good recovery, 17% moderate disability, 8% severe disability, 5% PVS and 16% death
	Vazquez-Barquero *et al* (1992)[61]	91/100,000/year	19.7/100,000/year	88%	7%	5%	GOS was assessed one year later with 97% good recovery, 2% moderate disability, 0.5% severe disability and 0.5% PVS.
	Annoni *et al* (1992) [62]	20/100,000/year	NA	30%	46%	24%	GOS was assessed with 66.7% good recovery, 22.2% moderate disability, 8.9% severe disability and 2.2% PVS
	Tiret *et al* (1990)[64]	281/100,000/year	22/100,000/year	80%	11%	9%	NA
	Nestvold *et al* (1988) [12]	236/100,000/year	4.5%[19]	80.7%[20]	NA	11.1%[21]	NA
Asian	Aghakhani *et al* (2013)[66]	NA	0.5%[14]	81.7%	NA	NA	NA
	Rahimi-Movaghar (2011)[67]	56.3/100,000/year	19%[22]	42.9%	23.8%	28.6%	GOS was assessed with 52.4% good recovery, 14.3% mild disability, 4.8% moderate disability, 9.5% severe disability and 19% death
	Wu *et al* (2008)[4]	NA	NA	62%	18.1%	20%	GOS was assessed at the time of discharge with 77.3% good recovery, 7.2% moderate disability, 2.2% severe disability, 2.6% PVS and 10.8% death
	Chiu *et al* (2007)[5]	218/100,000/year[22] 417/100,000/year[23]	NA	87%[23] 83%[24]	6%[23] 9%[24]	7%[23] 8%[24]	GOS was assessed with 85.9% good recovery, 5.3% moderate disability, 5.2% severe disability, 0.4% PVS and 3% death

	Raja et al (2001)[6]	NA	18%[25]	52%	30%	18%	GOS was assessed with 67% good recovery, 8% moderate disability, 6% severe disability, 1% PVS and 18% death
	Zhao et al (2001)[10]	55.4 /100,000/year[26] 64.1 /100,000/yea[r27]	6.3 /100,000/year[26] 9.7 /100,000/year[27]	NA	NA	NA	NA
	Wang et al (1986)[9]	56/100,000/year	NA	NA	NA	NA	NA
Africa	**Nell & Brown (1991) [69]**	316.42/100,000/year	80.73/100,000/year	87.5%	7.9%	4.6%	NA

[1]based on Glasgow Come Score 13-15, [2]based on Glasgow Come Score 9-12, [3]based on Glasgow Come Score≤8, [4]based on Abbreviated Injury Score 1-2, [5]based on Abbreviated Injury Score 3, [6]based on Abbreviated Injury Score 4-6, [7]based on Injury Severity Score<9, [8]based on Injury Severity Score 9-15, [9]based on Injury Severity Score 16-75, [10]mortality assessed at one month follow-up, [11]mortality assessed at six month follow-up, [12]90 day mortality, [13]favorable outcome was defined as GOS score 4-5, [14]in-hospital mortality, [15]ICU mortality, [16]Romagna region in Italy, [17]Trentino region in Italy, [18]unfavorable outcome was defined as GOS score 1-2, [19]mortality based on death before admission and death in hospital and death after discharge, [20]based on PTA score 0-3, [21]based on PTA score 4-5 and death, [22]mortality based on local residents with traumatic brain injury, [23]Taipei city in Taiwan, [24]Hualien country in Taiwan, [25]mortality based on death before admission and death in hospital, [26]6 big cities in China, [27]21 rural areas in China, NA= not available, GOS= Glasgow Outcome Scale, PVS= Progressive Vegetative State, PTA=Posttraumatic Amnesia.

Table 3: External cause in selected studies.

Study author(s) (year) [ref.]		External cause				
		MVC	Fall	Assault /violence	Sport-related	Work-related
North America	**Sugarman et al (2012)[14]**	66%[1] 45.4%[2]	11.3%[1] 22.3%[2]	NA	NA	NA
	Colantonio et al (2010)[2]	11.9%	41.6%	31.1%	20.2%	NA
	Selassie et al (2008)[30]	37%	34.8%	7.4%	NA	NA
	Rutland-Brown et al (2006) [31]	19%	32%	10%	NA	NA
	Tieves et al (2005)[3]	34.2%	38.3%	8.1%	NA	NA
	Wagner et al (2000)[7]	NA	NA	35%	NA	NA
	Annegers et al (1980)[35]	46.8%	28.8%	3.8%	9.4%	4.4%
Oceania	**Feigin et al (2013)[36]**	20%	38%	17%	NA	NA
	Myburgh et al (2008)[37]	61.4%	24.9%	7.2%	3.5%	1.1%
	Tate et al (1998)[38]	40%	20.6%	8.2%	25.2%	NA
	Hillier et al (1997)[39]	57%	29%	4%	NA	NA
Europe	**Shivaji et al (2014)[40]**	NA	47%	18%	NA	NA
	Mauritz et al (2013)[41]	6.8%	NA	1.8%	5.4%	2.7%
	Perez et al (2012)[11]	26.1%	NA	NA	NA	NA
	Numminen (2011)[43]	17.8%	58.4%	7.6%	NA	NA
	Andriessen et al (2011)[15]	50.6%	37.9%	3.9%	2.5%	NA
	Koskinen & Alaranta (2008)[45]	16.6%	51.8%	2.9%	NA	NA
	Andelic et al (2008)[44]	29.7%	51%	12.8%	NA	NA
	Mauritz et al (2008)[17]	41%[3] 44%[4] 48%[5]	38%[3] 40%[4] 30%[5]	2%[3] 3%[4] 5%[5]	NA	NA
	Maegele et al (2007)[47]	55.3%	35%	NA	NA	NA
	Rosso et al (2007)[21]	44%	41%	2%	5%	NA
	Styrke et al (2007)[46]	30%	55%	NA	NA	NA
	Andersson et al (2003)[50]	15.75%	58.08%	14.72%	NA	NA
	Baldo et al (2003)[13]	48.5%	NA	NA	NA	8.8%
	Masson et al (2003)[19]	59%	30%	NA	NA	NA
	Servadei et al (2002)[53]	47.9%	32.6%	1.3%	1.1%	7.8%
	Servadei et al (2002)[54]	48.2%[6] 23%[7]	NA NA	1.4%[6] NA	1.2%[6] NA	7.6%[6] 2.4%[7]
	Masson et al (2001)[18]	48.3%	41.8%	6.4%	NA	NA
	Thornhill et al (2000)[58]	11%	46%	28%	NA	NA
	Murray et al (1999)[20]	56%	16%	NA	NA	NA

	Murray _et al_ (1999)[16]	42%	12%	5%	3%	6%
	Ingebrigtsen _et al_ (1998)[59]	21%	62%	7%	NA	NA
	Vazquez-Barquero _et al_ (1992) [61]	60%	24%	NA	NA	8%
	Tiret _et al_ (1990)[64]	59.6%	32.5%	6.1%	NA	NA
	Nestvold _et al_ (1988)[12]	57.6%	NA	NA	4.1%	4.5%
Asian	**Rahimi-Movaghar _et al_ (2013) [67]**	47.6%	38%	NA	9.5%	NA
	Wu _et al_ (2008)[4]	60.9%	13.1%	13.4%	NA	NA
	Chiu _et al_ (2007)[5]	45%[8] 55%[9]	34%[8] 28%[9]	11%[8] 13%[9]	NA NA	NA NA
	Nakamura _et al_ (2002)[68]	63.9%	31.7%	NA	NA	NA
	Zhao _et al_ (2001)[10]	31.7%[10] 33.0%[11]	21.8%[10] 33.5%[11]	23.8%[10] 12.0%[11]	NA NA	NA NA
	Raja _et al_ (2001)[6]	52.8%	28%	14%	1%	NA
	Wang _et al_ (1986)[9]	31.7%	21.8%	23.8%	15.4%	NA

[1]Patients transferred to Level-I or -II Trauma center, [2]Patients admitted direct to Level-I or -II trauma center, [3]Patients in Austria, [4]Patients in Crotia and Slovakia, [5]Patients in Bosnia and Macedonia, [6]Romagna region in Italy, [7]Trentino region in Italy, [8]Taipei city in Taiwan, [9]Hualien country in Taiwan, [10]6 big cities in China, [11]21 rural areas in China, NA= not available, MVC=Motor Vehicle Collision.

enrolled patients with all severity levels, good recovery was the major clinical outcome.

External causes: 42 studies gave data on external cause or mechanism of injury. The causes of TSCI are summarized in Table 3. In Asian countries such as China, Pakistan, Iran and Japan, the main cause of TBI was MVCs. In North America, falls were the leading causes in both United States and Canada. The leading cause of TBI in Australia, France, Spain, Austria, England, Croatia, Slovakia, Bosnia, Macedonia, Netherland and Italy were MVCs whereas falls were the most common reason in New Zealand, Sweden, Scotland, Norway and Finland.

The MVC-related TBIs were the most common cause (42.4%) in developing countries whereas the fall-related TBIs (34.4%) were the most common cause in developed countries (Figure 2). Developed countries have significantly higher percentage of sport-related TBIs as compared to developing countries (18.2% versus 1%). No data were available for work-related TBIs in Developing countries. A comparison of etiology in different continent based on aggregated data is shown in Figure 3. The percentage of MVC-related TBIs from low to high were in 22.3% in North America, 29% in Europe, 35.8% in Oceania and 42.4% in Asia. Europe had the highest percentage of fall-related TBIs (47.4%) and work-related TBIs (8.5%) as compared to other continents. No data were available on work-related TBIs to Asian. North America (19.8%) followed by Oceania (12.1%) had the highest percentage of sport-related TBIs as compared to other continents.

Discussion

Cases of different age groups represent different epidemiological features. This systemic review excluded studies with an age restriction in order to draw universal conclusions. However, the epidemiological features were quite different in elderly and children. There was a trend of aging of the population with TBI [22]. Older adults acquired TBI due to an increased life expectancy and greater mobility in elderly. Falls are the most common cause of TBI in older adults [23]. Mortality rates for older people with mild TBI were higher than for their younger counterparts [24]. In studies that have examined disability
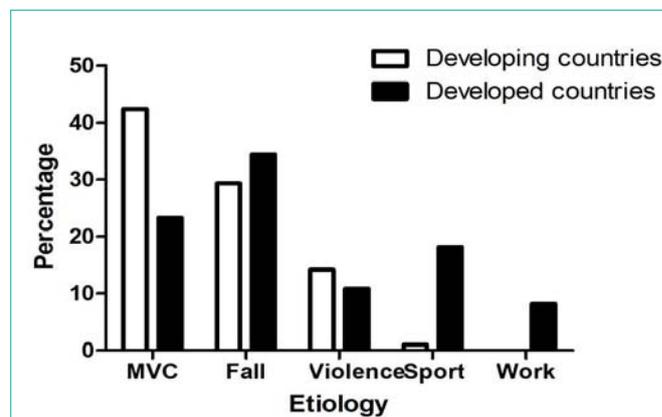

Figure 2: A comparison of etiology between developing countries and developed countries.
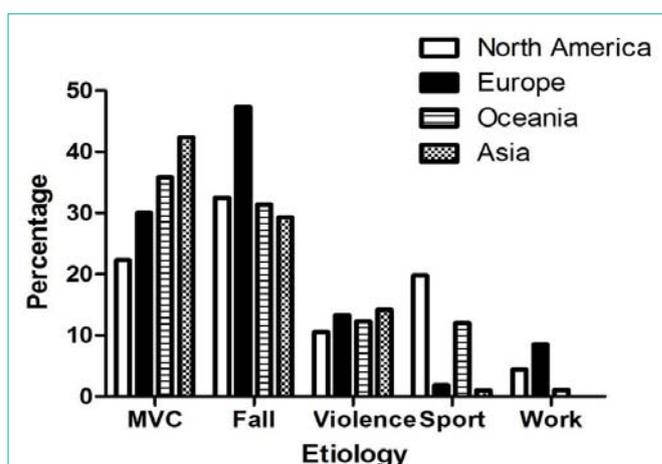

Figure 3: A comparison of etiology between North America, Europe, Oceania and Asian.

after TBI, older adult TBI survivors had better outcomes than younger survivors using GOS [25]. As a result of the longer hospital stays in older adults, the cost of their care is significantly greater.

Causes of injury vary with child developmental age, with more inflicted injuries in infants, fall-related injuries among toddlers, sports-related injuries among middle-school-aged children and motor vehicle crashes in older children [26]. One half of severely injured children suffered poor outcomes [27]. Their outcomes were correlated with the severity of injury, child age at injury, pre-morbid child characteristics, family factors and the families' socioeconomic status [26].

Another factor which affects the mechanism of injury and its outcome was local income. In high-income countries, individuals with TBI are generally motor-vehicle occupants, whereas in middle-income and low-income countries patients with TBI are often vulnerable pedestrians, cyclists and motorcyclists [22]. The most common cause of TBI in developing countries was MVCs. Increased use of motor vehicles, a lack of awareness of safety, and delayed implementation of traffic safety regulations account for these MVC-related TBIs. The traffic safety regulations were demonstrated to be effective in Taiwan, where implementation of the motorcycle helmet law decreased the incidence of motorcycle-related TBI by 33% [5].

Military subjects were considered to have a higher incidence rate and more severe as compared to civilians. It is reported that the overall TBI mortality rates in the US civilian population declined in the 1980 and 1990s. An analysis by severity shows that severe TBI incidence rates rose, moderate TBI rates were level, and mild TBI hospitalizations dropped dramatically. However, a decrease in TBI hospitalization was reported for all severity levels in military subjects during the 1990s [28]. A study by Orman et al. described penetrating brain injury from the wars in Iraq and Afghanistan. 69.8% of penetrating TBIs were caused by explosions. Explosions were the leading cause of combat-related injuries (74%-78%) followed by gunshot wounds [29].

The leading cause in different countries was studied in this article. Fall prevention programs should be implemented to reduce the incidence of TBI in United States, Canada, New Zealand, Sweden, Scotland, Norway and Finland. More specific traffic regulations, strict management and profound education on road safety were required in China, Pakistan, Iran, Japan, Australia, France, Spain, Austria, England, Croatia, Slovakia, Bosnia, Macedonia, Netherland and Italy.

Conclusion

Men were at higher risk of TBI than women. The average age at the time of TBI ranged from 27 to 59.67 years while the median age ranged from 29 to 45 years. The overall mild: moderate: Severe ratio was 55: 27.7: 17.3 based on Glasgow Coma Scale (GCS). Motor vehicle collision (MVC) was the leading cause of TBI in China, Pakistan, Japan, Australia, France, Spain, Austria, England, Croatia, Slovakia, Bosnia, Macedonia, Netherland and Italy, whereas fall was the leading cause in The United States, Canada, New Zealand, Sweden, Scotland, Norway and Finland. The MVC-related TBIs were the most common causes in developing countries, whereas the fall-related TBIs were the most common causes in developed countries. The percentage of MVC-related TBIs were the highest in Asia. Europe had the highest percentage of fall-related TBIs and work-related TBIs. North America, followed by Oceania, had the highest percentage of sport-related TBIs.

References

1. Tagliaferri F, Compagnone C, Korsic M, Servadei F, Kraus J. A systematic review of brain injury epidemiology in Europe. Acta Neurochir (Wien). 2006; 148: 255-268.

2. Colantonio A, Saverino C, Zagorski B, Swaine B, Lewko J, Jaglal S, et al. Hospitalizations and emergency department visits for TBI in Ontario. The Canadian journal of neurological sciences Le journal Canadian des sciences neurologiques. 2010; 37: 783-790.

3. Tieves KS, Yang H, Layde PM. The epidemiology of traumatic brain injury in Wisconsin, 2001. WMJ. 2005; 104: 22-25, 54.

4. Wu X, Hu J, Zhuo L, Fu C, Hui G, Wang Y, et al. Epidemiology of traumatic brain injury in eastern China, 2004: A prospective large case study. J Trauma. 2008; 64: 1313-1319.

5. Chiu WT, Huang SJ, Tsai SH, Lin JW, Tsai MD, Lin TJ, et al. The impact of time, legislation, and geography on the epidemiology of traumatic brain injury. J Clin Neurosci. 2007; 14: 930-935.

6. Raja IA, Vohra AH, Ahmed M. Neurotrauma in Pakistan. World J Surg. 2001; 25: 1230-1237.

7. Wagner AK, Sasser HC, Hammond FM, Wiercisiewski D, Alexander J. Intentional traumatic brain injury: epidemiology, risk factors, and associations with injury severity and mortality. J Trauma. 2000; 49: 404-410.

8. Engberg A. Severe traumatic brain injury-epidemiology, external causes, prevention, and rehabilitation of mental and physical sequelae. Acta neurologica Scandinavica Supplementum. 1995; 164: 1-151.

9. Wang CC, Schoenberg BS, Li SC, Yang YC, Cheng XM, Bolis CL. Brain injury due to head trauma. Epidemiology in urban areas of the People's Republic of China. Arch Neurol. 1986; 43: 570-572.

10. Zhao YD, Wang W. Neurosurgical trauma in People's Republic of China. World J Surg. 2001; 25: 1202-1204.

11. Pérez K, Novoa AM, Santamariña-Rubio E, Narvaez Y, Arrufat V, Borrell C, et al. Incidence trends of traumatic spinal cord injury and traumatic brain injury in Spain, 2000-2009. Accid Anal Prev. 2012; 46: 37-44.

12. Nestvold K, Lundar T, Blikra G, Lønnum A. Head injuries during one year in a central hospital in Norway: a prospective study. Epidemiologic features. Neuroepidemiology. 1988; 7: 134-144.

13. Baldo V, Marcolongo A, Floreani A, Majori S, Cristofolettil M, Dal Zotto A, et al. Epidemiological aspect of traumatic brain injury in Northeast Italy. Eur J Epidemiol. 2003; 18: 1059-1063.

14. Sugerman DE, Xu L, Pearson WS, Faul M. Patients with severe traumatic brain injury transferred to a Level I or II trauma center: United States, 2007 to 2009. J Trauma Acute Care Surg. 2012; 73: 1491-1499.

15. Andriessen TM, Horn J, Franschman G, van der Naalt J, Haitsma I, Jacobs B, et al. Epidemiology, severity classification, and outcome of moderate and severe traumatic brain injury: a prospective multicenter study. Journal of neurotrauma. 2011; 28: 2019-2031.

16. Murray GD, Teasdale GM, Braakman R, Cohadon F, Dearden M, Iannotti F, Karimi A. The European Brain Injury Consortium survey of head injuries. Acta Neurochir (Wien). 1999; 141: 223-236.

17. Mauritz W, Wilbacher I, Majdan M, Leitgeb J, Janciak I, Brazinova A, et al. Epidemiology, treatment and outcome of patients after severe traumatic brain injury in European regions with different economic status. European journal of public health. 2008; 18: 575-580.

18. Masson F, Thicoipe M, Aye P, Mokni T, Senjean P, Schmitt V, Dessalles PH. Epidemiology of severe brain injuries: a prospective population-based study. J Trauma. 2001; 51: 481-489.

19. Masson F, Thicoipe M, Mokni T, Aye P, Erny P, Dabadie P, et al. Epidemiology of traumatic comas: A prospective population-based study. Brain Inj. 2003; 17: 279-293.

20. Murray LS, Teasdale GM, Murray GD, Miller DJ, Pickard JD, Shaw MD. Head injuries in four British neurosurgical centres. Br J Neurosurg. 1999; 13: 564-569.

21. Rosso A, Brazinova A, Janciak I, Wilbacher I, Rusnak M, et al. Severe traumatic brain injury in Austria II: epidemiology of hospital admissions. Wien Klin Wochenschr. 2007; 119: 29-34.

22. Roozenbeek B, Maas AI, Menon DK. Changing patterns in the epidemiology of traumatic brain injury. Nat Rev Neurol. 2013; 9: 231-236.

23. Thompson HJ, McCormick WC, Kagan SH. Traumatic brain injury in older adults: Epidemiology, outcomes, and future implications. Journal of the American Geriatrics Society. 2006; 54: 1590-1595.

24. Susman M, DiRusso SM, Sullivan T, Risucci D, Nealon P, et al. Traumatic brain injury in the elderly: increased mortality and worse functional outcome at discharge despite lower injury severity. J Trauma. 2002; 53: 219-223.

25. Mosenthal AC, Lavery RF, Addis M, Kaul S, Ross S, Marburger R, et al. Isolated traumatic brain injury: age is an independent predictor of mortality and early outcome. J Trauma. 2002; 52: 907-911.

26. Keenan HT, Bratton SL. Epidemiology and outcomes of pediatric traumatic brain injury. Dev Neurosci. 2006; 28: 256-263.

27. Reid SR, Roesler JS, Gaichas AM, Tsai AK. The epidemiology of pediatric traumatic brain injury in Minnesota. Arch Pediatr Adolesc Med. 2001; 155: 784-789.

28. Summers CR, Ivins B, Schwab KA. Traumatic brain injury in the United States: an epidemiologic overview. Mt Sinai J Med. 2009; 76: 105-110.

29. Orman JA, Geyer D, Jones J, Schneider EB, Grafman J, et al. Epidemiology of moderate-to-severe penetrating versus closed traumatic brain injury in the Iraq and Afghanistan wars. J Trauma Acute Care Surg. 2012; 73: S496-502.

30. Selassie AW, Zaloshnja E, Langlois JA, Miller T, Jones P, et al. Incidence of long-term disability following traumatic brain injury hospitalization, United States, 2003. J Head Trauma Rehabil. 2008; 23: 123-131.

31. Rutland-Brown W, Langlois JA, Thomas KE, Xi YL. Incidence of traumatic brain injury in the United States, 2003. J Head Trauma Rehabil. 2006; 21: 544-548.

32. Day H, Roesler J, Gaichas A, Kinde M. Epidemiology of emergency department-treated traumatic brain injury in Minnesota. Minn Med. 2006; 89: 40-44.

33. Gerberding JL, Snider DE, Popovic T, Solomon SL, Bernhardt JM, Aguilar JR, et al. Incidence rates of hospitalization related to traumatic brain injury-12 states, 2002. MMWR Morbidity and mortality weekly report. 2006; 55: 201-204.

34. Harmon RL, Hodgson MJ, Cobb JD. Trends in incidence of hospitalization for traumatic brain injury in Wisconsin from 1989 through 1992. Brain Inj. 1996; 10: 139-144.

35. Annegers JF, Grabow JD, Kurland LT, Laws ER Jr. The incidence causes, and secular trends of head trauma in Olmsted County, Minnesota, 1935-1974. Neurology. 1980; 30: 912-919.

36. Feigin VL, Theadom A, Barker-Collo S, Starkey NJ, McPherson K, Kahan M, Dowell A. Incidence of traumatic brain injury in New Zealand: A population-based study. Lancet Neurol. 2013; 12: 53-64.

37. Myburgh JA, Cooper DJ, Finfer SR, Venkatesh B, Jones D, Higgins A, Bishop N. Epidemiology and 12-month outcomes from traumatic brain injury in australia and new zealand. J Trauma. 2008; 64: 854-862.

38. Tate RL, McDonald S, Lulham JM. Incidence of hospital-treated traumatic brain injury in an Australian community. Aust N Z J Public Health. 1998; 22: 419-423.

39. Hillier SL, Hiller JE, Metzer J. Epidemiology of traumatic brain injury in South Australia. Brain Inj. 1997; 11: 649-659.

40. Shivaji T, Lee A, Dougall N, McMillan T, Stark C. The epidemiology of hospital treated traumatic brain injury in Scotland. BMC Neurol. 2014; 14: 2.

41. Mauritz W, Brazinova A, Majdan M, Leitgeb J. Epidemiology of traumatic brain injury in Austria. Wien Klin Wochenschr. 2014; 126: 42-52.

42. Stocchetti N, Paternò R, Citerio G, Beretta L, Colombo A. Traumatic brain injury in an aging population. J Neurotrauma. 2012; 29: 1119-1125.

43. Numminen HJ. The incidence of traumatic brain injury in an adult population-how to classify mild cases? Eur J Neurol. 2011; 18: 460-464.

44. Andelic N, Sigurdardottir S, Brunborg C, Roe C. Incidence of hospital-treated traumatic brain injury in the Oslo population. Neuroepidemiology. 2008; 30: 120-128.

45. Koskinen S, Alaranta H. Traumatic brain injury in Finland 1991-2005: A nationwide register study of hospitalized and fatal TBI. Brain Inj. 2008; 22: 205-214.

46. Styrke J, Stålnacke BM, Sojka P, Björnstig U. Traumatic brain injuries in a well-defined population: epidemiological aspects and severity. J Neurotrauma. 2007; 24: 1425-1436.

47. Maegele M, Engel D, Bouillon B, Lefering R, Fach H, Raum M, et al. Incidence and outcome of traumatic brain injury in an urban area in Western Europe over 10 years. European surgical research Europaische chirurgische Forschung Recherches chirurgicales europeennes. 2007; 39: 372-379.

48. Steudel WI, Cortbus F, Schwerdtfeger K. Epidemiology and prevention of fatal head injuries in Germany-trends and the impact of the reunification. Acta Neurochir (Wien). 2005; 147: 231-242.

49. Lannoo E, Brusselmans W, Van Eynde L, Van Laere M, Stevens J. Epidemiology of acquired brain injury (ABI) in adults: prevalence of long-term disabilities and the resulting needs for ongoing care in the region of Flanders, Belgium. Brain Inj. 2004; 18: 203-211.

50. Andersson EH, Björklund R, Emanuelson I, Stålhammar D. Epidemiology of traumatic brain injury: a population based study in western Sweden. Acta Neurol Scand. 2003; 107: 256-259.

51. Kleiven S, Peloso PM, von Holst H. The epidemiology of head injuries in Sweden from 1987 to 2000. Inj Control Saf Promot. 2003; 10: 173-180.

52. Santos ME, De Sousa L, Castro-Caldas A. Epidemiology of craniocerebral trauma in Portugal. Acta Med Port. 2003; 16: 71-76.

53. Servadei F, Antonelli V, Betti L, Chieregato A, Fainardi E, Gardini E, et al. Regional brain injury epidemiology as the basis for planning brain injury treatment. The Romagna (Italy) experience. Journal of neurosurgical sciences. 2002; 46: 111-119.

54. Servadei F, Verlicchi A, Soldano F, Zanotti B, Piffer S. Descriptive epidemiology of head injury in Romagna and Trentino. Comparison between two geographically different Italian regions. Neuroepidemiology. 2002; 21: 297-304.

55. Engberg Aa W, Teasdale TW. Traumatic brain injury in Denmark 1979-1996. A national study of incidence and mortality. Eur J Epidemiol. 2001; 17: 437-442.

56. Firsching R, Woischneck D. Present status of neurosurgical trauma in Germany. World J Surg. 2001; 25: 1221-1223.

57. Alaranta H, Koskinen S, Leppänen L, Palomäki H. Nationwide epidemiology of hospitalized patients with first-time traumatic brain injury with special reference to prevention. Wien Med Wochenschr. 2000; 150: 444-448.

58. Thornhill S, Teasdale GM, Murray GD, McEwen J, Roy CW, Penny KI. Disability in young people and adults one year after head injury: prospective cohort study. BMJ. 2000; 320: 1631-1635.

59. Ingebrigtsen T, Mortensen K, Romner B. The epidemiology of hospital-referred head injury in northern Norway. Neuroepidemiology. 1998; 17: 139-146.

60. O'Brien DP, Phillips JP. Head injuries in the Republic of Ireland: a neurosurgical audit. Ir Med J. 1996; 89: 216-218.

61. Vázquez-Barquero A, Vázquez-Barquero JL, Austin O, Pascual J, Gaite L, Herrera S. The epidemiology of head injury in Cantabria. Eur J Epidemiol. 1992; 8: 832-837.

62. Annoni JM, Beer S, Kesselring J. Severe traumatic brain injury-epidemiology and outcome after 3 years. Disabil Rehabil. 1992; 14: 23-26.

63. Johansson E, Rönnkvist M, Fugl-Meyer AR. Traumatic brain injury in northern Sweden. Incidence and prevalence of long-standing impairments and disabilities. Scand J Rehabil Med. 1991; 23: 179-185.

64. Tiret L, Hausherr E, Thicoipe M, Garros B, Maurette P, Castel JP, et al. The epidemiology of head trauma in Aquitaine (France), 1986: a community-based study of hospital admissions and deaths. Int J Epidemiol. 1990; 19: 133-140.

65. Servadei F, Ciucci G, Piazza G, Bianchedi G, Rebucci G, Gaist G, et al. A prospective clinical and epidemiological study of head injuries in northern Italy: the Comune of Ravenna. Italian journal of neurological sciences. 1988; 9: 449-457.

66. Aghakhani N, Azami M, Jasemi M, Khoshsima M, Eghtedar S, Rahbar N. Epidemiology of traumatic brain injury in urmia, iran. Iran Red Crescent Med J. 2013; 15: 173-174.

67. Rahimi-Movaghar V, Saadat S, Rasouli MR, Ghahramani M, Eghbali A. The incidence of traumatic brain injury in Tehran, Iran: a population based study. Am Surg. 2011; 77: e112-114.

68. Nakamura N, Yamaura A, Shigemori M, Ono J, Kawamata T, Sakamoto T. Epidemiology, prevention and countermeasures against severe traumatic brain injury in Japan and abroad. Neurological research. 2002; 24: 45-53.

69. Nell V, Brown DS. Epidemiology of traumatic brain injury in Johannesburg-II. Morbidity, mortality and etiology. Soc Sci Med. 1991; 33: 289-296.