The Epidemiology of Traumatic Brain Injuries (TBI) – A Literature Review

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ABSTRACT: *A search of the literature showed limited reported research on the epidemiology of TBI in South Africa. This prompted a search of literature on the epidemiology of TBI in the rest of the world. Traumatic brain injury (TBI) is a leading cause of death and disability in most western countries. Motor vehicle accidents (MVA) are the main cause of TBI, followed by gunshot wounds (GSW) and falls. In South Africa, road accident fatalities are 27,3 per 100 000 of the population. The causes of death and disability vary with age, race and gender groups. Improved medical emergency care has resulted in a decrease in the mortality rate following TBI, but has increased the morbidity rate. The increase in the number of people living with neurological impairments is a significant economic burden when taking into account hospitalization, rehabilitation, medication and the loss of working hours. The emotional burden is unknown. The purpose of this paper is to place in perspective, the epidemiology of TBI, by looking at the published literature in the rest of the world. In the developing world it is projected that the burden of disease resulting from interpersonal violence will nearly double by 2020 unless preventive action is taken. Many more people survive acts of interpersonal violence than die from them.*

KEY WORDS: TRAUMATIC BRAIN INJURY, EPIDEMIOLOGY, WORLD.

INTRODUCTION

This literature review deals with the epidemiology of Traumatic brain injury (TBI) in South Africa and the rest of the world. The content is made up of information about traumatic brain injury from primary and secondary sources of literature including anecdotal information where necessary.

METHOD OF SEARCH

The first line of search was Medline for the years 1976 to 2000 and thereafter from 2000 to 2006. The first Medline search led to core articles on the subject. From these core articles, references were used to identify other primary and secondary sources. The next line of search was the Sabinet. Other databases like the Cochrane library and Pedro also helped identify other sources of limited information. In addition subscriptions to contents pages in selected journals eg Brain injury led to currently published articles on the topic. Finally key words were entered in Google and some sources were identified. The health System Trust website yielded some useful information.

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WHAT IS TRAUMATIC BRAIN INJURY?

Traumatic brain injury or craniocerebral trauma may be defined as an occurrence of injury to the brain (arising from blunt or penetrating trauma or acceleration-deceleration forces). The signs and symptoms that are often attributable to the injury are a decreased level of consciousness, amnesia, other neurological and neuropsychological abnormalities, skull fractures, diagnosed intracranial lesions or death (Thurman et al 1999).

Brain damage resulting from a head injury can be classified as focal or diffuse (Liau et al 1996). Focal lesions include cerebral contusions and lacerations, haematomas, brain stem trauma and injuries to the cranial nerves and pituitary stalk (Liau et al 1996). Diffuse brain injuries include cerebral concussion and diffuse axonal injury (Liau et al 1996). Focal and diffuse injuries can be further classified as primary or secondary. The primary injury occurs at impact and may involve injury to the scalp, cranium and parenchyma and neural or vascular elements of the brain (Liau et al 1996). Secondary injury is the result of immediate or delayed physiological processes. This may result in further damage of neural tissue leading to clinical deterioration (Liau et al 1996). In most cases TBI results in neurological impairment with physical, psychological, cognitive and emotional signs and symptoms (Bell and Sandel 1998, Chua 2000, Emanualson and Ostergard 1999, Jennet and Bond 1975, Maas et al 1983, Michaud 1998, Sandel et al 1998, O'Dell et al 1998[a], O'Dell et al[b] 1998). The neurological impairment may persist for a few hours to several years.

Traumatic brain injuries resulting from motor vehicle accidents (MVA - pedestrians, cyclists, and vehicle occupants), gunshot wounds (GSW), stabbings,

violence, falls and sporting accidents is a major health burden in many countries (Emanualson and Ostergard 1999, Jennet and Bond 1975, Tiret et al 1990, Thurman et al 1999, Chua 2000). In 1985, in the United States of America (USA), the economic burden related to TBI was estimated at $ 37,8 billion (Thurman et al 1999). The lifetime cost for an individual sustaining a head injury can exceed $4 million (Beers and De Bellis 2002). This does not include the loss of potential income. The total national bill for TBI is estimated at $25 billion per year for rehabilitation, support services and lost income for injured patients (Eyster et al 1996).

In the USA, 1, 5 million people sustain TBI annually (Thurman et al 1999). Two hundred and thirty thousand are hospitalized and 50 000 die annually (Thurman et al 1999). In a study among 7 states, serious TBI requiring hospitalization were far more common than injuries resulting in death (Thurman et al 1999). Mild TBI constitutes about 80 to 90% of all TBI in the USA (O'Dell et al 1998)[b].

The proportion of individuals who sustained moderate or severe brain injuries from closed injuries was 86.2% while penetrating injuries claimed the remaining 13.8%. Penetrating injuries were more common in males than in females. Firearms were the cause of 93.6% of penetrating injuries and 0.7% of closed injuries. Penetrating injuries had a case fatality more than twice that of closed head injuries (Peek-Asa et al 2001).

CAUSES OF TBI

In **South African** females road traffic accidents produced the highest rate of TBI. compared to males where it was the second highest (Bradshaw et al 2005). These rates were higher in developed provinces such as the Western province, Gauteng and Mpumalanga. Bradshaw et al (2005) also reported that mortality rates due to injury decreased from 1996 to 2000.

In the **USA**, MVA and falls remain the leading causes of closed brain injuries while GSW is the leading cause of penetrating injuries (Geddes et al 2001). Brain injury surveillance from 1984 to 1992 showed an increase of 13% in firearm related injuries while MVA decreased by 25% (Peek-Asa et al 2001). Firearms surpassed MVA as a leading cause of TBI in 1990 and this trend has continued to 1995 (Peek-Asa et al 2001).

The leading cause of death following TBI varied depending on the age of the patient. Among African Americans, in the 15 to 84 age group, the firearm related death rate of 75 to 80% (Sandel et al 1998). was greater than that due to motor vehicle accidents (under 15 years) and falls in persons over the age of 75 years (Thurman et al 1999). In African Americans firearm related fatalities were almost twice that of MVA. Among white males the firearm related fatalities were only slightly higher than the MVA fatalities (Thurman et al 1999). In females, MVA claimed the highest number of fatalities from birth to 70 years. (Thurman et al 1999).

In summary, motor vehicle accidents accounted for 49%, falls 26% and firearms 10% of TBI. Firearms claimed 75-80% of all deaths. Assault not involving firearms accounted for 8% of the injuries (Thurman et al 1999). Firearms in the home are likely to be used in suicide, homicide and domestic violence (Sandel et al 1998).

In the **United Kingdom** (U.K.), over a 2 year period (1986 - 1988), 988 patients who had sustained severe head injuries were admitted to 4 neurosurgical centers (Murray et al 1999)[b]. Motor vehicle accidents were the major cause of accidents in all 4 centers and accounted for half to two thirds of all severe head injuries (Murray et al 1999)[b]. Falls as a result of alcohol abuse ranged from 9% in Southampton, 12% in Liverpool, 15% in Edinburgh and 22% in Glasgow. In studies involving 16 hospitals, conducted from May 1989 to April 1990 in the Mersey region in the U.K motor vehicle accidents contributed to 78%, falls 16%, assaults 5% and other causes 1%, of all the admissions following head injuries (Dunn et al 2000).

The European Brain Injury Consortium (EBIC) conducted a study in 1995 over a 3 month period. (Murray et al 1999)[a]. The incidence of TBI in Germany was 241, the U.K. 219, Italy 184 and France 95. Several other countries reported head injuries but on a minor scale. Motor vehicle accidents caused 51% of all injuries, falls while under the influence of alcohol 12%, unknown causes 10% and sport 3% (Murray et al 1999)[a].

In **Singapore**, the main cause of TBI was falls at 23,8% while assault contributed to 5%. The firearm related injuries were insignificant but the fatality rate was significantly high (Murray et al 1999)[a].

In **Australia**, over a 35 year period, from January 1956 to December 1990, the commonest cause of extradural haematoma (EDH) was MVA at 50% (Jones et al 1993). Over the same period falls accounted for 30.5% of EDH, sporting accidents 7.5% and assault 5%. In 1998, Tate et al (1998) reported an annual incidence of 100/100 000 resident population. Although most injuries (62%) were mild, 38% were serious and 4% died after admission to hospital. Severe brain injury represented an annual incidence of 12/100 000 resident population with road accidents accounting for a higher proportion.

PAEDIATRICS

In **South Africa**, in a study done at the Red Cross Memorial Children's Hospital in Cape Town between 1991-2001, 37 610 records of children with head injuries were analysed. The majority of the injuries (41%) was caused by falls (off beds, stairs, playground equipment, other heights etc,) with vehicle related trauma making up 19% (Lalloo and van As 2004). In this study almost 60% were boys. Half the sample was under 5 years of age with 20% less than 2 years of age.

In the **USA** traumatic injury including falls (55%), MVA and recreational activities (32% in the 0 - 4 year age group), pedestrian injuries (in the 5 to 9 year age group), abuse (65% in infants less than 1 year old) is the leading cause of death and disability in childhood (Beers and De Bellis 2002, Michaud 1998). Child abuse predominated in children under the age of 2 years. Among children under the age of 15 years, MVA (bicyclists, pedestrians, and vehicle occupants) was the most common cause of TBI (Michaud 1998). Younger children in general, experienced more severe injuries than their older peers. Almost one quarter of infants in

the developed world experienced moderate to severe TBI. Traumatic brain injuries accounted for 30% of all deaths in the 0 to 19 year age group (Beers and De Bellis 2002). Conservative estimates suggest that 20 to 25% of childhood TBI may be inflicted. In a 10 year study completed by the National Incidence Study in 1986 in the USA the reported incidence of physical abuse has increased by 42% (Beers and De Bellis 2002).

Subdural haematomas are more likely to be due to child abuse and extradural haematomas are more likely to be due to unintentional injuries (Sandel et al 1998). Subdural, subarachnoid and retinal hemorrhage with few signs of external injuries is often a result of shaking and impact. These are the signs of "shaking-impact" or "shaking-baby syndrome" (Sandel et al 1998).

In the **U.K.**, the findings in a series of 37 post-mortems of infants under the age of 9 months reported that 75% of the infants had signs of significant apnea and the most common histological finding was global hypoxic damage (Geddes et al 2001). Extradural cervical damage and focal axonal injury to the brain stem and spinal nerve roots was found in 30% of the infants indicating that the craniocervical junction is vulnerable in infant head injury (Geddes et al 2001).

In **South Western Sweden**, a study amongst children and adolescents, from 1 January 1987 to 31 December 1991 showed that 60% of TBI was due to MVA, 22% to falls, 7% to sporting injuries, 3% were struck on the head by an object and for 6% the etiology was unknown (Emanualson and Ostergard 1999). In the 0 to 4 year age group, 49% of the injuries were due to falls and MVA resulted in 44%. In the 5 to 9 age group, 47% of the injuries were due to MVA and 37% were due to falls. Motor vehicle accidents were the main cause of injuries in the 10 to 14 and the 15 to 17 age groups at 74% and 69% respectively (Emanualson and Ostergard 1999).

TBI IN THE ELDERLY

In the elderly, a head injury is much more likely to be due to a fall either at home or on the street (Maurice-Williams 1999). Alcohol appears to contribute to 20% of these injuries and more frequently in men than in women. A chronic subdural haematoma (CSDH) is a predominant pathological consequence of minor head injury in the elderly (Maurice-Williams 1999). Apart from the CSDH, a head injury is more likely to give rise to intracranial bleeding or a cerebral contusion (Maurice-Williams 1999).

In **Poland**, in patients older than 70 years, falls contributed to 50% of injuries, MVA to 42% and assaults to 5% (Liau et al 1996). The fatality rate following TBI in the elderly is significantly high. This is often due to co-existing complications like pneumonia, myocardial infarction and femoral fractures (Liau et al 1996). In patients admitted with a Glasgow Coma Scale (GCS) of 9 or less the mortality rate was 85%. Those who had a GCS of 12 and above died mostly of pneumonia and the mortality rate was 20% (Liau et al, 1996). In patients who sustained acute subdural haematoma (ASDH) and had a GCS of less than 9, the mortality rate was 100%. In patients who sustained ASDH with a GCS greater than 9, the mortality rate was 60%. The male:female ratio was 1,8: 1. The most important prognostic factor that influenced the overall outcome was the GCS on admission (Liau et al 1996).

TBI IN SPORT AND RECREATIONAL ACTIVITIES

Traumatic brain injuries have been documented since games were first held. The understanding and treatment of cerebral insults have improved significantly in the past century. Mild TBI or concussion following sporting accidents has become more extensively documented and more common and serious than previously thought (Bailes and Cantu 2001). Forces that are imparted to the cranium of athletes are generally of 2 types. Acceleration-deceleration injuries, also considered as linear impact, usually occur when the subject's body and head are traveling at a particular speed and strike a solid object. The resulting injury causes linear, tensile and comprehensive strains that disrupt the cerebral cytoarchitecture. The second possibility of a rotational movement occurring is due to the fixation of the brain at the foramen magnum and craniospinal junction and the relative tethering of the midbrain as it passes through the tentorial hiatus (Bailes and Cantu 2001). Biomechanical studies concerning athletic injuries have suggested that angular head accelerations have an increased risk of injury (Bailes and Cantu 2001).

In sport injuries, contact sport carries the highest risk of head injuries (Sandel et al 1998). This is true for professional and scholar athletes participating in organized contact sports as well as for recreational events. Although the incidence of serious or life threatening brain injury has decreased in many sports, there is evidence suggesting that mild TBI may be more common than previously thought. It is estimated the 750 000 Americans sustain injuries from sport annually. Of this 9.1% sustain head injuries (Bailes and Cantu 2001).

Cerebral concussion is a common injury among football players. It ranks as the fifth most common injury among college football players, with an estimated incidence of 10% (Naunheim et al 2001). In American football approximately 8 deaths and 250 000 cases of concussions are reported annually (Sandel et al 1998).

Soccer is the most popular and frequently played sport with at least 200 million registered participants (Matser et al 1998). The American Academy of Paediatrics classifies soccer as a contact/collision sport. The concussion rates per 1000, in athletes playing soccer and American football are equal. Unlike other sport, soccer players do not wear protective headgear. In soccer, concussions may occur head to head, head to goal post/ground or head to body collisions (Matser et al 1998). Repetitive heading of the ball is another mechanism of chronic TBI. This is compounded by the weight of the ball, which varies from 396 to 453g and travels at a speed of 60 to 120km/h. Chronic TBI represents the long-term cumulative neurological consequence of concussive and subconcussive blows to the head (Matser et al 1998).

Boxing differs from all other sport in that repetitive blows to the head, made in the attempt to disable the opponent's

central nervous system are part of the strategy (Bailes and Cantu 2001). Boxing is also a major contributor and cause of dementia (Sandel et al 1998). Recommendations to ban the sport have been unsuccessful (Sandel et al 1998).

Equestrian sports account for approximately 46 000 hospital emergency visits annually with 20% experiencing head injuries. Seventy percent of deaths are related to head injuries (Bailes and Cantu 2001). In Sweden horse riding is a popular sport among young girls. Three in every 100 000 suffers a serious head injury every year (Emanualson and Ostergard 1999).

The highest ratio of TBI per sporting event occurs in downhill skiing (Bailes and Cantu 2001). Many occur as a result of collisions, often at high speed, with trees, boulders and other skiers. Head injuries are the leading cause of fatalities in alpine skiing resorts causing approximately 32 deaths a year in the USA (Bailes and Cantu 2001).

CONCLUSION

The epidemiology of TBI in the USA, U.K. and in most European countries has been reported and is the subject of numerous ongoing studies. Surveillance systems have been established to continuously monitor the changing incidence and causes of TBI. It is clear that in some countries MVA as a primary cause of TBI is on the decline. The epidemiological surveys have provided these countries with sufficient data to implement legislative changes and educational programmes to reduce the high incidence of TBI. It has also resulted in the health departments establishing specialized, multidisciplinary rehabilitation facilities to meet the needs of the head injured patient and their families (Chua 2000, Dunn et al 2000, Sandel et al 1998, Thurman et al 1999).

In Kwa-Zulu Natal or in the Republic of South Africa (RSA), few epidemiological studies on TBI have been published (Lalloo and va As 2004, Reed and Welsh 2002) and anecdotal information suggests that the incidence is high. The morbidity and mortality rates are unknown and the number of patients living with disability is unknown. The impact on the health system is unknown. In the year 2000, 40% of the patients that were admitted to the only public acute neurosurgical unit in KZN were diagnosed as TBI. The number of patients that received rehabilitation following their discharge from this unit is unknown. There are no specialized, multidisciplinary facilities to cater for the management of the specialized needs of the head injured patients and their families in this province. In the private sector the Life Healthcare unit at Entabeni Hospital provides this service. Detailed epidemiological studies and surveillance systems are essential to provide reliable data on causes of injuries, risk factors, and trends in the incidence of TBI in the province. This analysis should document the need for the provincial health departments to establish appropriate facilities that will provide acute, sub-acute and rehabilitation facilities, which will provide support for the head injured individual and care givers through the various stages of recovery, including and appropriate placements in schools and community integration. Legislative departments will be able to implement cause-specific prevention programmes. On the basis of this paper it is suggested that epidemiological studies of TBI be carried out for each of the provinces in South Africa

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