

The Demographic Profile of Pediatric Traumatic Brain Injury in Cape Town

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ABSTRACT

The study describes the demographic profile of pediatric traumatic brain injury (TBI) in Cape Town. Records from the Red Cross War Memorial Children's Hospital (RXH) were used to identify cases of TBI in children up to 15 years of age, who were admitted within the months of April and August, 2007. The research design was thus of the retrospective observational type. Statistical analyses described the demographic trends in sex, age, TBI severity, socio-economic status, and etiology of TBI. These results are discussed against the backdrop of international research on pediatric TBI, and thus shed light on the extent to which epidemiological findings on TBI in developed countries are applicable to developing countries such as South Africa.

Keywords: demographic profile; epidemiology; pediatric; TBI; South Africa; cross-cultural.

An estimated 57 million people worldwide have been hospitalized with one or more traumatic brain injuries (TBI), while the proportion of people living with TBI-related disability is unknown (Murray & Lopez, 1996, as cited in Langlois, Rutland-Brown, & Wald, 2006). In the United States alone, an estimated 1.5 to 2 million individuals succumb to a traumatic brain injury annually, leading to approximately 52,000 deaths due to TBI (Ragnarsson, 2002). Furthermore, international research also indicates that traumatic brain injury (TBI) is a primary cause of death and disability in young children (Kraus, Rock, & Hemyari, 1990, as cited in Hawley, Ward, Long, Owen, & Magnay, 2003).

In South Africa, head injuries alone have been shown to account for 25.2% of non-natural deaths for children younger than 15 years of age (Knobel, De Villiers, Parry, & Botha, 1984). Head injuries are also the most frequently reported explanation for admission to hospital in children younger than 13 years of age (Cywes et al., 1990).

Given the global and local severity of the problem it is not surprising that Semple, Hass, and Peter (1998, p. 440) refer to TBI as a “sociological disaster”.

Four important factors contributed to the rationale for the present study. Firstly, current epidemiological data for the South African pediatric TBI population is limited (Levin, 2004). Secondly, epidemiology data on pediatric TBI is also lacking in other developing countries; thus, this study will not only benefit the local context, but will also contribute towards building the knowledge base of developing countries as a whole. Thirdly, if causative factors can be identified, such data may be powerful in proposing targets for intervention and prevention of TBI in South Africa. Finally, socio-economic systems in South Africa are diverse and varied and have been suggested to contribute *uniquely* to the occurrence of pediatric TBI in South Africa compared to developed countries (Levin, 2004).

TRAUMATIC BRAIN INJURY-(TBI)

Traumatic brain injury refers to a non-congenital assault to the brain caused by mechanical energy to the head from external forces (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004; Tabish, Lone, Afzal, & Salam, 2006). TBI severity is gauged according to a continuum from mild to moderate to severe. Although there is variation concerning the most appropriate means of defining TBI severity (addressed below), three measures have regularly been used

as “gold standard” (Malec et al., 2006, p. 1422) indicators of TBI severity. These include: Loss of Consciousness (LOC), Post Traumatic Amnesia (PTA), and the Glasgow Coma Scale (GCS; Jennett & Teasdale, 1974, in Anderson, Northam, Hendy, & Wrenhall, 2001).

Common Indicators of Brain Pathology

LOC relates to the duration of an unconscious episode or coma after the moment of the traumatic event. Unconsciousness of 30 minutes or less is often used to define mild TBI, while longer lengths of coma are used to define more severe forms of TBI. PTA refers to an episode of amnesia following the injury. Typically, PTA of less than 24 hours indicates a mild TBI, while greater lengths of amnesic episodes define more severe forms of TBI (Malec et al., 2007).

GCS scores assess the depth of unconsciousness as measured by three components: eye opening, verbal response, and best motor response (Appendix A). Scores can range from a low of 3 to a high of 15. The higher the GCS score, the less pathology is assumed, while lower scores are associated with increased pathology. A score of 3/15, naturally, indicates severe pathology (severe TBI) or death (Granacher, 2003). Because very young children may not have fluent verbal ability at the time of GCS assessment, a different yet related scoring system is used. Specifically, the pediatric Glasgow Coma Scale (pGCS; Appendix B) allows for the assessment of eye movement (ocular response) instead of verbal responses (Raimondi & Hirschauer, 1984, in Clikeman 2001).

PTA, LOC, and GCS have been suggested to be more accurate than biologically objective measures such as computerized tomography (CT) and magnetic resonance imaging (MRI) abnormalities at gauging TBI severity (Alexander, 1995). However, despite this fact and the frequency with which these indicators are used in current TBI epidemiology research, great variation exists in the case definitions of the TBI subgroups.

Incongruence in Case Definitions of TBI severity

Consensus on the valid criteria for indicating the relative severity of a TBI is lacking in current TBI epidemiological research. In a comprehensive review of the literature on mild TBI, Carroll et al. (2004) found that many studies did not explicitly state case definitions for mild TBI. Among those which did provide explicit definitions, 62% used GCS scores as part of the case definition. Some studies also included LOC or PTA or both as part of the case

definition. Within these studies there was variation as to the specific range of GCS scores that were used to define mild TBI. Generally, these scores ranged from 13 to 15. There was also variation concerning the length of LOC and PTA used in the studies. LOC was occasionally not defined, in others the length was described as “brief”, while still others used a length of LOC ranging from less than 5 minutes to less than 30 minutes. Those studies using PTA as part of the case definition used length of PTA ranging from undefined, to less than 5 minutes, to less than 24hrs, for mild TBI.

The remaining 38% of reviewed studies did not use GCS scores to help define mild TBI (Carroll et al., 2004). These studies used LOC, PTA or both, with variation in time periods specified as criteria for mild TBI. Other studies used hospital discharge codes such as the International Classification of Disease (ICD) codes for traumatic brain injury or the patient’s Abbreviated Injury Score (AIS) to define mild TBI.

Variation also exists for defining moderate TBI, although many researchers have used the following criteria: injury causing unconsciousness for longer than 15 min and a GCS score of 9-12 (Hawley et al., 2002). Other researchers have used GCS scores of 9-12 and hospital stay of at least 48 hours, operative intracranial lesion and abnormal CT scan findings (Tabish et al., 2006). Severe TBI has been defined as unconsciousness of 6 hours or more following injury and/or a GCS score of 3-8 following resuscitation (Hawley et al., 2002). Alternatively, a GCS score of below 9 within 48 hours of the injury has also been used to define severe TBI (Tabish et al., 2006).

These are clear instances of variation in defining the subgroups of TBI. Such heterogeneity in defining TBI severity results in difficulties in interpretation and comparison of epidemiological findings regarding TBI (Bruns & Hauser, 2003; Carroll et al., 2004). These difficulties stem from the fact that different case definitions of TBI result in different methods of case ascertainment and consequently in different epidemiological findings (i.e., great variation in incidence rates for TBI may be reported within one region or country).

A clear example of different epidemiological findings resulting from differing case definitions of TBI severity is provided by Anderson, Bjorkland, Emanuelson, and Stalhammar (2003), who conducted an epidemiological study of TBI in western Sweden. The authors used seven categories of TBI severity defined by the American Congress of

Rehabilitation Medicine (ACRM; Kay, Harrington, & Adams, 1993, as cited in Anderson et al., 2003). The categories were labeled as categories A to G. The categories refer to increasing levels of brain pathology, with category A referring to the presence of head trauma and concussion, while categories B-D related to clear symptoms of brain disturbances and a history of external violence, and categories E-G referred to brain trauma resulting in a period of unconsciousness.

Using all seven categories (encompassing mild, moderate, and severe), the authors found an incidence of 546:100000, of which 98.5% were mild according to the ACRM definition of mild TBI. However, when restricting the definition to including only categories D, E, and F, which corresponded to case definitions of mild TBI in studies conducted in the United States (U.S.), they found an incidence rate of 204:100000 (Anderson et al., 2003). This example illustrates how a change in the case definition of mild TBI yields to an incidence rate that is almost 50% smaller than the original finding. The problem with using a valid case definition is further depicted by research on the validity of using hospital discharge codes.

Hospital Discharge Codes

Current research warns against the use of ICD-9 codes in the identification of mild TBI patients, stating that the codes not only appear to be inaccurate, but often result in significant false negative (under-inclusive) and false positive (over-inclusive) case assignments (Bazarian, Veazie, Mookerjee, & Lerner, 2006). The ICD-9 codes for mild TBI have been shown to identify approximately 23% of mild TBI cases, 29% of the moderate TBI cases and 13% of the severe TBI cases (Tate, McDonald, & Lulham, 1998, as cited in Carroll et al., 2004). Furthermore, it appears that the ICD 10th revision codes are able to identify fewer than 50% of all head injury admissions, consequently leading to inaccurately low incidence rates (Deb, 1998).

In light of the incongruence in TBI case definitions, it is highly problematic to compare TBI epidemiological studies, especially those involving incidence rates. However, comparisons of TBI incidence rates do nonetheless provide useful *estimates* of the *range* of TBI incidence in the relative populations. Epidemiological data on TBI patients generally focus on population-based incidence rates. These data are regularly dissected according to sex, age and etiological factors.

Because epidemiological studies on pediatric TBI are greatly lacking in developing countries, the variables of sex, age and etiology will be discussed by including data from adult samples where applicable, so as to demonstrate key points.

INCIDENCE RATES

Bruns & Hauser (2003) concluded, after a review of the literature, that epidemiological studies suggest a general range in TBI incidence of 150 to 250:100 000 population per year. All the studies reviewed were from developed countries. A different review of TBI epidemiology studies in Europe estimates the incidence to be approximately 235 to 243:100000 population per year (Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2005). Research from South Australia yields a much higher incidence of 322:100 000 (Hiller, Hiller, & Metzger, 1997) suggesting great similarity in the incidence rates for the United States and Europe but a proportionately higher incidence for South Australia.

In South Africa, Nell and Brown (1991) found TBI incidence figures of 316:100 000 per population per year. However, this study only represents the adult population (15 years and older). These results suggest that the incidence of TBI in South Africa may actually be similar to TBI incidence figures in developed countries like Australia, but may be higher than that in other developed countries.

The incidence figures depicted above are age-standardized incidence figures for TBI. This means they provide an estimate of the incidence of TBI in general populations (across large age groups). However, comparisons of TBI incidence rates across studies indicate clear age-related trends that illustrate the magnitude of TBI in the infant and adolescent age groups when compared with TBI incidence rates in the general population.

AGE-RELATED TRENDS

Bruns and Hauser (2003) found that peaks in TBI incidence occurred in early childhood, late adolescence/early adulthood and in the elderly.

Generally, in developed countries children aged younger than 1 year had a higher incidence of TBI (ranging from 190 to 350:100 000) than those aged 1-4 years (ranging from 100 to 345:100 000). Incidence figures then lowered for children aged 5-15 years (146 to 273:100 000; Bruns & Hauser, 2003). It is thus apparent that in developed countries the incidence rate for TBI in the pediatric population is higher than that in the general population.

Incidence then increased for adolescents and young adults (16-25 years). This latter group represents one of the peaks in TBI incidence with figures ranging from 154 to 415:100 000 per year. After early adulthood TBI incidence rates in adulthood is characterized by a decline which follows with a final peak after 75 years of age (Bruns & Hauser, 2003).

These trends are not supported in the South African study. In fact, they appear to oppose the South African findings where the highest peak in incidence was not in the 15 to 24 year age group (young adults and adolescents) with an incidence of 360:100 000, but in the 25 to 44 year age group at 409:100 000. This was the age range where other studies' TBI incidences declined before the final peak (Bruns & Hauser, 2003; Nell & Brown, 1991).

A similar 'opposing' trend emerged for South African geriatric population (65 years and older). While this age group constituted the final peak as identified by Bruns and Hauser (2003), in South Africa it was marked by a decline in incidence, with a rate of 63:100 000 (Nell & Brown, 1991). This suggests that South Africa may have a dissimilar trend in age-specific TBI incidence. The Nell and Brown (1991) study did not, however, include individuals younger than 15 years of age, and no such study currently exists in South Africa. Thus, the younger age groups cannot be represented in this assumption.

Research in another developing country (Pakistan) reports a similar trend to the U.S based studies (Raja, Vohra, & Ahmed, 2001). Specifically, the highest proportion of individuals were represented in the 21-30 year age group (25.2%) followed by individuals younger than 10 years (24%). However, these are proportions of a study sample and not population-based incidence figures, and may not be as accurate in predicting the distribution in the target population.

It is interesting to note that although some developing countries may follow similar age trends as identified in developed countries, the research in South Africa appears to contradict this trend not only in young adult age group (15 to 24 years), but also in older adult (25 to 44 years) and geriatric (60 and above) age groups. It would be interesting to see whether such disparities with international trends are observed in young South African children (0-15 years).

SEX DIFFERENCES

When observing trends in sex differences, researchers have found that males represent a higher proportion of TBI victims than do females. In a 15-year study of TBI in children (0 to

14 years) conducted in Denmark, Engberg and Teasdale (1998) found a male to female ratio of 1.4:1. In the United Kingdom, male to female ratios of 2.8:1 have been found for children (0 to 15 years) (Hawley et al., 2003). In the developing country of India, a ratio of 1.5:1 was found (0 to 15 years) (Tabish et al., 2006). This is very similar to the figure for Denmark, a developed country.

Similar trends have been reported for studies with a larger age range (including children and adults). In the USA, male to female ratios are reported to range between 1.5 and 2.8:1 (Bruns & Hauser, 2003). In their review of the literature from the United States, Australia and France on severe TBI, Finfer and Cohen (2001) report that incidence rates for males are at least twice that for females. In their review of the mild TBI literature, Holm et al. (2005) also found that MTBI was more common in males than in females. Thus, this trend of a large male to female TBI incidence appears to be relatively constant across developed countries, across TBI subgroups, and across age ranges in developed countries.

In South Africa, the same trend towards sex differences has been reported for TBI in adults, with an estimated male to female ratio of 4:1 (Nell & Brown, 1991). This ratio is clearly significantly higher than those reported in the developed countries. In Pakistan this trend is as apparent in a standardized age sample (i.e. including both children and adults), with a male to female ratio of 3:1 (Raja et al., 2001).

It appears that in developed and developing countries males represent a higher proportion of the TBI populace. Also, in the pediatric population, the male to female ratios for TBI in developed and developing countries may be more similar than the same ratios in the general population.

ETIOLOGY OF TBI

In the U.K., the most frequent causes of TBI in children are falls (45.1%), followed by road traffic accidents (RTAs; 21.1%). Falls are the major cause of injury amongst younger children (less than 5 years old), while RTAs are the major cause amongst older children (10 to 15 years old; Hawley et al., 2003). In the US, falls were the most frequent cause of TBI in the youngest and eldest age groups, while motor vehicle accidents (MVAs) and violence were the leading causes in adolescent and young adult males (Bruns & Hauser, 2003).

In India the same general trends emerge, with falls accounting for 68% of cause for TBI in young children, followed by RTAs at 26%. Here the majority of falls occurred within the 4-6 year old age group (50%), while the majority of RTAs came about in the 7-9 year old age group (30%; Tabish et al., 2006). Similarly, in South Africa falls are the most common cause of head injury (41%) among children younger than 13 years of age, followed by traffic-related accidents (19%) and being struck by an object (13%; Lalloo & van As, 2004). Thus, data from developing countries appear to support the trend that falls and RTAs are the primary causes of TBI in the younger populations, with falls occurring more frequently than RTAs in this age group (0 to 15 years).

TRENDS IN TBI SEVERITY

In the US, the distribution of mild, moderate, and severe TBI has been estimated to be 80% mild TBI, 10% moderate TBI, and 10% severe TBI (Bruns & Hauser, 2003). In Europe the same distribution has been reported to be approximately 90% mild TBI, 6% moderate TBI, and 4% severe TBI in the general population (Tagliaferri et al., 2005). For children (0 to 15 years) in Europe, research suggests a similar distribution: 82.7% mild TBI, 9.1% moderate TBI, 6.1% severe TBI, 0.8% fatality, and 1.3% unknown severity (Hawley et al. 2003).

Research from South Africa indicates a severity distribution of 87.5% mild TBI, 7.9% moderate TBI, and 4.6% severe TBI (Nell & Brown, 1991). Taken together, the results from both developed and developing countries indicate that mild TBI cases make up an overwhelmingly large distribution of TBI cases, followed by moderate, and then severe TBI. This is the case in both general populations and perhaps child populations. An exception is made for TBI in the US, where moderate and severe TBI are estimated to be of equal proportions in the general population. Data for the severity distribution of TBI in children are yet to be generated for South Africa.

The current study analyzed the data according to the variables of age, sex, etiology, severity, socio-economic status, language, and place of occurrence of TBI for children in Cape Town.

METHOD

Sample

The study sample consisted of all children aged 15 years and under who were treated at the RXH Trauma Ward for TBI within the months of April and August 2007.

Procedure

In each ward at the RXH, details of the patients being treated within those wards are recorded in an *admission register*. Before being referred to these wards, and thereby being entered into the admission register, all patients having suffered an injury are treated at the Trauma Ward. All the relevant details of these patients (such as name, age, sex, folder number, nature of accident, nature of injury, name of acting doctor, etc.) are kept in a *trauma register*.

The trauma register was the primary data source for identifying possible cases of TBI in the current study. All cases that were treated at the Trauma Ward in April and August of 2007 were reviewed in the trauma register against specified selection criteria for possible TBI. Upon meeting these criteria, the relevant names and surnames, dates of admission, nature of injury (this column in the trauma register refers to a short identification of the anatomical region which suffered the trauma), nature of accident (this column refers to a short description of the incident that caused the trauma such as “fell from bed” or “MVA pedestrian”), and folder numbers of the prospective cases were recorded.

Selection criteria for possible TBI. All cases implying an injury to the head or face region were included. Thus, if the nature of injury was specified as “eye”, “nose fracture”, “ear bleeding”, etc., these would have been included in the list of possible TBIs. Furthermore, any injury leading to a classification of “head injury” under the “nature of injury” column was also included. Finally, all classifications under the “nature of accident” column relating to a MVA were included since these accidents often lead to multiple mechanical assaults to the body, and are frequently found to be one of the leading causes of TBI, and the leading cause of severe TBI in children (Hawley et al., 2003; Semple et al., 1998).

Despite the fact that falls are often reported as the most common cause of TBI in children (Hawley et al., 2003; Lalloo & van As, 2004), time constraints restricted all falls (coded as: nature of accident – “fall” or “fell from...”) from being recorded. Previous research at the RXH found that falls were the cause of 43% of all injuries treated at the hospital (Kibel et al., 1990). However, falls result in a large variation of injuries across all regions of the body. Taking into account the large number of fall-related accidents recorded in the register and the time constraints of the research, an estimation of the coding validity of falls as indicating TBI was conducted.

Coding validity of falls. Thirty-five cases of falls were extracted from the trauma register and these folders were then reviewed against the criteria for TBI. Of the 35 falls, 57% (20) were coded (under “nature of injury”) as injuries peripheral to the head, i.e. “right ankle injury”, “left elbow injury”, “back injury”, etc. A further 11% (4) were coded as injuries relating to the head region, e.g., “left eye injury”, “right ear injury” etc. Finally, 31% (11) of the cases were coded as “head injuries”. After reviewing these cases for possible TBI, results indicated that none of the fall injuries coded as peripheral injuries were sufficient to meet the criteria for a TBI, 25% of the falls leading to a head region injury were sufficient for a TBI classification, and 91% of the fall injuries classified as “head injuries” were sufficient to meet the criteria for TBI. Based on these results, only falls leading to a head region injury and/or “head injury” were included for further review.

Once all possible cases of TBI for April and August 2007 were extracted from the trauma register, the folder numbers were used to retrieve the cases from the Medical Records department at the RXH. The folders and particularly the *trauma unit record form* (see Appendix C) of all possible TBIs were then further reviewed against the selection criteria/ case definition of TBI used in the current research.

Since 1991, every patient being treated in the trauma unit at the RXH has received a trauma unit record form (Lalloo & van As, 2004). This form contains detailed information pertaining to the cause of the accident, place of occurrence, anatomical region of the injury sustained, pathology of the injury, abbreviated injury score, type of treatment provided for the injury, and details of the initial examination of the patient. Demographic information is available in the form of a information sheet within the folder. This sheet contained details of the patients’ parents/guardians, place of residence, contact details, monthly family income, etc. Where

possible, additional information (e.g., Glasgow Coma Scale scoring sheets, health records, clinical notes, referral letters or documents from private doctors or other hospitals or other wards within the hospital) was reviewed against this study's selection criteria for TBI.

Selection criteria for TBI. Traumatic brain injury is defined here as a non-congenital assault to the brain caused by mechanical energy to the head from external forces (Carroll et al., 2004; Tabish, et al., 2006). Using the trauma unit records, such an assault could be identified by the type of accident, region of injury – such as the brain, scalp, skull, as opposed to areas peripheral to the head – and pathology of injury-such as concussion, laceration, fracture (closed or open), etc. Once this criterion was met, it was important to gauge the severity of the injury.

As noted above, in TBI there are levels of severity: mild, moderate, and severe. As also noted above, three clinical measures have been identified as crucial measures for the severity of neuropathology of TBI: post traumatic amnesia (PTA), an estimate of the length of post-injury amnesia, loss of consciousness (LOC), an estimate of the duration of unconsciousness, and Glasgow Coma Scale (GCS) score, a measure of the depth of unconsciousness. However, the RXH has not yet standardized the practice of assessing PTA in head injury assessment. Furthermore, although LOC is regularly reported in the trauma unit record form of most head injury patients, this information was at times inconsistently available, occasionally missing, and sometimes supplemented by additional information in the patients' folders (e.g., in the form of referral letters from private doctors).

The current study used GCS scores to define TBI severity. Researchers agree that consciousness levels as indicated by GCS scores is not only a widely accepted and valuable early assessment of brain injury severity, but that GCS scores are also the most common means for coding injury severity (Berg, Tagliaferri, & Servadei, 2005; Silver, McAllister, & Yudofsky, 2005). In line with similar research (Malec et al., 2007; Parslow et al., 2005), a GCS score of 13-15 was used to define mild TBI; a score of 9-12 was used to define moderate TBI; and a score of 3-8 was used to define severe TBI.

For children younger than 3 years of age the RXH uses a children's GCS score out of 11. These scores were converted to scores out of 15 by multiplying the child's score by 1.364, which is the ratio of 15:11.

The time at which a GCS assessment is made was also considered. GCS was originally intended to be a repeated measure (Silver et al., 2005). At the RXH repeated assessments/ observations are completed only when a patient exhibits sufficiently serious pathology. For example, a patient with an initial GCS assessment of 13/15 after a knock to the head may be requested to stay for further observation. During observation, X-rays, CT scans and repeated GCS assessments are made (often with 30 min intervals). During this time, fluctuations in GCS scores may be observed, depending on patient improvement or deterioration. In much of the research on TBI epidemiology the post-injury time of GCS assessment was not stipulated. In other studies there was variation in the time of GCS administration, where some assessments were administered at the scene of the trauma/accident, during emergency transport, or upon hospital admission (Silver et al., 2005). Given the fluctuation of GCS scores post-injury, and the availability of repeated GCS assessments (for more severe injuries) at the RXH, this study recorded the lowest GCS score within 24 hours post injury as representative score for TBI assessment. Similar methodology was used for defining severe TBI by Malec et al. (2007).

Once a case demonstrated a non-congenital assault to the brain from external mechanical forces and a GCS score was assessed, it met the selection criteria of a TBI and consequently was entered into a STATISTICA database for further analysis.

RESULTS

Analysis of Data

The variables of sex, age, severity, and etiology were all entered into STATISTICA and analyzed descriptively. Further analyses involved one-way ANOVAs and Pearson's Chi-square tests. A probability of less than 0.05 was considered statistically significant. All but one of the one-way ANOVAs met the assumptions for homogeneity of variance; however ANOVA is relatively robust to homogeneity of variance violations, and so I present the results of all of those analyses here. All of the one-way ANOVAs met the assumptions for normality. Out of approximately 1400 cases treated in the RXH Trauma Ward for April and August of 2007, more than 600 cases of possible TBI were identified, and 176 cases met the criteria for a TBI as defined in the current study. A further 65 folders were in use by various departments and/or doctors during data collection, and could therefore not be assessed.

Analysis by Age

Figure 1 indicates that the highest incidence of TBI occurred in the 0 to 5 year age group (57%), followed by the 5 to 10 year age group (31%), with the lowest incidence occurring in the 10 to 15 year age group (12%). The mean age of the sample was 4.91 years ($SD = 3.55$). The mean age for the mild TBI children was 4.82 years ($SD = 3.57$); the mean age for moderate TBI children was 7.48 ($SD = 3.26$); and the mean age for children with severe TBI was 4.53 ($SD = 3.08$). Age did not statistically significantly vary across the TBI severity subgroups, $F(2, 173) = 1.94864, p = 0.145582$.

Analysis did however indicate a significant difference between the age at which a TBI occurred and the sex of the victim, $F(1, 174) = 4.1949, p = 0.042048$. Specifically, males ($M = 5.35, SD = 3.55$) were found to be significantly older than females ($M = 4.23, SD = 3.48$) when they acquired a TBI.

Furthermore, statistically significant differences were observed between the age group of the TBI victim and the cause of the TBI, $\chi^2(16, N = 176) = 32.82067, p = 0.00781$. Falls accounted for the highest proportion of TBIs in the 0 to 5 year age group (58.42%), followed by pedestrian MVAs (19.8%) and being struck by/against an object (10.89%). Falls were also responsible for the majority of TBIs in the 5 to 10 year age group (42.59%), followed by pedestrian MVAs (24.07%) and being struck by/against an object (20.37%). For the 10 to 15 year age group being a pedestrian in a MVA accounted for the majority of TBIs (33.33%), followed by falls (28.57%) and being a passenger in a MVA (14.29%).

Analysis also indicated a significant difference between age of the children and the place at which the TBI occurred, $F(8, 167) = 4.18332, p = 0.000138$. The youngest TBI victims acquired a TBI inside their own home ($M = 3.20, SD = 2.87$), followed by outside someone else's home ($M = 4.42, SD = 2.53$), and their own homes ($M = 4.56; SD = 2.71$). The oldest children acquired TBIs on the road/pavement ($M = 5.95, SD = 3.66$), at public places ($M = 6.35, SD = 3.19$), and at the school/crèche ($M = 7.17, SD = 2.67$).

No significant difference between the age of the TBI victim and their respective language was observed, $F(6, 169) = 0.25149, p = 0.958159$.

Additional Results for Sex Differences

Of all 176 cases, 39% ($n = 69$) were female, and 61% ($n = 107$) were male, giving a male to female ratio of 1.6:1. (Refer to Table 1 for a representation of males and females along all the variables in the analysis).

Figure 2 shows the proportion of males to females within each subgroup of TBI. The figure shows that males constitute a larger proportion of the cases within each TBI severity.

Specifically: within the mild cases, males constituted 59% and females 41% of these cases, with a male to female ratio of 1.4:1; within the moderate cases, males constituted 86% and females 14% of these cases, with a male to female ratio of 6:1; finally, within the severe cases, males constituted 78% and females 22%, with a male to female ratio of 3.5:1.

However, no significant difference was observed between males and females regarding TBI severity, $\chi^2(2, N = 176), p = 0.20256$. Non-significant differences were also observed between sex and each of the variables of language, $\chi^2(6, N = 176) = 5.852824, p = 0.43988$, etiology of TBI, $\chi^2(8, N = 176) = 13.56587, p = 0.9382$, and place of occurrence, $\chi^2(8, N = 176) = 9.733645, p = 0.28423$.

Additional Results for Etiology of TBI

Etiological factors were coded into nine distinct categories, namely: Falls; Struck By/Against; MVA Pedestrian; MVA Passenger; MVA Cyclist; Assault; Assault by Animal; Caught Between; and Unknown.

Figure 3 illustrates that Falls accounted for the majority of TBIs (50%) followed by MVA Pedestrian (22.73%), Struck By/Against (13.07%), MVA Passenger (6.82%), Assault (3.98%), MVA Cyclist (1.14%), and Assault by Animal (1.14%). Caught Between (two objects) and “unknown” accounted for the lowest proportions of TBI etiology (0.57% each).

Within the mild cases, the three etiological factors with the largest proportions were Falls (53.13%), MVA Pedestrian (18.75%), and Struck By/Against (13.13%). Within the moderate TBI cases, MVA Pedestrian accounted for the largest proportion of etiological factors with 57.14%, followed by Falls (28.57%) and Struck By/Against (14.29%).

Finally, the etiological factor accounting for most of the severe TBI cases was MVA Pedestrian (66.67%). Falls, Struck By/Against, and MVA Passenger accounted for identical proportions of severe TBI etiologies (11.11% each). No significant difference was observed for the cause of a TBI between the TBI severity subgroups, $\chi^2(16, N = 176) = 18.14073, p = 0.31574$.

Additional Results for Place of Occurrence of TBI

The place at which a TBI occurred was coded along nine categories, namely: own home inside; road/pavement; public place; own home outside; school/crèche; other; and unknown.

In the general TBI sample, most of the falls occurred inside the child's own home (40.91%), followed by outside the child's own home (22.73%). Being struck by/against an object also mostly occurred inside the child's own home (39.13%), followed by the occurrence of this event in public places (21.74%), and outside the child's own home (17.39%). Furthermore, most of the assaults occurred at the school/crèche (42.86%), followed by outside the child's own home (28.57%). These results were statistically significant, $\chi^2(64, N = 176) = 418.2643, p = 0.000$.

Additional Results for Severity of TBI

The severity distribution in the present sample was 91% mild TBI, 4% moderate TBI, and 5% severe TBI. Finally, severity of TBI was not found to vary significantly with the variables of language, $\chi^2(12, N = 176) = 9.830939, p=0.63079$ and place of occurrence, $\chi^2(16, N = 176) = 17.34372, p=0.3672$.

Socio-economic status (SES) of children with TBI

Socio-economic status (SES) was calculated using the monthly family income (MFI) information available from the demographic sheet in the patients' folders. Results indicate a mean of 2177.095 (Std. Dev. = 1772.494) for MFI for the entire TBI sample. This result suggests that a low socio-economic status was characteristic for the sample. However, this result may have been skewed towards a lower SES because of miss-coding of the original data set.

DISCUSSION

The results indicate that the youngest children (0 to 5 years) accounted for the largest proportion of TBI cases observed in the data, while the oldest children (10 to 15 years) accounted for the lowest proportion. Although the results for differences by age and severity of TBI were found to be statistically non-significant, it is likely that the small number of observations observed for moderate TBI ($n = 7$) and severe TBI ($n = 9$) accounted for this non-significance. Statistically significant differences were, however, observed between the age at which a TBI was acquired and the sex of the child. Males were found to be significantly older than females at the time of injury.

Significant differences were also observed for the age of acquisition of a TBI and the cause of the TBI. The youngest children (0 to 5 years) were most likely to acquire a TBI after a fall, while the older children (10 to 15) were most likely to acquire a TBI through being involved in a pedestrian MVA. Additionally, the youngest TBI victims were significantly more likely to acquire a TBI inside and outside their own homes, and outside the home of someone else. On average, older children acquired their TBIs outside the home, with significantly higher age means calculated for injuries sustained on the road/pavement, public places, and at the school/crèche.

Males constituted a larger proportion of TBI cases than did females. The differences in proportion increased in the more severe forms of TBI, with moderate TBI staking claim to the largest male to female ratio. The large male to female ratio then decreased in severe TBI, but remained substantially higher than the same ratio in mild TBI. Sex differences were not found to be statistically significant across the severities of TBI, language of the child, cause of TBI, and place of occurrence of TBI. These results may be due to the small number of observations that were observed in some of the subgroups of each variable. For example, there was only one female in the moderate TBI category and two females in the severe TBI category.

It was also observed that the three main causes of TBI in the present sample were, respectively, falls, being a pedestrian involved in a MVA, and being struck by/against an object. Within the mild TBI cases, falls accounted for over half of the causal factors, followed by pedestrian MVAs and being struck by/against an object. Moderate TBI was mostly

accounted for by being a pedestrian involved in a MVA, followed by falls and being struck by/against an object. Finally, being a pedestrian in a MVA also accounted for the majority of severe TBI cases, followed by being a passenger in a MVA and being struck by/against an object, which occupied equal proportions in the severe TBI cases. These differences in severity of TBI by causes of TBI were found to be statistically non-significant.

However, significant differences were obtained for cause of TBI by place of occurrence. These indicated that a great preponderance of TBIs that were caused by having fallen occurred within or outside the child's own home. Being struck by/against an object was also mostly attributed to having occurred within or outside the child's own home environment; however, many of these incidents also happened in public places. It is also interesting to note that although many of the assaults that were recorded in the data were observed to have occurred outside the home of the child, most of these incidences happened at the child's school or crèche. It is unsurprising that the overwhelming proportion of MVA TBIs occurred on the road or pavement.

Age Trends Compared with International Trends

In their review of TBI epidemiology studies conducted in the US, Bruns and Hauser (2003) found that one of the peaks in TBI incidence occurred in the 0 to 15 year age range. Within this range the authors found that TBI occurred at a high incidence in the younger age groups (0 to 4), which then lowered in the older age groups (5 to 15). The results from this study were congruent with this trend. Specifically, this study found that the majority of TBI cases occurred in the younger age groups and then decreased in occurrence in the older age groups.

This diverges from the 'opposing' age trends identified by Nell and Brown (1991) in the Johannesburg study of TBI in adults. Those authors found trends in the incidence of TBI by the age of their sample that opposed the trends identified by Bruns and Hauser (2003). Specifically, Nell and Brown (1991) found a peak in the 25 to 44 year age group, which was the range in which the US studies' incidence was marked by a decline. Further results from the South African study identified a decline in the adolescent (15 to 24 years) and geriatric (65 years and older) age groups, which were characterized by an increase in TBI incidence in the US studies (Bruns & Hauser, 2003). The findings from the South African study suggested that the occurrence of TBI in the South African context may well have been unique in regard to the age trends identified in the US studies. However, the results of this study are in line

with those identified by Bruns and Hauser (2003) for the US, and therefore suggest that age related trends in South Africa are at least similar in the paediatric age groups.

Sex Differences Compared with International Trends

Results from this study were also congruent with other international trends, specifically, as related to sex differences. In Denmark, a 15-year study of TBI in children (0 to 14 years) found a male to female ratio of 1.4:1 (Engberg & Teasdale, 1998), while in the UK a male to female ratio of 2.8:1 was observed for children (0 to 15 years; Hawley et al., 2003). The results from the current study found a male to female ratio of 1.6:1 which is well within the range identified in the above studies.

Furthermore, in a study focusing on mild TBI in children (0 to 17) in Sweden, the researchers found a male to female ratio of 1.3:1 (Dahl et al., 2006). In another study based in Switzerland, which focused on the occurrence of severe TBI in children (1 month to 16 years), researchers reported a male to female ratio of 1.7:1 (Pfenniger & Santi, 2002). The current study found a male to female ratio of 1.4:1 for mild TBI; 6:1 for moderate TBI; and 3.5:1 for severe TBI. These results suggest that while the mild TBI cases in the current study's data appear similar to developed countries as regards sex differences, severe TBI appears to over-represent the male sample compared to severe TBI in developed countries. However, this observation may have been confounded by the small sample size in the moderate and severe TBI subgroups.

It should also be mentioned that moderate TBI is both understudied and under-reported in TBI research (Clikeman, 2001), which makes comparison between this study's moderate TBI group with other studies in developed countries very limited. However, the moderate TBI cases in the current study displayed the highest male to female ratio, namely, 6:1, suggesting that this category of TBI warrants closer investigation as pertains to the high risk of males in this group.

Etiological Factors Compared with International Trends

In the UK, the most frequent causes of TBI in children (0 to 15 years) were found to be falls, followed by road traffic accidents (RTAs). Falls were also the major cause of a TBI amongst the youngest children (less than 5 years old), while RTAs were the major cause amongst older children (10 to 15 years; Hawley et al., 2003); similar trends have been reported in the

US (Bruns & Hauser, 2003). These trends were also found in the current study. Falls accounted for the majority of all the TBI cases in the present study, followed by pedestrian MVAs, while the same incident (falls) accounted for the highest frequency of TBIs in the lowest age group (0 to 5 years) and MVAs accounted for the highest frequency of TBI's in the older age groups (10 to 15years).

Severity Distribution Compared with International Trends

In the US, the distribution of mild, moderate, and severe TBI has been estimated to be 80% mild TBI, 10% moderate TBI, and 10% severe TBI (Bruns & Hauser, 2003). In Europe, the distribution has been reported to be approximately 90% mild TBI, 6% moderate TBI, and 4% severe TBI in the general population (Tagliaferri et al., 2005). For children (0 to 15 years) in Europe, research suggests a similar distribution: 82.7% mild TBI, 9.1% moderate TBI, 6.1% severe TBI, 0.8% fatality, and 1.3% unknown severity (Hawley, et al. 2003).

The present study found a severity distribution of TBI as follows: 91% mild TBI, 4% moderate TBI, and 5% severe TBI. Thus, it appears that the severity distribution of pediatric TBI cases in the present study may be similar to that in Europe. However, the moderate TBI cases in the current study have a lower proportion of total TBI cases than the severe TBI cases, which diverges from the trend in Europe, where moderate TBI outweighed severe TBI. These data, may, however be confounded by the relatively small number of observations that were observed for moderate and severe TBI.

Taken together, the observed data in the present study suggest that the demographic profile of paediatric TBI in South Africa is consistent with international trends for TBI in children.

Recommendations for Future Research

The mean for the SES (socio-economic status) variable was derived from a category on the RXH demographic sheet that specifies the MFI (monthly family income) of the patient's family. However, for maximum income earners, the MFI category was left empty, and the word "maximum" was entered into a different part of the demographic sheet. Data that was missing from the MFI category in the patient folder was recorded as "missing data" in the data for this study. Consequently, all of the maximum income cases were also coded as "missing data". It is very likely that miss-coding the maximum income values would have had the result of skewing the SES mean of the sample towards a lower SES value.

Another factor that may have confounded the results of the present study is the relatively low number of cases in the moderate and severe TBI subgroups. Smaller data sets impede the accuracy of making generalizable conclusions. Future studies should thus focus on collecting data over a longer time frame, and thereby attain a larger sample size.

In addition, only 8 weeks were available for data collection. Folders were frequently in use by various departments/wards of the hospital, which meant that the researcher had to return on multiple occasions to monitor their availability. A number of possible cases of TBI were lost because those folders were in use; this may have been because of the recency of data collection post-injury. Having a longer time frame to collect data will potentially alleviate this problem. Another way to prevent the loss of potential cases of TBI would be to change the research design to a prospective design. Prospective designs focus on collecting new occurrences of TBI. Instead of using pre-existing data, a prospective design generates original data using given parameters defined by the particular study. For example, if a research project wishes to estimate the incidence of TBI in a given population, it would start by defining the relevant criteria for TBI then observe the admissions of trauma patients at a given hospital. If admissions meet the relevant case definitions of TBI in the respective study, then those individuals would make it into the data set. The study may continue for three months as in the Nell and Brown (1991) study, or it may continue for one or more years after which it would be able to make an estimate of the number of new cases of TBI in the population per year (i.e. the incidence of TBI in the population).

The design of the current study was of a retrospective observational type. This meant that the researcher did not have much control over the coding of the data. Because hospital records were used for data collection, the case ascertainment was dependent on data that was pre-existing in the folders of each of the possible TBI cases. Using GCS, PTA, and LOC scores would probably have resulted in more accurate case definitions of TBI severity (Anderson, 1995). Future research efforts should, as noted above, focus on using a prospective research design. This will allow the researcher more flexibility in case definitions of TBI severity and more control over the coding of individual cases. At present, no incidence rates exist for TBI in young children in South Africa; a prospective study would be an efficient and reliable means of obtaining such data.

CONCLUSION

In her influential paper, Levin (2004) highlighted the dearth of research on TBI in the pediatric population of South Africa. That paper not only served to highlight the lack of such current knowledge in South Africa, but also discussed the diverse socio-cultural influences and unique socio-economic context of South Africa and how this may contribute to the unique occurrence of pediatric TBI in the South African context. The results of the present study do not confirm these suggestions made by Levin (2004): It appears that the demographic profile of pediatric TBI in South Africa in fact is consistent with pediatric TBI in developed countries.

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Appendix

- Appendix A- RXH Glasgow Coma Scale scoring sheet
- Appendix B- RXH Pediatric Glasgow Coma Scale scoring sheet
- Appendix C- RXH Trauma Unit Record Form

Figure 1. *Frequency of TBI by age group*

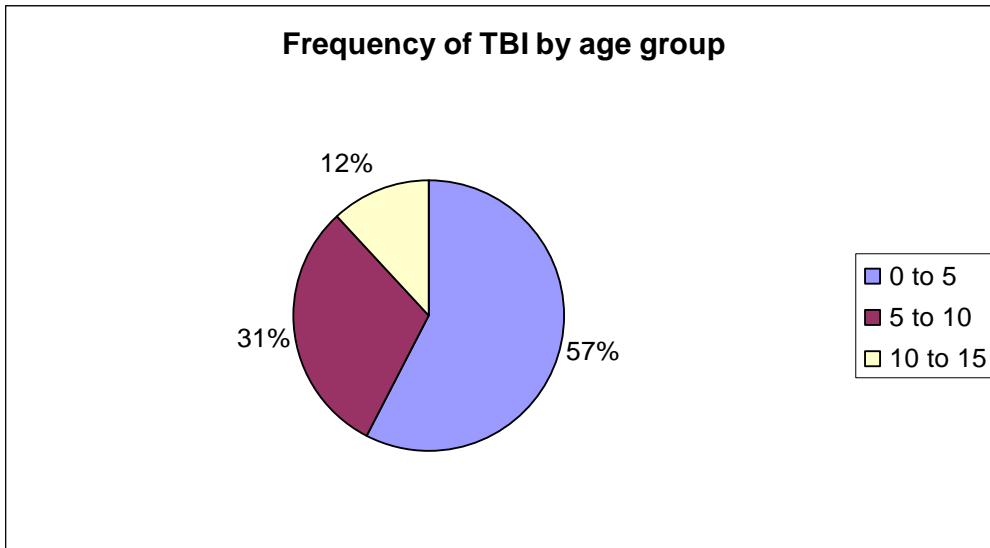


Figure 2. *Proportion of males to females per TBI severity*

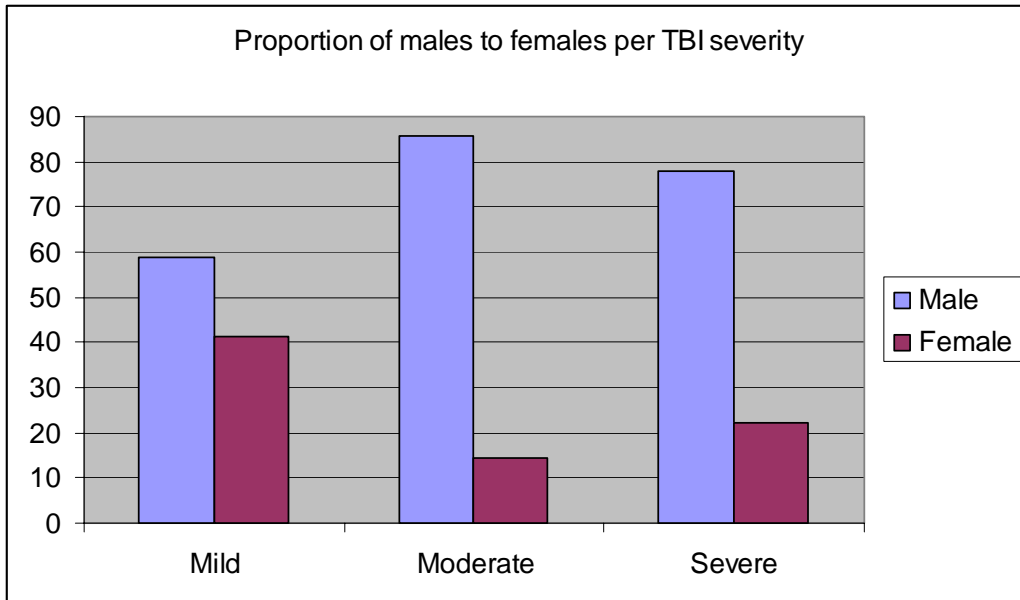


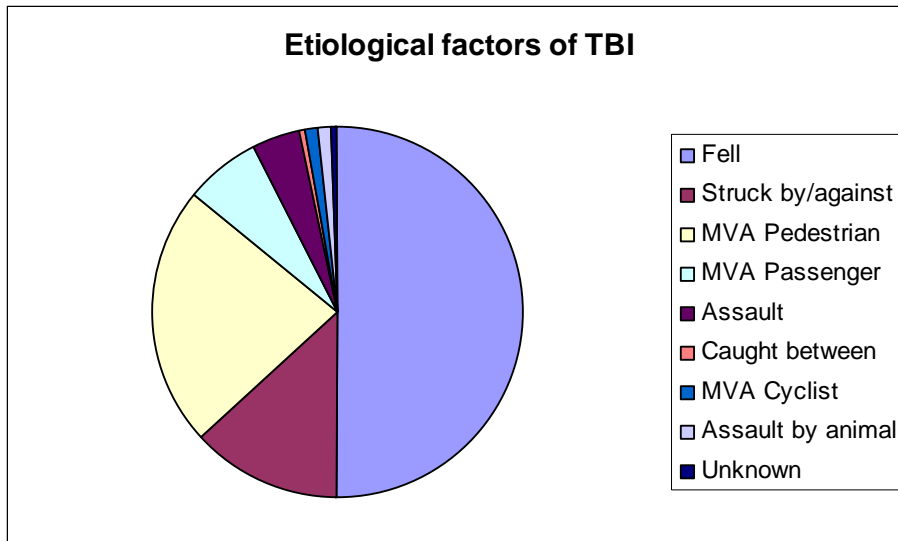
Figure 3. *Etiological factors of TBI*

Table 1.

Variable	Males (n = 107)	Females (n = 69)	<i>Demographic Characteristics of the Sample</i>
Age			
0 to 5 (n=101)	56.44%	43.56%	
5 to 10 (n=54)	66.67%	33.33%	
10 to 15 (n=21)	66.67%	33.33%	
Severity			
Mild (n=160)	58.75%	41.25%	
Moderate (n=7)	85.71%	14.29%	
Severe (n=9)	77.78%	22.22%	
Etiology			
Falls (n=88)	55.68%	44.32%	
MVA Pedestrian (n=40)	65.00%	35.00%	
MVA Passenger (n=12)	33.33%	66.67%	
MVA Cyclist (n=2)	100.00%	0.00%	
Assault (n=7)	71.43%	28.57%	
Struck by/against (n=23)	82.61%	17.39%	
Caught between (n=1)	100.00%	0.00%	
Assault by animal (n=2)	50.00%	50.00%	
Unknown (n=1)	0.00%	100.00%	
Language			
Home Language			
English (n=65)	60.00%	40.00%	
Afrikaans (n=44)	65.91%	34.09%	
Xhosa (n=49)	59.18%	40.82%	
French (n=3)	100.00%	0.00%	
Portuguese (n=1)	0.00%	100.00%	
Other (n=1)	100.00%	0.00%	
Missing data (n=13)	46.15%	53.85%	
Place of Occurrence			
Own home inside (n=46)	56.52%	43.48%	
Own home outside (n=30)	56.67%	43.33%	
Other home outside (n=3)	66.67%	33.33%	
Road/pavement (n=52)	61.54%	38.46%	
Public place (n=14)	78.57%	21.43%	
School/Creche (n=13)	69.23%	30.77%	
Unknown (n=1)	0.00%	100.00%	
Other (n=3)	0.00%	100.00%	
Missing data (n=14)	71.43%	28.57%	