A two-year demographic profile study: Pediatric traumatic brain injury admissions to the Red Cross War Memorial Children's Hospital

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ABSTRACT

Pediatric traumatic brain injury (pTBI) is a major public health problem both internationally and in South Africa (SA). However, recent local epidemiological data for pTBI in SA is lacking. The study aims to establish a demographic profile of pTBI admissions in a South African hospital for a two-year period, and to compare the findings with epidemiological trends emerging from other developing, as well as from developed countries. The study further aims to investigate the trends in age, sex, pTBI severity, monthly family income, place of residence and aetiology; and to assess trends in incidence for time of year for pTBI in Cape Town. A retrospective, descriptive, demographic study was conducted. All cases of pTBI admissions up to 12 years of age admitted to the Red Cross War Memorial Children's Hospital (RXH) over a two-year period were recorded. Statistical analyses describe the demographic trends investigated. These results are discussed in relation to international epidemiological research on pTBI, and thus indicate the extent to which epidemiological findings on TBI in resource-wealthy countries are similar to developing countries such as SA. Etiological factors, and demographic profiles identified in children sustaining TBI, constitute a basis for future preventative policy administration and intervention strategies in SA.

Keywords: demographic profile; epidemiology; traumatic brain injury; pediatric; South Africa; cross-cultural.

Traumatic brain injury (TBI) is a critical public health problem globally; of all types of injuries, TBI is the most common cause of childhood morbidity and mortality (Hawley, Ward, Long, Owen, & Magnay, 2003; Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007; Lalloo & van As, 2004). Due to this high prevalence and the associated devastating outcomes, TBI has been classified as a sociological disaster (Semple, Bass, & Peter, 1998).

Despite this social concern around TBI, there is no recent local epidemiological data available to assess the nature and severity of TBI in South Africa (Levin, 2004). TBI incidence is typically higher in developing countries, although far more epidemiological research is conducted in developed areas (Hyder et al., 2007). Future research should thus attempt to broaden the scope of current epidemiological knowledge in developing areas.

Epidemiological research may shed light on the incidence of TBI, and demographic profiles of individuals suffering as a result of TBI. Demographic factors, including sex, age, TBI severity, aetiology and socio-economic status (SES), can be used to advise preventative policy administration and intervention strategies. Current epidemiological data is necessary for successful TBI intervention; higher risk groups may be identified and effectively targeted, and seasonal trends in TBI incidence may be reduced.

PEDIATRIC TRAUMATIC BRAIN INJURY

TBI refers to a non-congenital assault to the brain caused by external mechanical energy to the head, resulting in temporary or permanent focal and/or diffuse, sensory and/or motor neurologic deficit, with an associated diminished or altered level of consciousness (Bruns Jr. & Hauser, 2003; Carroll, Cassidy, Holm, Kraus, & Coronado, 2004; Tabish, Lone, Afzal & Salam, 2006). Researchers often use head injury (HI) and TBI interchangeably, however HI does not necessarily indicate TBI. HI refers to trauma to the head, and may or may not include trauma to the brain (Bruns Jr. & Hauser, 2003). TBI affects people across the lifespan, but this research focuses specifically on children sustaining aTBI.

Measuring TBI Severity

TBI severity is measured according to a continuum ranging from mild to moderate to severe. However, there is variation in the extremities of indicators used in the definitions of TBI severity subgroups. This heterogeneity in TBI severity definitions results in complications surrounding comparison and interpretation of epidemiological findings regarding TBI (Carroll et al., 2004). Such complications arising from differing case definitions of TBI severity result in different methods of case ascertainment and inclusion criteria, and consequently in differing epidemiological findings (Bruns Jr. & Hauser, 2003; Christ, 2007).

Malec et al. (2007, p. 1422) describe the "gold standard" indicators of TBI severity as including loss of consciousness (LOC), posttraumatic amnesia (PTA) and the Glasgow Coma Scale (GCS, see Appendix A; Teasdale & Jennett, 1974), although severity is often gauged using only the GCS (Semple, Bass & Peter, 1998).

Glasgow Coma Scale

The GCS is the most frequently used and validated tool to evaluate state of consciousness (Laureys, Majerus & Moonen, 2002). It consists of three components: eye opening (E), best verbal (V) and best motor (M) response to external stimuli. The lower the GCS score (minimum 3) the more severe the assumed pathology, while higher scores (maximum 15) are associated with less severe pathology.

Severe TBI is typically defined by a post-insult period of unconsciousness lasting 6 or more hours and a GCS score of 3-8 following resuscitation, or a GCS score of less than 9 within 48 hours post-insult (Hawley et al., 2003; Tabish et al., 2006). Moderate TBI is generally indicated by GCS score of 9-12 and loss of consciousness lasting longer than 15 minutes (Hawley et al., 2003). A hospital stay longer than 48 hours, abnormal computed tomography (CT) scan findings, and an operative intracranial lesion, in conjunction with the above GCS score also indicate moderate TBI (Tabish et al., 2002). A GCS score of 13-15 indicates mild TBI. Loss of consciousness associated with mild TBI typically ranges from less than 5 to less than 30 minutes.

In an extensive review of mild TBI literature, Carroll et al. (2004) found that many studies did not give explicit case definitions for mild TBI. Of the studies that did not define mild TBI, 62% used the GCS within the case definition.

The normal verbal and motor responses required by the standard GCS are not attainable during early childhood (Simpson, Cockington, Hanieh, Raftos, & Reilly, 1991). Several rating scales including the Pediatric Glasgow Coma Scale (PGCS; see Appendix B) and Children's Coma Scale (CCS; see Appendix C; Raimondi & Hirschauer, 1984) have been developed to overcome these age-related issues. The PGCS uses the standard GCS criteria, with modifications for verbal responses and realistic age-related normal responses; and has the same maximum and minimum scores as the GCS. Whereas, the CCS modifies certain criteria used in the GCS; replaces the 'eye opening' category with 'ocular response', and has a maximum score of 11 (Perkin, Swift & Newton, 2006).

EPIDEMIOLOGICAL TRENDS IN TRAUMATIC BRAIN INJURY

Typically, epidemiological data on TBI focus on population-based incidence rates, generally dissected according to age, sex and etiological factors. Trends in severity and socio-economic status are also often of interest. Although comparison of TBI epidemiological studies based on incidence rates is problematic, particularly due to variation in case definitions, TBI incidence rates do provide relevant estimates of the range of these rates for comparison in relative populations.

Global Perspective on the Epidemiology of TBI

Traumatic brain injury is a universal phenomenon, affecting an estimated 10 million people per annum, and leading to either hospitalisation or mortality (Hyder et al., 2007). This estimation indicates the magnitude of the public health problem associated with TBI. Identification of incidence rates is thus essential to assess the impact of TBI in particular areas, and for comparison of incidence in resource-wealthy contexts with incidence in resource-poor contexts.

Although TBI is a global problem, TBI incidence is not similar across all contexts (Hyder et al., 2007). In the United States (US), approximately 1.6 million people sustain TBI every year, accounting for 52,000 fatalities and 80,000 patients presenting permanent neurologic morbidity (Rutland-Brown et al., 2006; Maegele et al., 2007). Almost 1 million patients are treated for head injury in the United Kingdom (UK) annually (Lalloo & van As, 2004). A study of TBI in the UK estimates an incidence rate of 300 per 100,000 (British Society for Rehabilitative Medicine (BSRM), as cited in Hawley et al., 2003).

A study of severe TBI in France reported a general TBI incidence rate ranging from 152-300 per 100,000 (Masson et al., 2003). Another study reported incidence estimates using hospital data in the US, Australia, France and Spain, as ranging from 90-400 per 100,000, with most falling within the range of 200-300 per 100,000, which is the average incidence rate for developed countries (Bruns Jr. & Hauser, 2003; Finfer & Cohen, 2001). A similar study, including only hospital admissions, reported the lowest incidence rates in Spain and China (91 and 66 per 100,000 respectively; Basso, Previgliano, Duarte & Ferrari, 2001).

Epidemiological data from a population-based study in Sweden reported higher TBI incidence rates than the general range for developed countries. The result of 546 per 100,000 includes mortalities (0.7%), hospital admissions (67%), and patients treated in the emergency department but not admitted (32%, Andersson, Björklund, Emanuelson, & Stålhammar, 2003). The incidence rate in Sweden was more than double that of Denmark, 240 per 100,000 in 1993 (Engberg & Teasdale, 1998). The latter study recorded only hospital admissions, illuminating the disparity of epidemiological results based on inclusionary criteria in the study methods.

Although TBI incidence rates emerging from developed countries vary considerably, the average range (200-300 per 100,000) indicates that TBI is a social concern in developed areas. Incidence rates from developed countries constitute a basis for comparison with incidence rates from developing countries.

Epidemiology of TBI in Developing Countries, Including South Africa

Hyder et al. (2007), in a review comparing TBI incidence in developed and developing countries, reported higher incidence rates in developing countries. The general population incidence in India was estimated at 160 per 100,000 (Gururaj, 2002). A sample-based study in Yemen found the same incidence rate for the adult population, but the estimated pediatric incidence rate was much higher (480 per 100,000). The overall incidence estimate in Yemen was 219 per 100,000 (Levin, Linn, Revach & Feinsod, 1990).

A sample-based study in Sao Paulo, Brazil (De Andrande, Marino, Ciquini, Figueiredo & Machado, 2001) estimated an incidence of 360 per 100,000 population. A much higher TBI incidence rate was reported for the pediatric population in Latin America (566 per 100,000; Murgio, Mila, Manolio, Maurel & Ubeda, 1999).

In contrast to the high incidence rates found in other developing countries, in Sub-Saharan Africa the incidence estimate is relatively low (170 per 100,000), although, this estimate is problematic as the literature for these areas is far less extensive than more developed areas. Sub-Saharan studies often do not differentiate HI from TBI, most studies are hospital based, and access to health care is very limited (Bruns Jr. & Hauser, 2003). Thus, the population incidence estimate of TBI is largely underrepresented in Sub-Saharan Africa. Sample-based studies may better illuminate the magnitude of TBI incidence in developing countries.

Current local comparative epidemiological data for children in South Africa (SA) is scarce. It was recently reported that no incidence rates are available for pediatric TBI admissions in SA (Levin, 2004). Thus, discussion of TBI epidemiology in SA will include data from adult samples where relevant.

In the early 1990s, an estimated 5000 adult patients in Johannesburg, suffered TBI per annum (Nell & Brown, 1991,1992) This equates to an annual TBI incidence rate in Johannesburg of 316 per 100,000. The age-adjusted rate of fatal TBI was 81 per 100,000, accounting for 20% of all TBI in Johannesburg, not much higher than the 15% recorded in the US. TBI was associated with 42.9% of all non-natural deaths recorded in Johannesburg. The incidence rate for adult TBI in Johannesburg for 15 - 24-year-olds was reported as 360 per 100,000; the same as the incidence rate in the Sao Paulo adult population (Bruns Jr. & Hauser, 2003). No pediatric incidence estimates were available for either of these studies.

In SA, injury is the leading cause of death in children aged 5-14, with the mortality rate 1.5 - 3.8 times higher than in the US (Cywes et al., 1990). Between 1981 and 1985, injury accounted for 8% of mortality in children younger than 15 (Kibel, Bradshaw, & Joubert, 1990). Fatal head injuries accounted for 25.2% of these non-natural deaths in children younger than 15 (Knobel, De Villiers, Parry, & Botha, 1984).

More recent research reports that 17.1% of patients consulting at the RXH trauma unit between 1990 and 1993 were admitted with head injury diagnoses (Semple et al., 1998). During this period, head injuries accounted for a range of 25 - 80% of pediatric trauma-related deaths. Annually, over 3000 children younger than 15 were permanently disabled due to accidental injury treated at the RXH between 1991 and 2001 (Lalloo & van As, 2004).

In summary, the literature indicates that estimated TBI incidence is typically higher in developing countries than in developed countries. This could be due to the reduced level of education, safety of road and rail networks, and amount of resources available for the creation and maintenance of safe environments, associated with developing countries compared to developed countries. In line with this, earlier South African literature estimates an incidence rate higher than the average range seen in developed countries. Although there is no comparative average incidence rate for developing countries, data from sample-based studies estimate incidence rates typically higher than the incidence in SA. This could be due to the fact that South Africa is more closely aligned with developed countries than many developing countries as it contains many features of developed countries.

Trends in Level of Severity

The general TBI incidence rate estimate of 200-300 per 100,000 in developing countries includes only TBI patients admitted to hospitals (Bruns Jr. & Hauser, 2003). Patients treated in the emergency department but not admitted, and medically unattended patients with TBIs are excluded in some studies. This results in an underrepresentation of the incidence rate for mild TBI, and consequently an overestimation in the frequency of TBIs of higher severity. With this, distribution of TBI severity is typically skewed toward mild TBI (80-90%), with moderate TBI accounting for a further 6-10% and severe TBI the final 4-10% (Bruns Jr. & Hauser, 2003; Tagliaferri et al., 2005).

Distribution of TBI severity in children (0-15 years) in Europe is estimated as 82.7% mild, 9.1% moderate and 6.1% severe, 0.8% fatal, and 1.3% unknown (Hawley at al., 2003). Similarly, the distribution of TBI severity in SA was reported as 87.5% mild, 7.9% moderate, and 4.6% severe by Nell and Brown (1991). These results suggest homogeneity in distribution of level of TBI severity across developed and developing countries.

Age-related Trends

Although TBI affects individuals across the lifespan, the incidence of TBI varies considerably among different age groups in both developed and developing contexts. Age-related trends in TBI incidence have emerged from epidemiological studies.

Bauer and Fritz (2004) identify two peak periods of TBI incidence: in children < 4-5 years old, and during mid- to late adolescence. Similarly, Bruns Jr. and Hauser (2003), in a US-based study including adults, found three peaks in TBI incidence occurring in early childhood, late adolescence/early adulthood, and in late adulthood.

In the US, injury is the primary cause of mortality in individuals younger than 45 years of age (Bruns Jr. & Hauser, 2003). TBI is the most common cause of death, disability, and morbidity among this group and is responsible for one-third to one-half of all traumatic deaths in the US. However, a more recent study reported a decline in the annual TBI incidence rate for hospital admissions in children (0-18 years) decreasing from 1991 (119.4 per 100,000) to 2005 (72.7 per 100,000; Bowman, Bird, Aitken, & Tilford, 2008).

In developed countries, a higher TBI incidence is typically reported for children younger than 1 year (190–350 per 100,000) than children aged 1-4 years (100-345 per 100,000; Bruns Jr. & Hauser, 2003). Incidence rates further declined in 5-15 year olds (146-273 per 100,000), although the overall incidence rate for the pediatric population in developed countries was higher than the general population. Specifically, TBI incidence rates were highest for young children aged 0-4 years in the US (118.5 per 100,000; Rutland-Brown et al., 2006).

At the second peak (young adults, 16-25 years), incidence increased to 154-415 per 100,000. Subsequently adult TBI incidence continued to decline, peaking only after 75 years of age (Bruns Jr. & Hauser, 2003).

TBI incidence rates in SA are not aligned with Bruns Jr. and Hauser's (2003) claims. Earlier research in Johannesburg reported the highest peak in incidence in the 25–44 year age group (409 per 100,000; Nell & Brown, 1991), considerably higher than the 360 per 100,000 reported in the 15-24 year age group (Bruns Jr. & Hauser, 2003). A decline in incidence was observed in elderly South Africans (63 per 100,000), again differing from the increasing trend observed in developed countries (Nell & Brown, 1991; Bruns Jr. & Hauser, 2003).

Nell and Brown (1991) did not include individuals younger than 15 years in their study, but a recent pilot study of RXH admissions revealed results congruent with Bruns Jr. & Hauser's (2003) trend: a higher incidence was expected in younger children (0-4 years), decreasing in older children (5-15 years; Christ, 2007). Thus, despite disparities in trends between SA and the US in young adults (15-24 years), older adults (25-44 years), and elderly (60+) age groups, trends in pediatric incidence appear to be similar (Bruns Jr. & Hauser, 2003; Christ, 2007).

Finally, age-related trends in developing countries are similar to age-related trends in developed countries. For instance, Raja, Vohra and Ahmed (2001) reported the highest TBI incidence in Pakistan in young adults (21-30 years, 25.2%), followed by younger children (< 10 years, 24%). However, these are proportions of a study sample and not population based incidence figures. Such proportions may not be as accurate in predicting the distribution of incidence in the target population.

In summary, trends in TBI incidence across age are more similar for the pediatric population in developed areas compared with developing areas. TBI incidence in South African adults differed from the trends seen in developed areas, while age-related trends in other developing countries were more similar to age-related trends in developed countries.

Trends in Sex Differences

Epidemiological data in developed and developing countries consistently reveal that males are more at risk for TBI than females. For instance, in a review of TBI in western countries, Finfer and Cohen (2001) report severe TBI incidence rates for males as at least twice that of females across developed areas. Mild TBI also affects more males than females (Holm, Cassidy, Carroll, & Borg, 2005).

Male to female (M:F) incidence ratios are similar across developed and developing contexts. In Denmark, reported M:F incidence ratio was 1.4:1 in 0-14 year olds (Engberg & Teasdale, 1998). The M:F ratio in Sweden was 1.46:1 across all ages (Andersson et al., 2003). In the UK, a M:F ratio of 2.8:1 was reported for children (0-15 years; Hawley et al., 2003). A similar M:F ratio (3:1) was reported in Aquitain, France in a population-based study (Masson et al., 2003).

Nell and Brown (1991) report the same trend in sex differences for TBI in South African adults, with an M:F ratio of 4:1, considerably higher than those in other developing countries. Data from Pakistan reveal a similar trend in distribution of incidence across sex for all ages (children and adults), with an M:F ratio of 3:1 (Raja et al., 2001). In India, the M:F ratio was estimated at 1.5:1 for children (0-15 years; Tabish et al., 2006). Christ (2007) estimated a ratio of 1.6:1 in children admitted to the RXH over 2 months, falling within the range identified above.

In summary, males are more susceptible to TBI than females. The literature suggests homogeneity of M:F ratios across developed and developing countries. However, South African studies have found a large range in M:F ratios, extending well above the ratios observed in other countries, suggesting the need for further investigation of local M:F ratios. A possible reason for the higher incidence found in males compared with males could be the increased risk-taking behaviour.

Trends in Aetiology

Aetiology refers to the cause of injury. In TBI frequency of aetiology is typically stratified by age. Thus, aetiology allows for investigation of the most common causes of TBI in various contexts, or across various age groups.

In the US, Bruns Jr. & Hauser (2003) found falls to be the primary cause of TBI in the youngest and oldest age groups, with motor vehicle accidents (MVAs) the most frequent cause in adolescents and young adult males. The most commonly reported causes of TBI in children in the UK were falls (45.1%) and motor vehicle accidents (MVAs, 21.1%); falls were the primary cause of TBI in children less than 5 years old and MVAs the primary cause among children aged 10-15 years (Hawley et al., 2003). In Aquitain, France, MVAs accounted for 58.9% and falls for 29.8% of TBIs across all ages (Masson et al., 2003).

Similar trends emerge from developing countries: Tabish et al. (2006) found falls and MVAs to be the leading causes of TBI in children (0-15 years), with falls occurring more frequently than MVAs. In India, falls account for 68% of TBI in young children, while MVAs are responsible for 26%. Similarly, the majority of falls occurred in younger children (4-6 years) and MVAs mainly in 7-9 year olds. In SA, falls are also reported as the primary cause of TBI in children under 13 (41%), with MVAs accounting for 19% of TBI (Lalloo & van As, 2004).

Together, these findings show that falls and MVAs are the most frequent cause of pTBI in both developed and developing contexts. Younger children appear to be more susceptible to TBI as a result of falls while older children are more susceptible to TBI as a result of MVAs.

Trends in Socio-economic Status

SES can influence the incidence of TBI. In general there is an inverse relationship between TBI incidence and SES, with high rates of TBI among low socio-economic groups (Basso et al., 2001; Bruns Jr. & Hauser, 2003; Levin, 2004). Epidemiological TBI studies usually include stratification across race or ethnicity; however these classifications are confounded by SES. Socio-economic systems in SA are varied; it is suggested that these systems contribute uniquely to the incidence of pediatric TBI in SA in comparison to developed countries (Levin, 2004).

As a result of unequal wealth distribution, higher incidence rates are reported for black individuals and minorities, than for other race groups internationally (Bruns & Hauser, 2003). SA shows a greater difference in race-specific incidence compared with other countries, due to extreme disparities in distribution of wealth. Typically, black and 'coloured' (mixed race) race groups in SA are of particularly low SES (De Villiers et al., 1984; Knobel et al., 1984). SA has a history of government enforced racial discrimination, emanating from the now abolished Apartheid regime that lead to extreme inequality in income and access to resources and social services. Distribution ratios of income and resources compared with whites was reported as 3.3:1 for Africans and 2.7:1 for Coloureds (Nell & Brown, 1991).

In summary low SES is associated with high rates of TBI, suggesting that the TBI incidence rate in SA, and other developing countries, should be higher than the incidence estimates in developed countries. Furthermore, the political history and resulting unequal wealth distribution in SA may have placed previously disadvantaged race groups, for example, black and coloured people, at a greater risk for TBI and may increase pTBI incidence in SA compared to other countries.

Summary & Conclusion

Epidemiological literature typically classifies TBI as a global problem, and even a sociological disaster (Semple et al., 1998). TBI is the leading cause of mortality and disability in children in both developed and developing countries. Limited recent local data has been published about the nature and severity of TBI in our immediate environment. Thus, such data is desperately needed to assess the outcome and severity of the problem.

Several epidemiological trends have been observed across developed and developing countries. TBI severity is typically skewed towards mild injuries, with smaller proportions of moderate and severe injuries. Males are more susceptible to TBI than females; falls are the leading cause of pTBI followed by MVAs and being struck by or against an object; and low SES is associated with increased rates of TBI.

RATIONALE FOR RESEARCH

Despite typically higher TBI incidence rates and other differences found in developing countries, there is far less literature emerging from developing areas than developed. Current epidemiological data for pTBI in SA are unavailable. Research in this area will broaden the scope of current epidemiological knowledge in SA and other developing areas.

The unique setting in SA leads us to expect different epidemiological findings from that found in developed countries (Levin, 2004). The proposed research will document the demographic profile of a South African sample of children who have sustained TBIs. The research will shed light on the scope of the problem of pTBI in SA and the extent to which pTBI findings in developed countries are applicable to developing countries such as SA.

The identification of etiological factors, and demographic profiles of individuals suffering TBI, will direct or inform pTBI preventive policy, administration and intervention strategies, and further research in SA by elucidating the kind of sample most in need of attention. By highlighting the avoidable causes of TBI, the data could inform preventative policy. Furthermore, the demographic profile can be used to tailor intervention strategies and research programs to the specific needs of pTBI patients in SA. The development and evaluation of such intervention strategies for children post-TBI will result in improved quality of life for the affected children and their families (Catroppa & Anderson, 2009).

Finally, the study will help to further advance pTBI research by helping future sample-based studies in Cape Town to obtain sufficient samples; information captured in the study can be used to form a database from which to draw future research participants.

SPECIFIC AIMS

The study aimed to describe the demographic profile of pTBI admissions at the RXH over a 2 year period. Specifically, trends in level of TBI severity, age, sex, aetiology, language, place of residence and monthly family income (MFI) were investigated. Proportions of pTBI aetiology and levels of pTBI severity were cross-tabulated with the variables of age, sex and SES. Subsequently, groups most at risk for sustaining pTBI were identified. The study further aimed to determine whether there are trends in the time of year when pTBI admissions are most common.

DESIGN AND METHOD

Design

A retrospective, descriptive, demographic profile study was conducted. A retrospective design allowed for data to be collected covering a longer time period (2 years) than would have been possible using a prospective design (approximately 3 months) due to the time constraints placed on the data capturing phase of the study. A longer data collection span typically increases the value of results obtained.

This study is part of a larger study that aims to report the demographic profile of pTBI admissions to RXH over a 5-year period. This study covers the periods from 1 January 2005 to 31 December 2005 and 1 February 2007 to 31 January 2008. The time period covered is not continuous owing to technical difficulties with the trauma database from which the researchers retrieved the necessary folder numbers to investigate.

Sample and Materials

Data was collected from the RXH trauma unit database and case folders of children admitted to the trauma unit at RXH from 1 January 2005 to 31 December 2005 and 1 February 2007 to 31 January 2008. These time periods will in future be referred to as 2005 and 2007, respectively. The RXH admits children up to 12 years of age; therefore, the study only included cases within the 0 to 12, age bracket. It was expected that the majority of children admitted for TBI would be from a low socio-economic background, as "the majority of [patients at the RXH] come from disadvantaged communities" (Children's Hospital Trust, 2008).

Trauma unit database. The RXH trauma unit treats all patients admitted to the hospital with an injury. Hospital administrative staff record the details of patients treated at the trauma unit in a Microsoft Access database. The cause code (a code pertaining to the cause of injury), date, name, age, sex, folder number and a comment describing the nature of accident (a short description of the event causing the trauma) and/or the nature of the injury (a short description of the anatomical region injured), are recorded.

Case folders. A case folder containing each patient's records is created for every patient treated at the RXH and stored at the Records Department at RXH. In addition to other important documents, the case folders include a trauma unit record form and an information sheet.

The trauma unit record form provides a full account of the cause and location of the accident; the anatomical region affected by, and pathology resulting from, the accident; the GCS score; and treatment provided for the injury; as well as information regarding the initial patient examination. The information sheet provides demographic information including the patient's parents'/guardians' details, place of residence, contact details and monthly family income (MFI). Sometimes the case folders are not fully completed, and one or more of the aforementioned patient details are omitted.

Finally, additional documents, including GCS scoring sheets, health records, clinical notes, referral letters, or notes from private practitioners, and other hospitals or other wards are also found in the case folders.

Procedure

The trauma unit database was used to identify possible pTBI cases. As the trauma unit database only provides limited data, the case folders of possible TBI patients were then reviewed to confirm whether individual cases were a result of TBI. Demographic data was recorded for confirmed TBI cases.

Identification of possible TBI cases from trauma database. All causes of injury that could potentially result in pTBI were searched for in the database (see Appendix D). Only new admissions, inter-hospital transfers and doctors' referrals were included. Patients returning for checkups or presenting with complications following discharge were excluded. The relevant patient details, including the cause code, date of admission, name, and folder number for all possible pTBI cases were recorded in a Microsoft Excel spreadsheet. The trauma unit database does not indicate whether a TBI is present, or provide information regarding language, level of TBI severity, place of residence and contact information. This information is documented in the individual case folders.

Once all possible pTBI cases had been identified from the trauma database and captured, the researchers examined the individual case folders to confirm whether the possible pTBI admissions were actually a result of TBI.

Confirmation of TBI cases using case folders. The trauma unit record form contains a more detailed description of the incident including type of accident, and the region and pathology of injury, from which the researchers could ascertain whether the injury was a TBI. The presence of TBI was further confirmed by the presence of a GCS/CCS score.

The GCS score was used to define TBI severity. Consistent with conventional criteria, a 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. The RXH the CCS score for children under 3 years of age. In such cases the CCS score out of 11 was converted to a score out of 15 by multiplying the score out of 11 by 1.364. Sometimes multiple GCS/CCS scores were available. In such cases the lowest GCS score within 24 hours post-injury was recorded.

Disconfirmed cases were removed from the Microsoft Excel spreadsheet of possible pTBI cases. Where available, additional data were included for the confirmed pTBI cases. The additional data included whether the TBI was open or closed, the GCS score, the patient's language, contact numbers, addresses, parents' or caregivers' names and MFI. In cases where data pertaining to a variable of interest was not present in the case folders, the variable was recorded as 'missing'.

Once data for TBI admissions at the RXH for 2005 and 2007 had been captured, the variables from the Microsoft Excel dataset were imported into STATISTICA (StatSoft, 2007) for analyses.

Statistical Analysis

Statistical analysis was conducted on the data to assess the demographic trends in pTBI admissions. Descriptive statistics for variables including age, sex, severity of injury, aetiology, language, area of residence, MFI, month of injury, and year of injury were reviewed.

Inferential statistics were then calculated; one-way analysis of variance (ANOVA) tests assessed whether there were statistically significant differences between the means of various pairs of continuous variables, and Pearson's Chi-square Goodness-of-fit tests explored whether the differences between the observed versus expected frequency scores for categorical variables were statistically significant. Statistical significance was indicated by a probability score of less than 0.05.

ETHICAL CONSIDERATIONS

The University of Cape Town Faculty of Health Sciences Ethics Review Committee granted approval for the study (Reference Number: 165/200, see Appendix E). The UCT Code of Ethics for Research was used as an ethical guide during the completion of this research. There were no foreseeable risks for physical, psychological or social harm for participants, as the retrospective data was collected from an existing computerized database, trauma registers, and archived medical records. The study required no direct contact with patients.

Consent for the use of the case folders had previously been granted. The parents or guardians of children admitted to the RXH are required to sign a form granting consent for their child's medical records to be used for research purposes.

Confidentiality was maintained. The data was stored on the personal computers of the researchers and will be exclusively available to those researchers involved in the larger study or studies directly connected to this research, for the means of recruiting participants. Patients' names are not mentioned in the research report.

RESULTS

Of the 4413 cases included in Microsoft Access database of children treated for injuries to the head area at the RXH trauma unit in 2005 and 2007, 3395 cases of possible TBI were identified by the current study. Of the possible pTBI cases, 2093 cases of pTBI were confirmed; 1017 cases were disconfirmed and a further 285 folders were in use by doctors or hospital staff, or missing, during the data capturing phase of the study.

Examination of the probability plots revealed that all one-way ANOVAs met the assumption of normality, whilst Levene's tests demonstrated that all one-way ANOVAs, with the exception of the analysis of age by sex, met the assumption of homogeneity of variance. However, ANOVA is relatively robust to violations of the homogeneity assumption, thus the results are reported for all analyses. Phi was reported as a measure of effect size for chi-square analyses; the large sample size justifies this application.

Analysis of Demographic Characteristics

Results for age. Analysis of descriptive statistics revealed that overall, younger children were more at risk for sustaining pTBI (M=4.48, SD=3.37). Incidence of pTBI was considerably higher in children between the ages of 0 and 4 (n=1189) than in the upper age ranges. Further, incidence tended to decrease as age increased; incidence in the 5-8 year age bracket (n=597) was lower than the 0-4 bracket, with the lowest incidence occurring in the 9-12 age range (n=307). The mean age for the 0-4 range was 1.98 (SD=1.37), while the mean for the 5-8 range was 6.40 (SD=1.10), and the mean for the 9-12 range was 10.40 (SD=1.19).

Results for sex. Of all cases, incidence of pTBI in males accounted for 64.17% (n=1343) and females 35.83% (n=750) for the 24 month period, equating to an M:F ratio of 1.79:1 (see Table 1 for a detailed summary of differences in demographic characteristics between males and females).

Table 1. Demographic Characteristics of the Sample by Sex

Variable	*Frequency (n)*	*Males (n=1343)*	*Females (n=750)*
Age			
0-4 Years	1189	62.91 (n=748)	37.09 (n=441)
5-8 Years	597	66.00% (n=394)	34.00% (n=203)
9-12 Years	307	65.47% (n=201)	34.53% (n=106)
Severity			
Mild	1896	63.82% (n=1210)	36.18% (n=686)
Moderate	90	68.89% (n=62)	31.11% (n=28)
Severe	54	70.73% (n=38)	29.27% (n=16)
Missing	53	62.26% (n=33)	37.74% (n=20)
Aetiology			
Fall	986	61.17% (n=603)	38.83% (n=383)
MVA Pedestrian	507	67.06% (n=340)	32.94% (n=167)
Struck By/Against	256	64.45% (n=165)	35.55% (n=91)
MVA Passenger	159	62.89% (n=100)	37.11 (n=59)
Assault	99	73.73% (n=73)	26.27% (n=26)
Other Transport Related	38	81.56 (n=31)	18.44% (n=7)
Miscellaneous	48	64.58% (n=31)	35.42% (n=17)
Language			
English	784	62.12% (n=487)	37.88% (n=297)
Afrikaans	560	68.75% (n=385)	31.25% (n=192)
Xhosa	583	63.12% (n=368)	36.78% (n=198)
Missing	152	61.84% (n=94)	39.16% (n=58)
Other	14	64.29% (n=9)	35.71% (n=5)

Results for aetiology. Analysis of the data by aetiology revealed that falls (47.11%) accounted for the greatest proportion of the overall incidence, followed my motor vehicle accidents involving a pedestrian (31.82%), being struck by or against an object (12.23%), motor vehicle accidents involving a passenger (7.60%), assault (4.7%), other transport related accidents (including motorcycle and bicycle accidents, 1.82%), and miscellaneous causes of injury (including being caught between objects, being injured by a sharp instrument, firearm, machinery, or unknown causes, 2.29%) respectively.

Crosstabulations between Age, Sex, Severity and Aetiology.

The differences observed between age at injury, for males compared with females, was not statistically significant, χ_2 (2, N = 2093) =1.91, $p = 0.384$. Similarly, there was no statistically significant difference between the categories for age, and severity of injury, $F(2, 2090) = 0.36$, $p = 0.697$. The incidence rate in males compared with females increased as pTBI severity increased, however this difference was nonsignificant, $F(1, 2091) = 0.378$, $p = 0.539$.

Further analysis revealed that the differences observed in incidence rates between various causes of injury compared with severity of injury were statistically significant, χ_2 (18, N = 2093) =70.89, $p<0.01$, although, this difference only explains a relatively small amount of variance, ø=.18.

The M:F ratio for mild pTBI was 1.76:1, increasing to 2.21:1 for moderate pTBI and 2.38:1 for severe pTBI. The mean age observed for cases of mild pTBI (4.94, SD=31.51), was lower than the mean age for moderate pTBI (5.85, SD=3.68), which in turn was very similar to the mean age for severe pTBI (5.83, SD=3.19).

Falls were the most frequently reported aetiology for mild injuries (n=929, 49.00%; see Table 2), followed by MVAs involving a pedestrian (n=426, 23.00%), and being struck by or against an object (n=234, 12.34%) respectively. MVAs involving a passenger accounted for the highest proportion of moderate (n=36, 40.00%) and severe injuries (n=26, 48.15%). Falls accounted for the subsequent most frequent aetiology in both moderate injuries (n=20, 22.22%) and severe injuries (n=17, 31.48%). Similar to mild injuries, MVAs involving a passenger represented the third most common aetiology in both moderate injuries (n=14, 15.56%) and (n=5, 9.26%) in severe injuries.

Table 2. Proportions of TBI Severity Crosstabulated with Aetiology

Severity of Injury	*Fall (n=986)*	*MVA Pedestrian (n=507)*	*Struck By/Against (n=256)*	*MVA Passenger (n=159)*	*Assault (n=99)*
Mild (n=1896)	94.22%	86.00%	91.41%	84.91%	86.87%
Moderate (n=90)	2.03%	7.10%	3.13%	8.81%	8.08%
Severe (n=54)	1.72%	1.78%	1.56%	3.14%	0.00%
Missing (n=53)	2.03%	1.78%	3.91%	3.14%	5.05%
Total (n=2093)	100%	100%	100%	100%	100%

Relative to other causes of injury, MVAs involving a passenger tended to have a more severe outcome; the proportions of moderate (n=14, 8.81%; see Table 2) and severe (n=5, 3.14%) injuries were higher relative to the proportions reported across the sample. Further, injuries caused by assault evidenced the second lowest proportion of mild injuries (n=86, 86.87%) relative to other aetiologies. Falls tended to have a less severe outcome, with mild injuries accounting for 94.22% (n=929) of incidence.

The differences reported between categories of aetiology and the sex of the patient were statistically significant, χ_2 (6, N = 2093) =14.81, p =0.022, with these differences accounting for a considerable proportion of variability, ø=84.13. Across etiologies, the number of cases observed for male patients was considerably higher than seen in female patients (see Table 1). Similarly, the differences evident between categories of aetiology and age groups were statistically significant, χ_2 (12, N = 2093) =112.86, p<0.01, although, the proportion of variance explained was much smaller for this analysis, ø=.23.

Additional Demographic Results

Area of residence. Pediatric TBI admissions to the RXH came from a relatively wide catchment area (n=128), although, incidence was more common in specific areas. The 10 areas of residence portrayed in Table 3 cumulatively account for 67.22% of all pTBI incidence.

The observed differences between categories of TBI severity and areas of residence were statistically significant, χ_2 (381, N = 2093) =530.21, p <0.01. These differences account for a relatively large amount of variance, ø = .50. Further analysis demonstrated that the difference in age groups across areas of residence was nonsignificant χ_2 (254, N = 2093) =291.24, p = 0.543.

Table 3. Frequencies of Aetiology by Area of Residence

Area of Residence	*Frequency (n)*	*Fall (n = 986)*	*MVA Pedestrian (n = 507)*	*Struck by/Against (n = 256)*	*MVA Passenger (n = 159)*	*Assault (n = 99)*
Mitchells Plain	(n = 385)	48.83%	21.56%	11.17%	8.13%	4.42%
Khayelitsha	(n = 224)	25.00%	45.01%	10.71%	10.27%	6.69%
Gatesville	(n=188)	59.04%	18.09%	10.64%	3.72%	5.32%
Athlone	(n = 145)	62.76%	8.97%	13.10%	5.52%	5.51%
Hanover Park	(n = 124)	64.45%	11.29%	16.13%	3.23%	2.42%
Gugulethu	(n = 110)	31.82%	40.91%	11.82%	4.55%	5.46%
Milnerton	(n = 65)	33.84%	44.62%	3.08%	4.61%	12.31%
Maitland	(n = 59)	57.63%	13.56%	16.95%	0.00%	6.78%
Nyanga	(n = 54)	29.63%	46.30%	11.11%	3.70%	3.70%
Langa	(n = 53)	47.17%	16.98%	15.09%	13.21%	3.77%

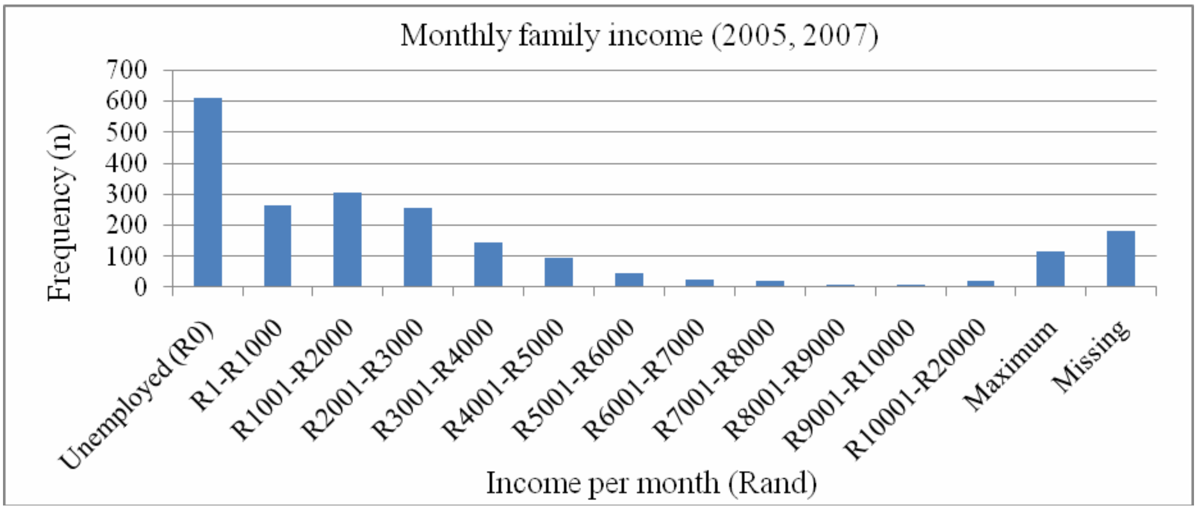
Differences in types of aetiology across areas of residence was also statistically significant, χ_2 (762, N = 2093) =991.45, p <0.01. A considerable amount of variance is explained by these differences, ø = .69. The results indicate that Khayelitsha, Gugulethu, Milnerton and Nyanga have disproportionately high rates of MVA pedestrian accidents (between 40.91% and 46.30%) compared to other areas of residence. Khayelitsha and Langa have disproportionately high rates of MVA passenger accidents (10.27% and 13.21% respectively). Gatesville, Athlone, Hanover Park and Maitland have the highest rates of falls (between 57.63% and 64.52%). Finally, assault accounts for a disproportionately high percentage (12.31%) of pTBI cases in Milnerton and Maitland (6.78%).

Language. The results show that English was the most frequently spoken language (n=784, 37.47%), followed by Afrikaans (n=583, 26.76%) and Xhosa (n=560, 26.85%) respectively. There was no statistically significant difference between language groups and age, χ_2 (10, N = 2093) =9.27, p = 0.507, or language groups and severity of injury χ_2 (30, N = 2093) =23.53, p = 0.793.

Monthly family income. Figure 1, below, illustrates a trend in MFI suggestive of a predominantly low socioeconomic status (M = R1772.26, SD = R2303.75). Of the 2093 recorded cases, 611 had no MFI, indicating an unemployment rate of 29.19% for the sample. Further, 52.78% of the families reported a monthly income of between R1 and R6000 (n=1108). Thus, including cases with no MFI, 81.97% (n=1719) of the sample reported a

MFI equal to or less than R6000. MFI higher than R6000 accounted for the remaining 18.30% of the sample. Finally, the greatest specified MFI was R19000.

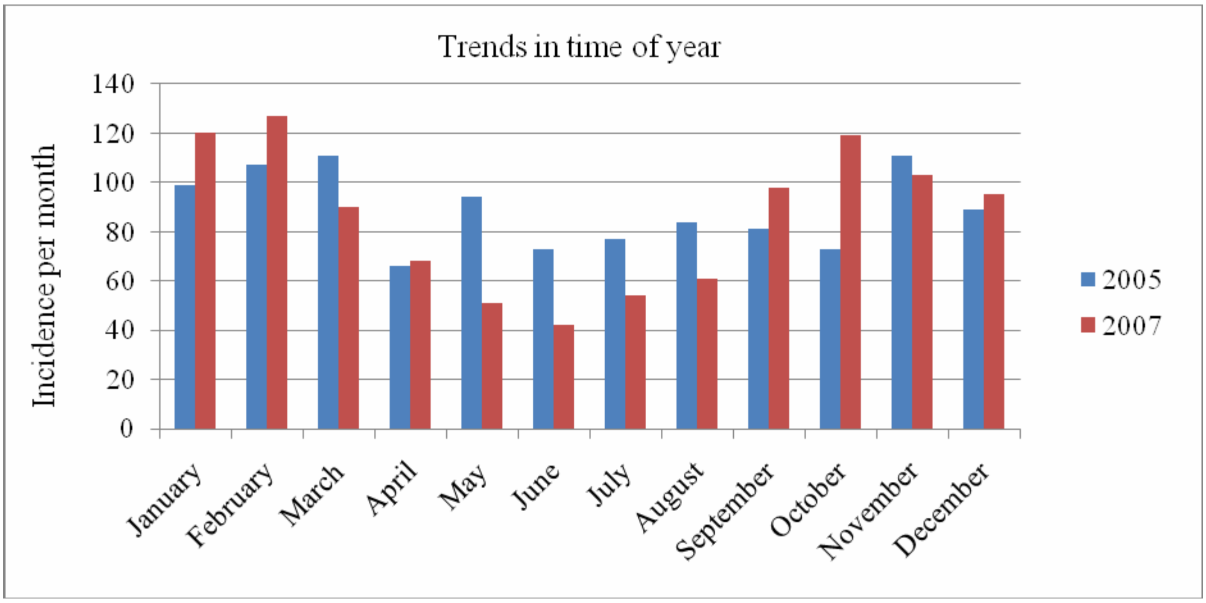
Figure 1. Monthly Family Income



Time of year. The mean incidence of pTBI admissions to the RXH per month was 87.21 cases (SD=23.16). An overall trend for higher rates of pTBI incidence at the beginning and end of both years emerged (see Figure 2). The months with the highest incidence rate for 2005 were March (n=111), November (n=111), and February (n=107), while the highest incidence rates in 2007 occurred in February (n=127), January (n=120), and October (n=119). Conversely, the lowest incidence rates for 2005 were seen in April (n=66), June (n=73), and October (n=73), with June (n=42), May (n=51), and July (n=54) accounting for the lowest incidence in 2007. Furthermore, the disparity in frequency of pTBI incidence across the months tended to be considerably greater in 2007 than 2005. These differences in incidence rates per month across both years were statistically significant, χ_2 (11, N = 2093) =97.53994, $p<0.01$.

Further analysis revealed that the differences reported between the various months when the injury occurred and the severity of the injury were not statistically significant, χ_2 (33, N = 2093) =44.33, $p = 0.090$. Similarly, observed difference between month of injury and type of aetiology was not significant, χ_2 (66, N = 2093) =62.08, $p = 0.614$.

Figure 2. Monthly Rates of Incidence, 2005, 2007



Analysis by Year of Injury

The mean age for the total incidence in 2005 (M=5.03, SD=3.22) was similar to the mean for total incidence in 2007 (M=4.93, SD=3.14). Further, descriptive statistics demonstrated very little variation across the age groups for 2005 and 2007 (see Table 4). Similarly, there was little variation in levels of pTBI severity across both years.

Table 4. Demographic Characteristics by Year, 2005, 2007

Variable	*2005 (n=1028)*	*2007 (n=1028)*
Age		
0-4 Years	49.03% (n=583)	51.97% (n=606)
5-8 Years	51.42% (n=307)	48.58% (n=290)
9-12 Years	57.00% (175)	43.00% (n=132)
Sex		
Male	49.96% (n=671)	50.04% (n=672)
Female	52.53% (n=394)	47.47% (n=356)
Severity		
Mild	51.05% (n=968)	48.95% (n=928)
Moderate	42.22% (n=38)	57.78% (n=52)
Severe	50.00% (n=27)	50.00% (n=27)
Aetiology		
Falls	50.30% (n=496)	49.70% (n=490)
MVA Pedestrian	45.17% (n=229)	54.83% (n=278)
Struck by/Against	53.90% (n=138)	46.10% (n=118)
MVA Passenger	49.69% (n=79)	51.31% (n=80)
Assault	45.45% (n=45)	54.55% (n=54)

The M:F ratio increased from 1.70:1 in 2005 to 1.89:1 in 2007, although the difference in incidence of pTBI in males and females across the 2 years was not statistically significant, χ^2 (1, N = 2093) =1.27, p =0.260. Further, the frequency of incidence by aetiology showed very little variation across 2005 and 2007. Incidence of MVAs involving a pedestrian, and assaults, increased slightly from 2005 to 2007. The incidence for being struck by or against an object decreased slightly from 2005 to 2007, while all other aetiologies remained reasonably stable across the two years.

DISCUSSION

Statistical analyses of admissions to the RXH revealed that younger children were more at risk for sustaining pTBI than older children were. Incidence of pTBI was highest in the 0-4 age group. Trends in admissions also showed that males were more likely to sustain pTBI than females were. Further, the incidence of pTBI was consistently higher in males, relative to females, admitted to the trauma unit across all children between the ages of 0-12.

The distribution observed in levels of pTBI severity was largely skewed toward mild injuries, with moderate and severe injuries accounting for comparatively small proportions of incidence. Further, moderate injuries accounted for a larger proportion of incidence than severe injuries. There was no statistically significant difference between distribution of mild, moderate, and severe injuries observed between males and females. Further, no statistical significance was found for differences by age and severity of injury. This is potentially attributable to the relatively small number of observations for moderate and severe pTBI.

Falls represented the most common aetiology, followed by MVAs involving a pedestrian, being struck by or against an object, MVAs involving a passenger, and assaults respectively. To a degree, aetiology proved to be an indicator of level of severity. MVAs involving passengers, and assaults, were associated with more severe outcomes than other aetiologies, while falls and being struck by or against and object were typically associated with more mild outcomes.

Trends in MFI, while not an empirical measure of SES, indicated that the majority of the sample would most probably be categorised as low SES. Descriptive analysis demonstrated that considerably higher rates of pTBI incidence were observed in various specific areas within Cape Town. Finally, the most frequently spoken languages were English, Afrikaans, and Xhosa respectively.

The results revealed that the number of admissions to the RXH for patients sustaining TBI was similar in 2005 and 2007. There were no statistically significant differences between the reported M:F ratios, the mean age across all age groups, or proportions of pTBI severity across 2005 and 2007. Finally, monthly rates of pTBI admissions fluctuated within 2005 and 2007, across both years however, the differences observed in incidence of pTBI by time of year were similar across both years.

In summation, investigation of demographic characteristics, and trends in incidence of pTBI in a South African sample, supports the notion that pTBI is a public health problem and social concern in SA. Consequently, there is an urgent need to reduce the incidence of pTBI through the development and improvement of prevention and intervention strategies (Lalloo & van As, 2004). The trends observed in this study could potentially inform such strategies.

Comparison with International Trends

Similar to the reported results, research emanating from developed countries typically identifies younger children as a higher risk group for sustaining pTBI, relative to older children (Bruns Jr. & Hauser, 2003; see Table 5). Specifically, children aged four years and younger constitute the highest risk group for such injuries. Previous research at the RXH found that children younger than 5 years of age accounted for approximately half the sample (Lalloo & van As, 2004). These finding are also congruent with the observations made in the recent pilot study of admissions to RXH following pTBI (Christ, 2007).

The results from this study with regard to sex differences were in line with most international trends, with males being more susceptible to pTBI than females (see Table 5). Similar M:F ratios were reported in both developed and developing contexts, further supporting the idea that M:F ratios are homogenous across developed and developing contexts. The M:F incidence ratio evidenced across studies typically ranges from 1.4:1 to 3:1 (Engberg & Teasdale, 1998; Raja et al., 2001).

Nell and Brown (1991) reported a greater difference between incidence in males and females (4:1) for an adult population in Johannesburg. This M:F ratio was considerably higher than the ratio observed in the current study (1.79:1). This finding, however, may not be generalizable to a pediatric population. Similar results were evidenced in a pediatric population in India (M:F ratio = 1.5:1), which may provide a better basis for comparison of sex differences.

The disparity in incidence across sex may be attributable to the fact that male children are often more active than female children. In the present study, the greatest difference in M:F ratio was evidenced in the 5-8 year age group. Children at this age are generally more active than younger children, but may lack competence in motor coordination, for example; balance and strength, associated with typical development in older children.

The distribution of pTBI severity was aligned with the proportions reported in both developed and developing contexts, although this distribution for the current sample more closely represented the proportions seen in developing countries. The proportion of mild (relative to moderate and severe) was greater in the present study, compared to that found for pediatric populations across Europe, and for a general population in the US (Hawley, et al., 2003; Bruns Jr. & Hauser, 2003). The proportions evidenced in a sample-based study in Brazil were similar to the current study.

These results may suggest that mild injuries typically account for a greater proportion of pTBI incidence in developing countries (Tabish et al., 2006). This could be due to a higher mortality rate for more severe cases in developing contexts. A large number of these cases may result in death at the scene of the accident, due to poor or sparse medical facilities, and inadequate resources.

Interestingly, the difference observed between the level of pTBI severity in males compared with females was not statistically significant. This lack of significance may be due to the small rate of incidence observed for moderate and severe injuries, compared to mild injuries. Finally, level of pTBI severity is often associated with aetiology (Hawley et al., 2003).

The trends in developed and developing countries indicate that falls are typically the leading cause of pTBI, followed by MVAs. This trend was observed in the US, UK, and Yemen, as well as the current study (Bruns Jr. & Hauser, 2003; Hawley et al., 2003; Tabish et al., 2006; see Table 5). Further, younger children (0-5 years) are generally more susceptible to TBIs as a result of falls, while older children (10-15 years) are more susceptible to pTBI caused by MVAs (Hawley, et al., 2003).

Corresponding with the literature, the results further indicate that younger children (0-8years) are more susceptible to TBI as a result of falls while older children (9-12years) are more susceptible to TBI as a result of MVAs involving a pedestrian (Hawley et al., 2003). While other studies have found this trend peaks by approximately 9 years of age (Tabish et al., 2006; Kibel, Bass & Cywes, 1990).

MVAs accounted for a greater proportion of pTBI incidence in the present sample. This result was also seen in a previous study at the RXH (Semple, Bass & Peter, 1998). This could be attributed to the fact that SA has one of the highest national MVA rates worldwide

(Levin, 2004). This high proportion of MVAs, in particular MVAs involving a pedestrian, presents a major cause for concern for SA, as they are associated with more severe injuries.

These results could inform intervention strategies targeted specifically at relevant higher risk groups; for example, road safety education campaigns (for both children pedestrians, and drivers), enforcement of reduced speed limits, more stringent seatbelt legislation (particularly in the public transport sector), and increasing safety measures at pedestrian crossings. To this end, intervention strategies targeted at reducing MVAs involving pedestrians have proved to be effective (Retting, Ferguson & McCartt, 2003).

The most commonly reported areas of residence for pTBI patients (see Table 3) are traditionally associated with low SES. Risk factors for sustaining pTBI may be enhanced in low SES communities; for example, poor community resources, lack of recreational facilities, poor lighting, and the absence of pavements all contribute to this risk. Trends in MFI further support the assumption that patients in the current sample were predominantly from lower SES backgrounds.

The rate of unemployment for the present sample was relatively high (29.11%, see Figure 1), compared to the current national unemployment rate (23.60% in the second quarter of 2009, StatisticsSA). Low income groups may be overrepresented in this sample, as high income groups may better afford the private sector healthcare fees, which are comparatively higher than those in the public healthcare sector, including the RXH (Kibel, Bass & Cywes, 1990).

Further, determining the accuracy of results for MFI is problematic. Coding in the case folders compromised the interpretation of MFI in the upper income brackets; in some cases where the MFI exceeded R6000, the case was coded as 'maximum', while in other cases the actual MFI was indicated. Additionally, information for MFI was based on data disclosed by the patient's guardian, which also poses a further challenge in assessing the accuracy of MFI data. Despite these challenges, it is expected that children treated at the RXH come from low SES backgrounds (Children's Hospital Trust, 2008).

Poor coding of demographic information in the case folders presented a further problem in the analysis of language. As such, English may be overrepresented in the sample, because the patient demographic information sheet does not stipulate whether English is the patient's home language, or if the patient is merely able to speak the language, the latter of which is more relevant to neuropsychological interventions.

Language is an important consideration for the treatment and management of neuropsychological sequelae following pTBI. Therefore, researchers could consider translating assessment and rehabilitation tools into the languages most frequently spoken by pTBI patients. Further, these tests and tools could be adapted, where necessary, to ensure that they are also culturally relevant.

Analysis of trends in the time of year (that is, the month) when injury occurred revealed a seasonal trend, with the highest observed incidence occurring at the beginning and end of the year, across both years investigated (see Figure 2). A statistically significant reduction was seen in the frequency of pTBI incidence in the winter months. Higher pTBI incidence in the summer months may reflect risks associated with increased time spent playing outdoors; for example, falls from playground equipment and other heights, and MVAs involving pedestrians.

Recommendations for Future Research

A prospective study is proposed for future demographic or epidemiological research on pTBI. A prospective design offers three distinct advantages over the retrospective design used in this study. Firstly, a prospective design would allow for the use of a broader case definition of TBI. Future researchers could possibly employ a case definition that uses a combination of measures of LOC, PTA, as well as the GCS. Secondly, a prospective design would allow for greater control by the researchers over the coding of the data used (for example, more accurate measures of SES could be obtained).

Thirdly, a prospective design would enable the researchers to establish a pTBI incidence rate for Cape Town. This design would also allow for data to be collected from more than 1 hospital in Cape Town; such results would be more representative of the sample-based population of Cape Town. Thus, the findings could be more generalizable to the broader population of SA. Finally, the results demonstrated in the current study will be more generalizable to the Cape Town population on completion of the 5-year study.

CONCLUSION

Epidemiological literature unanimously indicated that TBI presents a dire sociological and public health problem internationally. This problem extends to pTBI in particular; these injuries represent the primary cause of mortality and neuropsychological morbidity in children across both developing and developed contexts. The current research illuminates both the lack of recent local epidemiological or demographic information pertaining to the nature and severity of pTBI, and the critical need for intervention. Thus, the current research attempts to address these issues by establishing a demographic profile of patients with pTBI admitted to the RXH.

The demographic profile identified the fundamental trends associated with age, sex, level of severity, aetiology, area of residence, MFI, language, and time of year. Observed trends evidenced characteristics in common with epidemiological research emerging from both developed, and other developing countries, however, the results reported tended to be more congruent with those of developed countries.

Finally, these findings could constitute a basis for intervention and prevention strategies, and public policy administration. Prevention strategies may help reduce the extent of the epidemic, and avoid the devastating consequences associated with sustaining pTBI. Further, intervention strategies could aid in the rehabilitation and recovery of patients following pTBI.

REFERENCES

Andersson, E. H., Björklund, R., Emanuelson, I. & Stålhammar, D. (2003). Epidemiology of traumatic brain injury: a population based study in western Sweden. *Acta Neurologica Scandinavica, 107,* 256-259.

Annoni, J.M., Beer, S., Kesselring, J. (1992). Severe traumatic brain injury–epidemiology and outcome after 3 years. *Disability Rehabilitation, 14,* 23-26.

Basso, A., Previgiliano, I., Duarte, J. M. & Ferrari, N. (2001). Advances in management of neurosurgical trauma in different continents. *World Journal of Surgery, 25,* 1174-1178.

Bauer, R. & Fritz, H. (2004). Pathophysiology of traumatic injury in the developing brain: an introduction and short update. *Experimental and Toxicological Pathology, 56,* 65-73.

Bowman, S., Bird, T. M., Aitken, M. E. & Tilford, J. M. (2008). Trends in hospitalisations associated with pediatric traumatic brain injuries. *Pediatrics, 122,* 988-993.

Brown, D. S. O. & Nell, V (1992). Recovery from diffuse traumatic brain injury in Johannesburg: a concurrent prospective study. *Archives of Physical Medicine and rehabilitation, 73,* 758-770.

Bruns Jr., J & Hauser, W. (2003). The epidemiology of traumatic brain injury: a review. *Epilepsia, 44,* 2-10.

Carroll, L. J., Cassidy, J. D., Holm, L., Kraus, J. & Coronado, V. G. (2004). Methodological issues and research recommendations for mild traumatic brain injury: the WHO collaborating center task force on mild traumatic brain injury. *Journal of Rehabilitative Medicine, 43,* 113-125.

Catroppa, C. & Anderson, V. (2009). Subject Review: Traumatic brain injury in childhood: rehabilitation considerations. *Developmental Neurorehabilitation, 12,* 53-61.

Christ, B. (2007). *The demographic profile of pediatric traumatic brain injury in Cape Town.* Unpublished honours thesis, University of Cape Town, South Africa.

Children's Hospital Trust. (2008). 12 October 2008, Popular Gun Run set to help the hospital. Retrieved May 18, 2009, from http://www.childrenshospitaltrust.org.za/event/3085/popular-gun-run

Cywes, S., Kibel, S. M., Bass, D. H., Rode, H., Millar, A. J. W. & De Wet, J. (1990). Review article: pediatric trauma care. *South African Medical Journal, 78,* 413-418.

De Andrade A., Marino R., Ciquini O., Figueiredo E., & Machado A. (2001). Guidelines for neurosurgical trauma in Brazil. *World Journal of Surgery*, 25, 1186-1201.

Engberg, A. & Teasdale, T. W. (1998). Traumatic brain injury in children: a national 15-year study. *European Journal of Epidemiology, 14,* 165-173.

Engberg, A. & Teasdale, T. W. (2001). Traumatic brain injury in Denmark 1979-96. A national study of incidence and mortality. *European Journal of Epidemiology, 17,* 437-442.

Finfer, S. R. & Cohen, J. (2001). Severe traumatic brain injury. *Resuscitation, 48,* 77-90.

Gururaj, G. (2002) Epidemiology of traumatic brain injuries: Indian scenario. *Neurological Research, 24*, 24-28.

Hawley, C. A., Ward, A. B., Long, J., Owen, D. W. & Magnay, A. R. (2003). Prevalence of traumatic brain injury amongst children admitted to hospital in one health district: a population based study. *International Journal of the Care of the Injured, 34,* 256-260.

Hiller, S.L., Hiller, J.E., & Metzer, J. (1997) Epidemiology of traumatic brain injury in South Austrailia. *Brain Injury, 11,* 649-659.

Holm, L., Cassidy, J. D., Carroll, L. J. & Borg, J. L. (2005). Summary of the WHO collaborating centre for neurotrauma task force on mild traumatic brain injury. *Journal of Rehabilitative Medicine, 37,* 137-141.

Hyder, A. A., Wunderlich, C. A. , Puvanachandra, P., Gururaj, G., & Kobusingye, O. C. (2007). The impact of traumatic brain injuries: a global perspective. *Neurorehabilitation, 22,* 341-353.

Kibel, S.M., Bass, D.H. & Cywes, S. (1990). Five years' experience of injured children. *South African Medical Journal, 78,* 387-391.

Kibel, S. M., Bradshaw, D. & Joubert, G. (1990). *Injury-related deaths in South African children*. Unpublished medical reports, Child Safety Centre, Red Cross War Memorial Children's Hospital & UCT, Cape Town.

Kleiven, S., Pelos, P.M., & von Holst, H. (2003). The epidemiology of head injuries in Seden from 1987 to 2000. *Inj Control Saf Promot, 10,* 173-180

Knobel, G. J., De Villiers, J. C., Parry, C. D. H. & Botha J. L (1984). The causes of non-natural deaths in children over a 15 year period in greater Cape Town. *South African Medical Journal, 66,* 795-801.

Lalloo, R. & van As, A. B. (2004). Profile of children with head injuries treated at the trauma unit of Red Cross War Memorial Children's Hospital, 1991-2001. *South African Medical Journal, 94,* 544-546.

Laureys, S., Majerus, S. & Moonen, G (2002). Assessing consciousness in critically ill patients. *Yearbook of Intensive Care and Emergency Medicine, 2002,* 715-727.

Levi, L., Linn, S., Revach, M., & Feinsod, M. (1990). Head trauma in northern Israel: incidence and types. *Neuroepidemiology, 9*, 278-284.

Levin, K. (2004). Pediatric traumatic brain injury in South Africa: some thoughts and considerations. *Disability and Rehabilitation, 26,* 306-314.

Maegele, M., Engel, D., Bouillon, B., Lefering, R., Fach, H., Raum, M. et al. (2007). Incidence and outcome of traumatic brain injury in an urban area in Western Europe over 10 years. *European Surgical Research, 39*, 372-379.

Malec, J. F., Brown, A. W., Leibson, C. L., Flaada, J. T., Mandrekar, J. N., Diehl, N. N. & Perkins, P. K. (2007). The Mayo classification system for traumatic brain injury severity. *Journal of Neurotrauma, 24,* 1417-1424.

Masson, F., Thicoipe, M., Mokni, T., Aye, P., Erny, P. & Dabadie, P. (2003). Epidemiology of traumatic comas: a prospective population-based study. *Brain Injury, 17,* 279-293.

Murgio A., Fernández M. J., Manolio A., Maurel D., Ubeda C. (1999). Minor head injury at pediatric age in Argentina. *Journal of Neurosurgical Sci*ence,43,15-23.

Nell, V. & Brown, D. S. O. (1991). Epidemiology of traumatic brain injury in Johannesburg–II. morbidity, mortality and aetiology. *Social Science Medicine, 33,* 289-296.

Perkin R.M., Swift J.D., Newton, D.A. (2003). Pediatric Hospital Medicine: Textbook of ... Philadelphia: Lippincott Williams & Wilkins, chapter 48.

Pfenniger, J., and Santi, A. (2002). Severe traumatic brain injury in children–are the results improving? *Swiss Medical Weekly, 132,* 116-120.

Raimondi, A.J. Hirschauer, J. (1984). Head injury in the infant and todler. Coma scoring and outcome scale. *Childs Brain, 12,* 13.

Raja, I. A., Vohra, A. H. & Ahmed, H. M. (2001). Neurotrauma in Pakistan. *World Journal of Surgery, 25,* 1230-1237.

Retting, R.A., Ferguson, S.A., and McCartt. A.T. (2003). A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes. *American Journal of Public Health*, 93, 1456-63.

Rutland-Brown, W., Langlois, J., Thomas, K. & Xi, Y. (2006). Incidence of traumatic brain injury in the United States, 2003. *Journal of Head Trauma Rehabilitation, 21,* 544-548.

StatSoft, Inc. (2007). STATISTICA version 8. Tulsa, OK.

StatisticsSA (2009) P0211 - Quarterly Labour Force Survey (QLFS), 2nd Quarter 2009 Retrieved October 18, 2009, from http://www.statssa.gov.za/keyindicators/keyindicators.asp.

Simpson, D., Cockington, R., Hanieh, A., Raftos, J. & Reilly, P. (1991) Head injuries in infants and young children: the value of the Pediatric Coma Scale. *Child's Nervous System, 7,* 183-190.

Semple, P. L., Bass, D. H., & Peter, J. C. (1998). Severe head injury in children–a preventable but forgotten epidemic. *South African Medical Journal, 88,* 440-444.

Tabish, A., Lone, N. A., Afzal, W. M., & Salam, A. (2006). The incidence and severity of injury in children hospitalized for traumatic brain injury in Kashmir. *International Journal of the Care of the Injured, 37*, 410-415.

Tagliaferri, F., Compagnone, C., Korsie, M., Servadei F., & Kraus, J. (2005). A systematic reveiw of brain injury epidemiology in Europe. *Acta Neurochirururgica*, 148, 255-268.

Teasdale, G. & Jennett, B. (1974). Assessment of coma and impaired consciousness. *The Lancet, 2,* 81-84.

Vazquez-Barquero, A., Vazquez-Barquero, J.L., Austin, O., Pascual, J., GAite, L., & Herrera, S. et al., 1992 (1992) The epidemiology of head injury in Cantabria. *European Journal Epidemiology, 8,* 832-837.

APPENDIX A

Glasgow Coma Scale[a]

Score	*Response*
Eye Opening	
4	Opens eyes spontaneously
3	Opens eyes in response to speech
2	Opens eyes in response to painful stimulation
1	Does not open eyes in response to any stimulation
Motor Response	
6	Follows commands
5	Makes localized movement in response to painful stimulation
4	Makes non-purposeful movement in response to noxious stimulation
3	Flexes upper extremities in response to pain
2	Extends all extremities in response to pain
1	Makes no response to noxious stimuli
Verbal Response	
5	Is oriented to person, place, and time
4	Converses, may be confused
3	Replies with inappropriate words
2	Makes incomprehensible sounds
1	Makes no response

[a]Teasdale & Jennett, 1974

APPENDIX B

Pediatric Glasgow Coma Scale

Score	*Response*	*Response*	*Response*
Eye Opening	> 1 year	0-1 year	
4	Opens spontaneously		
3	Opens to a verbal command		
2	Opens in response to pain		
1	No response	No response	
Verbal Response	> 5 years	2-5 years	0-23 months
5	Oriented and able to converse	Uses appropriate words	Cries appropriately
4	Disoriented and able to converse	Uses inappropriate words	Cries
3	Uses inappropriate words	Cries and/or screams	Cries and/or screams inappropriately
2	Makes incomprehensible sounds	Grunts	Grunts
1	No response	No response	No response
Motor Response	> 1 year	0-1 year	
6	Obeys command	Spontaneous	
5	Localizes pain	Localizes pain	
4	Flexion withdrawal	Flexion withdrawal	
3	Flexion abnormal (decorticate)	Flexion abnormal (decorticate)	
2	Extension (decerebrate)	Extension (decerebrate)	
1	No response	No response	

APPENDIX C

Children' Coma Scale[a]

Score	*Sign*
Ocular response	
4	Pursuit
3	Extraocular movement in tact; pupils react appropriately
2	Fixed pupils or extraocular; movement impaired
1	Fixed pupils and extraocular; movement paralyzed
Verbal response	
3	Cries
2	Spontaneous Respiration
1	Apneic
Motor response	
4	Flexes and extends
3	Withdraws from painful stimuli
2	Hypertonic
1	Flaccid
Best total Score	
11	

[a] Raimondi & Hirschauer, 1984

APPENDIX D

Trauma Database Cause Codes

Cause Codes
Transport
01–MVA pedestrian
02–MVA Passenger–unrestrained
03–MVA Passenger–restrained
04 - MVA passenger–Bakkie/Minibus
05–Cycle
06–Motor-cycle
07–Other
Assault
10–Blunt
11–Sharp
12–Rape/ sexual assault
14–Other
Fall
30–Off bed
31–Stairs/steps
32–Attendants arms
33–Playground equipment
34–Mobiles
35–Other heights
36 - On level
Struck By/Against
40–Struck by/against another object
Miscellaneous
41–Caught between objects
42–Sharp instrument
43–Firearm
44–Machinery
51–Other Cause
99 - Unknown

APPENDIX E

Ethics Approval

UNIVERSITY OF CAPE TOWN

Health Sciences Faculty
Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
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18 March 2009

REC REF: 165/2007

Ms L Schrieff
Psychology

Dear Ms **Schrieff**

PROJECT TITLE: THE IMPLEMENTATION AND EVALUATION OF A PAEDIATRIC NEUROPSYCHOLOGICAL REHABILITATION SERVICE FOLLOWING TRAUMATIC BRAIN INJURY

Thank you for your letter to the Research Ethics Committee dated 16 March 2009.

It is a pleasure to inform you that the Ethics Committee has **granted approval to** extend the study for a further 12 months until 31st March 2010.

The amendment to include the following two students in this study is approved: Jessica Miller and Aimee Stander.

Please submit an annual progress report if the research continues beyond the expiry date. Please submit a brief summary of findings if you complete the study within the approval period so that we can close our file.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, HSF HUMAN ETHICS

lcmjedi