Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 2006 - 2011

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Background. Paediatric traumatic brain injury (PTBI) is a major public health problem. However, recent epidemiological data for PTBI in South Africa (SA) are lacking.
Objectives. To establish a demographic profile of severe PTBI admissions to the Red Cross War Memorial Children's Hospital (RCWMCH) over a 5-year period, by investigating trends in annual admissions, age, sex, language, time and day of injury, and aetiology.
Methods. This retrospective, descriptive, quantitative study included children admitted to the RCWMCH with severe traumatic brain injury (TBI) between June 2006 and April 2011, who required intracranial monitoring. We used the Division of Paediatric Neurosurgery's TBI database to identify cases for inclusion in the study and to gather demographic and injury information.
Results. Descriptive statistics suggested that: (*i*) the number of annual admissions did not vary substantially across the study period; (*ii*) the peak admission age was 6 years; (*iii*) more boys than girls were admitted; (*iv*) the major mechanism of injury was pedestrian road traffic accidents; and (*v*) most injuries occurred on weekends. These results are discussed against the backdrop of international research on PTBI and reflect the extent to which epidemiological findings on TBI in high-income countries compare with those from low- and middle-income countries such as SA.
Conclusion. The identification of aetiological factors and the description of demographic profiles of children sustaining TBI constitutes a basis for preventative policy administration and intervention strategies in SA.

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Traumatic brain injury (TBI) is a global public health problem. There are, however, differences in the ways that TBI is experienced and managed across different countries. For instance, incidence rates for paediatric TBI (PTBI) are generally higher in sub-Saharan Africa, and in low- and middle-income countries (LAMICs), than in high-income countries.[1] In South Africa (SA), one of the major reasons for a high incidence of PTBI is that the country has one of the highest motor vehicle accident (MVA) rates in the world.[2] As a result, there are increased rates of TBI-related morbidity and mortality, associated with more severe direct diffuse axonal injury, and an elevated probability of polytrauma. Infrastructural deficiencies in pre- and in-hospital healthcare, and other resource limitations, compound the problem.

There are few published studies regarding the epidemiology of PTBI in SA. One such study has been published approximately every 6 - 8 years since 1984, with the most recent covering a period of 10 years, up to and including 2001.[3-6] Only one of those studies focused specifically on children who had sustained severe head injuries.[6] Regular studies are required to keep healthcare professionals, researchers and policymakers well informed about the problem of TBI, so that prevention and treatment efforts can be directed properly.[7,8]

Objectives

This retrospective, descriptive, quantitative study sought to provide an update on trends in PTBI-related hospital admissions in SA. Specifically, we profiled the demographic characteristics of children who were admitted between June 2006 and April 2011 with severe TBI to the Red Cross War Memorial Children's Hospital (RCWMCH) and who required intracranial monitoring for intracranial pressure and brain oxygenation. Based on previous local and international studies,[5,6,9-15] we expected that the following trends would hold: most TBIs would be classified as closed rather than open; more boys than girls would be admitted; MVAs would constitute the primary mechanism of injury; and injury aetiology would vary as a function of age (e.g. falls would be a prominent cause of injury among very young children, whereas MVAs would be a prominent cause of injury among older children).

Methods

Study sample

At the RCWMCH, the triage system includes initial admission to a general trauma ward before referral to specialist units, including the intensive care unit. The Division of Paediatric Neurosurgery maintains an electronic record of all patients with severe TBI who require intracranial monitoring.

Included in the study sample were: (*i*) children who received intracranial monitoring for severe TBI (defined as a post-resuscitation Glasgow Coma Scale (GCS)[16] score of ≤8, or whose scores deteriorated to this level soon after admission); and (*ii*) children who were admitted to the RCWMCH between July 2006 and April 2011. Patients who presented with a GCS score of 2T/15, fixed dilated pupils, and a 'black brain' on head computed tomography (CT) scan were excluded; these patients were considered brain dead on arrival or soon thereafter.

The University of Cape Town's Faculty of Health Sciences Research Ethics Committee approved this study (ref. 166/2009). This study forms part of a larger prospective observational study of PTBI.

Data collection

We obtained information from two sources, namely the Division of Paediatric Neurosurgery's TBI patient database and the RCWMCH patient case records:

- **The Division of Paediatric Neurosurgery's patient database** includes demographic and neurosurgical data for TBI patients. We extracted the following information: age, sex, mechanism of injury, post-resuscitation GCS score, time and date of injury, nature of injury (blunt v. penetrating), and mortality.
- Following the hospital admission protocol, **a case folder** containing the patient's records is created for every patient treated at the RCWMCH. These are stored at the Records Department. Case folders include a trauma unit record form (which provides details about the accident and injury) and an information sheet (which includes personal demographic details about the patient and his/her parents/guardians).

Statistical analysis

We used SPSS version 20 to conduct descriptive analyses of trends in admission related to the following variables: nature of injury, mortality rate, number of admissions annually, age, sex, home language, time and day of injury, and mechanism of injury.

Results

The study included 137 children. The mortality rate was 14.6% (20/137). In the group of 117 survivors, 110 (94.02%) of the TBIs were classified as closed/blunt and 6 (5.13%) as open/penetrating; data were missing for one participant.

Annual admissions

Fig. 1 presents, for the entire study period disaggregated by year, the number of children who were admitted to the RCWMCH for severe TBI and who met the inclusion criteria listed above. Because the data for 2006 and 2011 do not cover the entire year, the years 2007 - 2010 represent the most complete datasets and are therefore a fairer reflection of annual trends. These data suggest that the number of annual admissions did not vary substantially over the study period.

Age

Fig. 2 displays the number of children admitted at each age from 0 to 15 years. The peaks in admissions by age occurred at 4, 6, 7 and 10 years.

The RCWMCH typically admits children up until the age of 12 years, with older children being referred to Groote Schuur Hospital (GSH). The two 14-year-olds therefore represent true outliers.

Sex

There were more males (n=89; 64.96%) than females (n=48; 35.04%) in the sample. This ratio held constant across all five years studied, with the exception of 2009, when an equal number of boys and girls were admitted. The ratio also held constant for all ages, except for 3- and 10-year-olds (Fig. 3).

Language

Hospital folders for deceased patients were not accessible at the time of data collection. Hence, we collected data regarding home language for survivors only. Reflecting the demographics of the Western Cape,[17] most of the children and their families had either Afrikaans (n=41; 35.04%), English (n=37; 31.60%) or isiXhosa (n=34; 29.06%) as a home language. One family's home language was Sesotho. Four sets of data were missing.

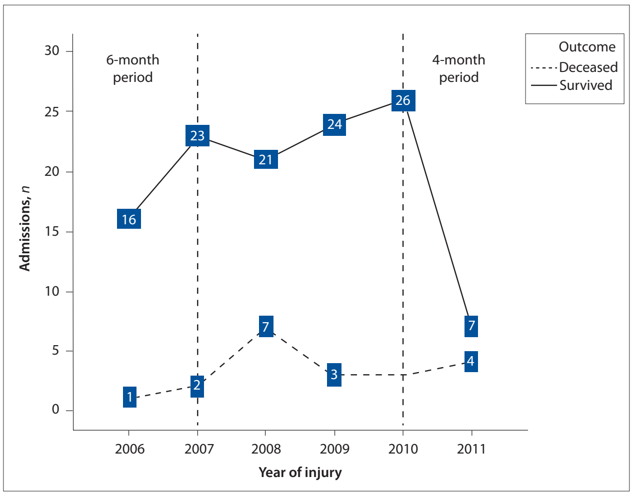

Fig. 1. Number of admissions per year for survivors (n=117) and non-survivors (n=20). Months covered in 2006 are April to December, and in 2011 are January to June.

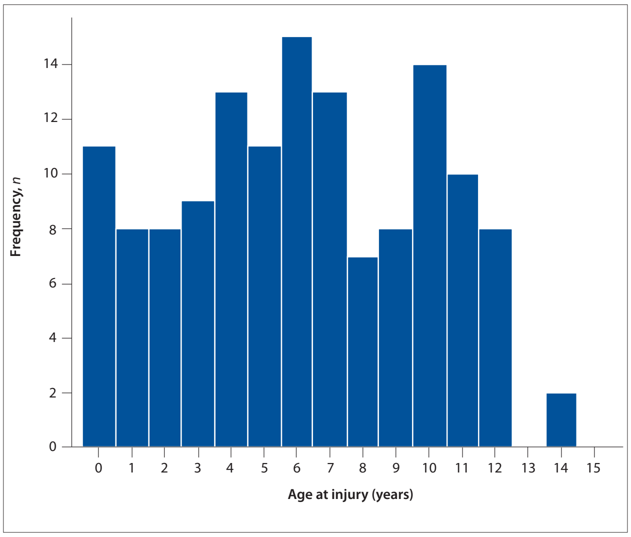

Fig. 2. Number of admissions for each year of age (0 - 15 years). For the entire sample (N=137), mean age was 6.14 years (SD ±3.88; range 0 - 14.75).

Time and day of injury

Fig. 4 displays a cross-tabulation of the time of injury by the day of the week. Most injuries occurred on Saturdays and Sundays from 12 noon to 5 pm or from 5 pm to 8 pm.

Mechanism of injury

As detailed in Table 1, most injuries occurred as a result of pedestrian-related MVAs, followed by passenger-related MVAs. Other mechanisms accounted for 20.44% (28/137) of TBIs.

The proportion of injuries relative to the total number of children in each of the three main age groups (0 - 4, 5 - 8, and 9 - 12 years) suggested that older children were more prone to injuries as a result of MVAs (and pedestrian-related MVAs, in particular).

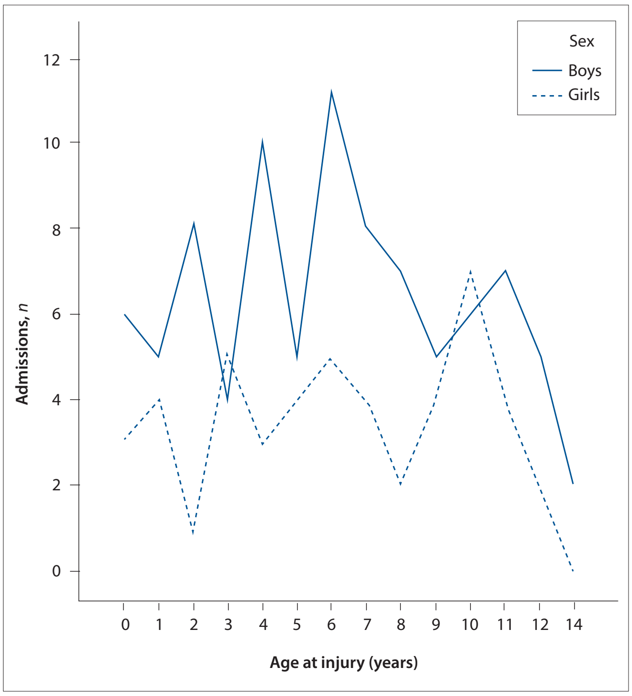

Fig. 3. Number of admissions, for boys and girls, disaggregated by age (N=137). Note: The two 14-year-olds are true outliers; they should not have been admitted to the RCWMCH because, typically, individuals older than 12 years are treated at GSH.

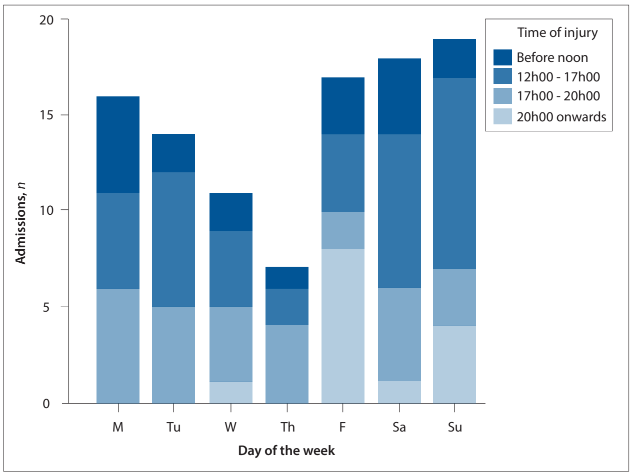

Fig. 4. Time of day and day of the week when most injuries occurred (N=137).

Fig. 5 shows that the proportion of boys injured as pedestrians in MVAs was almost double that of girls. There were no other significant between-sex differences with regard to mechanism of injury.

Discussion

PTBI is a global public health problem of major significance, and is associated with high mortality in children and adolescents.[18,19] One widely cited study reported that only 65% of children who sustain severe TBIs survive.[20]

In the current sample, the mortality rate was 14.6% (20/137). This represents an improvement over that presented by Semple *et al.*[6] (57%; 58/102), who studied a 4-year sample of children admitted to the RCWMCH following severe TBI. Such wide variation in TBI-related mortality statistics across studies is not unique to SA[11,12] and is probably associated with variation in sample characteristics (e.g. varying age range, varying inclusion criteria related to injury severity). However, the substantial difference between mortality rates in this study and in that by Semple *et al.*,[6] which represented outcomes at the RCWMCH in the early 1990s, holds, even if one accounts for the inclusion or exclusion of severely injured patients who presented with brain death. Furthermore, the current study did not include patients who did not require intracranial monitoring, a group that has a much better prognosis.

Hence, although severe PTBI in SA continues to be associated with a significant number of deaths, the results reported here are promising in that they suggest a downward trend in mortality rates for children admitted with severe TBI to the RCWMCH. This trend may be multifactorial in origin, but probably relates to the more aggressive approach to medical and surgical management given that no other factors are known to have changed since the publication of previous studies using samples drawn from the RCWMCH.

In the current sample, boys were 1.86 times more likely than girls to sustain a severe PTBI. This finding is consistent with the long-established trend that TBIs occur more frequently in males than in females.[9,21,22] For instance, Berry *et al.*[10] and Parslow *et al.*[12] reported likelihood ratios of 2 and 2.02, respectively, for similar age groups as studied here. This sex-based vulnerability might be attributable to the relatively rash behavioural tendencies of boys.[11,23]

Regarding language, knowing the mother-tongue languages of individuals admitted following TBI is key for neuropsychological assessment and intervention – important steps in the overall care of these children. Hence, the current results, which showed that only 31% of the sample had English as a first language, can be used to inform future studies that include assessment and/or intervention arms. Of particular concern is that many neuropsychological test batteries originate in countries where English is the dominant language. Hence, SA PTBI studies will be limited in the scope of assessment, in sample size, and in generalisability if efforts are not made to translate assessment measures into other official languages of the country, and to then validate and normalise these measures for, among others, different age, socioeconomic and clinical groups.

Most injuries occurred during the afternoon (12 noon - 5 pm) or early evening (5 pm - 8 pm) when children are returning home and engaging in extramural play. This finding is consistent with previous studies.[4,12] Furthermore, most injuries occurred on weekends. Consistent with this finding, Knobel *et al.* [24] reported that most deaths in their study occurred following injury on Saturdays and Sundays; because these are non school-going days, they allow for more activity and for more exposure of children to potentially dangerous environmental settings and events.

The pattern of injuries reported here regarding pedestrian- and passenger-related MVAs is consistent with global and national trends.[1,2,22] Previous SA TBI studies reported that pedestrian-related MVAs were a major cause of injury and death.[3,5,24] Semple *et al.*[6] reported that pedestrian-related MVAs accounted for 83% (85/102) of injuries in their RCWMCH sample. Although the same mechanism of injury accounted for only 54.74% (75/137) of injuries in the current sample, it cannot be concluded that this apparent decline is a direct result of more effective injury-prevention efforts employed in recent years; several other factors might account for the observed between-study discrepancies. For example, we might be observing random variation due to a small sample size, or we might be observing a relative increase in the frequency of other mechanisms of injury; in their sample, Semple *et al.*[6] reported that passenger-related MVAs, bicycle accidents and assaults accounted, together, for <6% (6/102) of injuries. In contrast, in the current sample passenger-related MVAs accounted for 21.17% (29/137) of injuries. Regardless, the overall morbidity and mortality rate related to MVAs remains

Table 1. Mechanism of injury disaggregated by age group (*N*=137)

Mechanism of injury	Age group (years) *n* (%) 0 - 4	5 - 8	9 - 12	13 - 15	Total *n* (%)
MVA					
Pedestrian	22 (44.9)	26 (56.52)	26 (65)	1 (50)	75 (54.74)
Passenger	11 (22.45)	11 (23.91)	7 (17.5)	0 (0)	29 (21.17)
Other	0 (0)	1 (2.17)	4 (10)	0 (0)	5 (3.65)
Fall	5 (10.2)	2 (4.35)	0 (0)	0 (0)	7 (5.11)
Struck by/against an object	0 (0)	1 (2.17)	0 (0)	1 (50)	2 (1.46)
Crush injury	2 (4.08)	1 (2.17)	0 (0)	0 (0)	3 (2.19)
Non-accidental injury	4 (8.16)	0 (0)	0 (0)	0 (0)	4 (2.92)
Gunshot wound	3 (6.12)	0 (0)	1 (2.5)	0 (0)	4 (2.92)
Stab wound	1 (2.04)	0 (0)	1 (2.5)	0 (0)	2 (1.46)
Assault	0 (0)	1 (2.17)	0 (0)	0 (0)	1 (0.73)
Missing data	1 (2.04)	3 (6.52)	1 (2.50)	0 (0)	5 (3.65)
Total, *N*	49	46	40	2	137

MVA = motor vehicle accident.

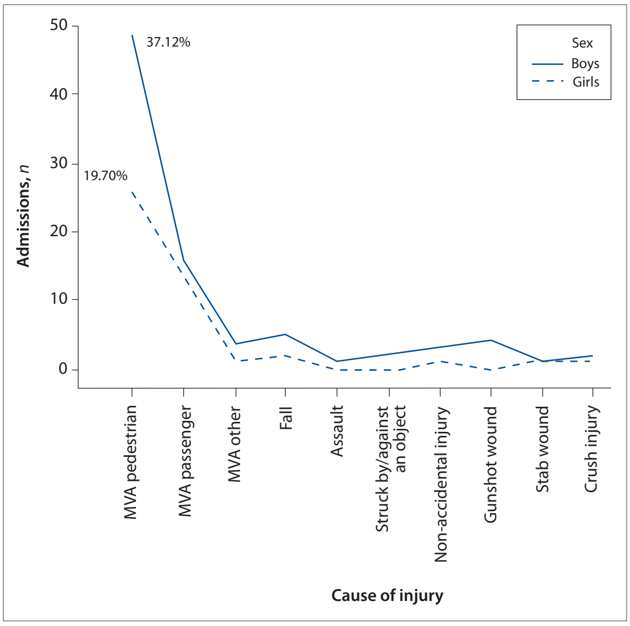

Fig. 5. Variation in mechanism of injury by sex (N=137).

concerning and intervention to mitigate this public health problem remains urgent.

Falls were not the leading cause of injury in the 0 - 4-year-old age group, as might have been expected according to some previously published studies.[25,26] Those studies were, however, conducted in countries where a relatively high proportion of the population lives in high-density housing consisting of apartments above the ground floor; this is not the case in SA. Furthermore, falls accounted for only 5.11% (7/137) of TBIs in this sample, which is similar to other published data (for severe TBI).[11] It appears, generally, that falls may be a leading cause of injury in samples of children with mild-to-moderate rather than severe TBI.[4] One explanation for this disparity is that MVAs often lead to diffuse axonal injury and severe, or even fatal, outcomes. Falls more commonly lead to focal insults because of translational forces,[27] with relatively better outcomes than those associated with MVAs.

Regarding variation in mechanism of injury by age, the trend noted here (*viz.* that older children are more prone to injuries as a result of pedestrian-related MVAs) is consistent with findings reported both locally and internationally.[8,11] Reasons for this trend might be that older children are likely: (*i*) to spend a large amount of their extramural time outdoors, in the absence of suitable recreational areas; and (*ii*) to travel to school without adequate adult supervision.[7,28]

Study limitations

The most notable study limitation is that these data are not completely representative of PTBI outcome following admission to the RCWMCH: patients who did not require intracranial monitoring were not included in the database and so were not sampled. However, those who do not require such monitoring tend to have less severe injuries; therefore, we suggest that our data on trends in mortality are reasonably accurate.

Another limitation of the current study is that we adopted a retrospective, cross-sectional design and did not include any long-term follow-up data. A third limitation is that we did not include information on multiple TBIs in our analyses. Previous research shows that sustaining a TBI increases one's vulnerability to future TBIs, with a cumulative effect in terms of risk.[29]

Conclusion

TBI requires careful epidemiological study because it accounts for the majority of injury-related deaths, and the vast majority of long-term morbidity in trauma survivors. The purpose of this study was to present a snapshot of the demographic profile of children who had experienced severe TBI and who were subsequently admitted to, and received intracranial monitoring at the RCWMCH. Our results showed a pattern of continuity with those reported by previous SA PTBI research: the number of annual admissions did not vary substantially across the study period; the peak admission age was 6 years; more boys than girls were admitted; the major mechanism of injury was pedestrian road traffic accidents; and most injuries occurred on weekends.

The World Health Organization projects that by 2020 the number of deaths and disabilities attributed to TBI will have increased substantially.[1] This forecast might be modified by advances in technology and more aggressive medical management of severe TBI. However, such advances may not be accessible to all, particularly in light of the high prevalence of TBI in lower socioeconomic status contexts. Improved protocols for care are needed urgently and they require generalisation across all centres.

The most accessible and implementable approach to ameliorating this global public health epidemic remains prevention. Any TBI-prevention strategy relies on current information about admissions, aetiological trends and outcomes.[7,29] SA prevention efforts should focus, broadly, on educating the high-risk subgroups we have identified (e.g. boys, regardless of age) and on limiting the number of pedestrian-related MVAs. Prevention strategies should also take into account that most TBIs occur over weekends, during the evening and afternoon. Key actions are active awareness-building campaigns and dissemination of road-safety information. Without funding for such efforts, TBI, and in particular PTBI, will remain 'a neglected disease of modern society'.[30]

Although the data presented here offer only a glimpse into the extent of this public health problem, this study contributes to the global and local epidemiological literature on PTBI. Given the magnitude of the PTBI problem and the poor associated outcomes in LAMICs, it is essential that larger and more sophisticated epidemiological studies (e.g. those employing prospective longitudinal designs) are conducted in these countries.

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References

1. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: A global perspective. NeuroRehabilitation 2007;22(5):341-353.
2. Levin K. Paediatric traumatic brain injury in South Africa: Some thoughts and considerations. Disabil Rehabil 2004;26(5):306-314. [http://dx.doi.org/10.1080/0963828032000174089]
3. De Villiers JC, Jacobs M, Parry CDH, Botha JL. A retrospective study of head-injured children admitted to two hospitals in Cape Town. S Afr Med J 1984;66(21):801-805.
4. Kibel SM, Bass DH, Cywes S. Five years' experience of injured children. S Afr Med J 1990;78(7):387-391.
5. Lalloo R, van As AB. Profile of children with head injuries treated at the trauma unit of Red Cross War Memorial Children's Hospital, 1991 - 2001. S Afr Med J 2004;94(7):544-556.
6. Semple PL, Bass DH, Peter JC. Severe head injury in children – a preventable but forgotten epidemic. S Afr Med J 1998;88(4):440-444.
7. Peacock WJ. Head injuries in children. S Afr Med J 1984;66(21):789-790.
8. Brysiewicz P. Pedestrian road traffic collisions in South Africa. Accid Emerg Nurs 2001;9(3):194-197. [http://dx.doi.org/10.1054/aaen.2001.0261]
9. Anderson V, Northam E, Hendy J, Wrennall J. Developmental neuropsychology: A clinical approach. Hove: Psychology Press, 2001.
10. Berry JG, Jamieson LM, Harrison JE. Head and traumatic brain injuries among Australian children, July 2000-June 2006. Inj Prev 2010;16(3):198-202. [http://dx.doi.org/10.1136/ip.2009.022442]
11. Tsai W, Chui W, Chiou H, Choy C, Hung C, Tsai S. Pediatric traumatic brain injuries in Taiwan: An 8-year study. J Clin Neurosci 2004;11(2):126-129. [http://dx.doi.org/10.1016/S0967-5868(03)00156-5]
12. Parslow R, Morris K, Tasker R, Forsyth R, Hawley C; on behalf of the UK Paediatric Traumatic Brain Injury Study Steering Group and the Paediatric Intensive Care Society Study Group. Epidemiology of traumatic brain injury in children receiving intensive care in the UK. Arch Dis Child 2005;90(11):1182-1187. [http://dx.doi.org/10.1136/adc.2005.072405]
13. Conner KA, Williams LE, McKenzie LB, Shields BJ, Fernandez SA, Smith GA. Pediatric pedestrian injuries and associated hospital resource utilization in the United States, 2003. J Trauma 2010;68(6):1406-1412. [http://dx.doi.org/10.1097/TA.0b013e3181b28b05]
14. Hawley CA, Ward AB, Long J, Owen DW, Magnay AR. Prevalence of traumatic brain injury amongst children admitted to hospital in one health district: A population-based study. Injury 2003;34(4):256-260. [http://dx.doi.org/10.1016/S0020-1383(02)00193-6]
15. Tabish A, Lone N, Afzal W, Salam A. The incidence and severity of injury in children hospitalised for traumatic brain injury in Kashmir. Injury 2006;37(5):410-415. [http://dx.doi.org/10.1016/j.injury.2006.01.039]
16. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. Lancet 1974;304(7872):81-84. [http://dx.doi.org/10.1016/S0140-6736(74)91639-0]
17. Statistics South Africa. South African Statistics, 2012. Pretoria: Statistics South Africa 2012. http://www.statssa.gov.za/publications/SAStatistics/SAStatistics2012.pdf (accessed 07 June 2013).
18. Tilford JM, Aitken ME, Anand KJS, et al. Hospitalizations for critically ill children with traumatic brain injuries: A longitudinal analysis. Crit Care Med 2005;33(9):2074-2781. [http://dx.doi.org/10.1097/01.CCM.0000171839.65687.F5]
19. Tude Melo JR, Di Rocco F, Blanot S, et al. Mortality in children with severe head trauma: Predictive factors and proposal for a new predictive scale. Neurosurgery 2010;67(6):1542-1547. [http://dx.doi.org/10.1227/NEU.0b013e3181fa7049]
20. Berger MS, Pitts LH, Lovely M, Edwards MS, Bartkowski HM. Outcome from severe head injury in children and adolescents. J Neurosurg 1985;62(2):194-199. [http://dx.doi.org/10.3171/jns.1985.62.2.0194]
21. Abelson-Mitchell N. Epidemiology and prevention of head injuries: Literature review. J Clin Nurs 2008;17(1):46-57. [http://dx.doi.org/10.1111/j.1365-2702.2007.01941.x]
22. Bruns J, Hauser WA. The epidemiology of traumatic brain injury: A review. Epilepsia 2003;44(S10):2-10. [http://dx.doi.org/10.1046/j.1528-1157.44.s10.3.x]
23. Venter P. Children in traffic: Vulnerable road users. Trauma Emerg Med 2000;17(1):10, 12.
24. Knobel GJ, de Villiers JC, Parry CDH, Botha JL. The causes of non-natural deaths in children over a 15-year period in greater Cape Town. S Afr Med J 1984;66(21):795-801.
25. Eisele JA, Kegler SR, Trent RB, Coronado VG. Nonfatal traumatic brain injury-related hospitalization in very young children-15 states, 1999. J Head Trauma Rehabil 2006;21(6):537-543. [http://dx.doi.org/10.1097/00001199-200611000-00008]
26. Langlois JA, Rutland-Brown W, Thomas KE. Traumatic Brain Injury in the United States. Emergency Department Visits, Hospitalizations, and Deaths. Atlanta: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, 2004.
27. Wetherington CE, Hooper SR. Preschool traumatic brain injury: A review for the early childhood special educator. Exceptionality 2006;14(3):155-170. [http://dx.doi.org/10.1207/s15327035ex1403_4]
28. Jamison DL, Kaye HH. Accidental head injury in childhood. Arch Dis Child 1974;49(5):376-381. [http://dx.doi.org/10.1136/adc.49.5.376]
29. McKinlay A, Grace RC, Horwood LJ, Fergusson DM, Ridder EM, MacFarlane MR. Prevalence of traumatic brain injury among children, adolescents and young adults: Prospective evidence from a birth cohort. Brain Inj 2008;22(2):175-181. [http://dx.doi.org/10.1080/02699050801888824]
30. Cywes S. The neglected disease of modern society and the Child Accident Prevention Foundation of Southern Africa. S Afr Med J 1990;78(7):381-382.

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