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Title: Prevalence of Traumatic Brain Injury Amongst Children Admitted to Hospital in one Health District : A Population-based Study

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Abstract

There is a dearth of information regarding the prevalence of brain injury, serious enough to require hospital admission, amongst children in the United Kingdom. In North Staffordshire a register of all children admitted with traumatic brain injury (TBI) has been maintained since 1992 presenting an opportunity to investigate the incidence of TBI within the region in terms of age, cause of injury, injury severity and social deprivation. The register contains details of 1553 children with TBI, two thirds of whom are male. This population-based study shows that TBI is most prevalent amongst children from families living in more deprived areas, however, social deprivation was not related to the cause of injury. Each year, 280 per 100,000 children are admitted for ≥24 hours with a TBI, of these 232 will have a mild brain injury, 25 moderate, 17 severe, and 2 will die. The incidence of moderate and severe injuries is higher than previous estimates. Children under 2 years old account for 18.5% of all TBIs, usually due to falls, being dropped or non-accidental injuries. Falls account for 60% of TBIs in the under 5s. In the 10-15 age group road traffic accidents were the most common cause (185, 36.7%). These findings will help to plan health services and target accident prevention initiatives more accurately.

Introduction

Traumatic brain injury (TBI) is a major health problem and the most common cause of death or disability in childhood.[1] There are no accurate figures available for the prevalence of TBI amongst children, although the British Society for Rehabilitation Medicine (BSRM) has estimated an incidence of 300 per 100,000 population for all age groups, suggesting that for young children the incidence may be up to four times higher.[2] It has also been estimated that in the UK approximately 150,000 children under fourteen attend hospital every year with a TBI.[3] More recently it has been argued that these figures are likely to be an underestimate because of inadequate recording.[4]

Following a serious TBI it is likely that there will be intellectual, academic and personality adjustment problems.[5-8] Furthermore, even mild brain injuries can lead to cognitive and behavioural deficits.[9,10] In North Staffordshire a unique register of all children admitted with TBI has been maintained continuously since 1992 presenting an opportunity to accurately establish the incidence of TBI leading to hospital admission within a region with a relatively stable population.

Participants and Methods

Participants were all children admitted for 24 hours or more to North Staffordshire Hospitals NHS Trust with a TBI. The Brain Injury Register (BIR) was maintained by a brain injury nurse who liaised with the Trauma Centre and wards to identify all children admitted with a brain injury and to gather information on age, sex, injury cause, Glasgow Coma Scale (GCS)[11] scores (where recorded) and duration of loss of consciousness. Injury severity was established using the British Society of Rehabilitation Medicine classification of severity.[2] *Minor* brain injury: an injury causing unconsciousness for 15 minutes or less, and a GCS after initial resuscitation of 13 to 15. *Moderate* brain injury: an injury causing unconsciousness for more than 15 minutes and a GCS after initial resuscitation of 9 to 12. *Severe* brain injury: an injury causing unconsciousness for more than 6 hours or more and/or GCS after initial resuscitation of 3 to 8.

Social deprivation was measured using Townsend scores [12] which were calculated using postcodes.

Results

From 1/11/92 to 31/12/98 1,553 children aged 0-15 years were admitted for at least 24 hours following a TBI. Two thirds were male (999, 64.3%). The age groups most frequently admitted were 1 year olds (173, 11.1%), <1 year olds (114, 7.3%), and 7 year olds (111, 7.1%), with an average of 88.9

children in each of the other age groups (mean age = 6.76, SD = 4.6). Table 1 gives details.

Table 1 about here

Cause of injury

The causes of injury are shown in table 2. The most frequent causes were falls (701, 45.1%), and road traffic accidents (RTAs) (328, 21.1%), often as a pedestrian (198, 12.7%). There were clear differences in the causes of injury for different age groups with more falls amongst younger children and more RTAs amongst older children. Being dropped was the cause of brain injury for 30% of babies under one year old. It is possible that some of these may have been non-accidental injuries.

Table 2 about here

Pattern of admissions

The number of admissions per year were fairly evenly spread between 1993 to 1997 with a mean of 264 per year. Table 3 gives details. 1996 saw the highest number of admissions, at 292. After 1996 the number of admissions has declined with the 1998 figure being the lowest when only 206 children were admitted. It is too early to conclude that there is a downward trend in the incidence of TBI, but it may be that recently introduced traffic calming schemes and improved road safety advice is leading to a reduction in childhood accidents. Table 4 shows the cause of injury by calendar year. There was little fluctuation in the incidence of most causes of injury between the years, and no statistically significant variations. Falls remain the most frequent cause, accounting for approximately 45% of all childhood injuries annually. The percentage number of assaults increased steadily up until 1997, when assault accounted for 7.9% (21) of TBIs. The number of children banging their heads on objects also increased up until 1997. The number of cyclists involved in RTAs fell slightly over the years.

Admissions were fairly evenly distributed throughout each calendar year and are shown in figure 1, with the lowest incidence in December (88, 5.7%) and January (90, 5.8%), and the highest in May (165, 10.6%), July (150, 9.7%), August (158, 10.2%) and October (156, 10%) which coincide with school holidays.

Table 3 about here
Figure 1 about here

Social deprivation and traumatic brain injury

Townsend deprivation scores were calculated for the1,517 participants with valid postcodes. The lower the negative score the more prosperous an area, the higher the positive score the more deprived. The mean value was +1.12 (SD = 2.85), compared to the national average of zero. Over two thirds of

families lived in areas with positive scores (68.2%). Using the cut-off values identified by North Staffordshire Health Authority [13], 16% of families lived in affluent areas (scores of –2.4 to –6.0), and 11.4% of families lived in considerably deprived areas (scores of +3.55 to +8.62). Figure 2 illustrates the spread of deprivation scores with a strong bias towards positive scores.

Figure 2 about here

All causes of injury were compared for children living in areas with positive (more deprived) Townsend scores, and children living in areas with negative (more prosperous) Townsend scores. No significant differences were found between the groups. In particular, we examined those causes of injury which might be expected to occur more frequently amongst children living in areas of greater social deprivation. These causes were pedestrians involved in road traffic accidents (RTAs); cyclists involved in RTAs; non-accidental injuries (NAIs); assaults; and being dropped. A slightly higher proportion of children in the more deprived group were injured as pedestrians in RTAs (136, 13.3%, compared to 56, 11.6%, children in the more prosperous group), and more children in the deprived group had been dropped, usually by a parent (43, 4.2%, compared to 12, 2.5%, in the more prosperous group). However, a slightly higher proportion of children in the more prosperous group were injured in assaults (22, 4.6%, compared to 39, 3.8%, in the more deprived group). There were no differences between the groups for TBIs caused by NAIs (more deprived = 16, 1.5%, more prosperous = 9, 1.9%) or as cyclists in RTAs (more deprived = 36, 3.5%, and more prosperous = 15, 3.1%).

Severity of injury

GCS scores were recorded for 745 (48%). GCS scores were frequently not recorded for younger children (405 (70.6%) of the 574 children aged under 5 years did not have a GCS score). Using GCS and/or length of unconsciousness 1,284 children (82.7%) had a mild TBI, 141 (9.1%) moderate, 95 (6.1%) severe, 13 (0.8%) died, and 20 (1.3%) were of unknown severity.

The 1991 Census showed the number of residents within North Staffordshire Health Authority to be 459,181. Within this population, 90,479 (19.8%) were children aged ≤15 years.[13] The BIR shows that each year, on average, 254 children under 16 are admitted with a TBI (SD = 1.65), representing 0.28% of the population, the equivalent of 280 children/100,000 with a TBI serious enough for hospital admission. Of these 232 will have a mild injury, 25 moderate, 17 severe, and 2 will die. These figures are higher than previous estimates of the annual incidence of serious paediatric TBI of 18 moderate/100,000 and 8 severe/100,000. [2].

1,381 patients were registered with 359 different general practitioners (GPs) from 236 GP practices. Over the 6 year study period, 34 individual GPs had

≥10 children with a TBI on their list (mean = 15, SD = 6.81), 1 in 10 of these children had suffered a moderate or severe TBI.

Conclusions

A register of all children admitted to one health district with a traumatic brain injury (TBI) has been maintained continuously since 1992 which enabled us to establish the prevalence, severity, and cause of injury for children aged between 0 and 15 years. This is the first large-scale population-based study of children admitted to hospital with a brain injury to be carried out in the UK. Results showed that annually 280 children/100,000 population require hospitalisation for 24 hours or more. Mild TBI accounts for 82.7% of admissions. The incidence of moderate and severe TBIs was higher than expected from previous estimates. Two thirds of children with TBI came from families living in relatively deprived areas. However, levels of social deprivation had no effect on the causes of the TBI. Falls account for 60% of TBI admissions amongst the under 5s, and non accidental injuries account for 8.7% of TBI admissions for under 2s. Advice on the prevention of falls should be aimed at parents of children aged ≤2 years, and road safety advice aimed at children aged over 2 years and their parents.

Each year approximately 15% of children admitted with TBI will have a moderate or severe brain injury. Such children are likely to suffer long lasting cognitive and behavioural sequelae and may require specialist help. The burden on individual GPs is low. However, GPs in large practices are likely to see one child with a moderate or severe brain injury over a six year period and these children and their parents may need considerable support and advice.

Given the significant numbers of children requiring hospital admission following a brain injury there is a need for future studies to evaluate outcomes in order to assess the impact of brain injury amongst children in terms of cognitive, behavioural, educational performance and employment prospects. The study team have begun to address this need by embarking upon a postal follow-up survey of the families on the register.

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Contributors: All authors participated in the writing of the paper. CAH developed the study, analysed the data and interpreted the results. ABW had the idea of the brain injury register and created the post of brain injury nurse. JL was the brain injury nurse responsible for maintaining the BIR

and collecting the data. DWO calculated the deprivation indices. CAH is guarantor for the paper.

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Competing interests: None

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Table 1 Age at time of injury

AGE	NUMBER	PERCENT
Under 1	114	7.3
1	173	11.1
2	99	6.4
3	95	6.1
4	93	6.0
5	99	6.4
6	96	6.2
7	111	7.1
8	84	5.4
9	85	5.5
10	89	5.7
11	99	6.4
12	97	6.2
13	89	5.7
14	68	4.4
15	62	4.0
Total	1553	100

Table 2: Cause of Brain Injury by Age

	AGE (YEARS)					
Cause of Injury	**Under 1 (n=114) No. (%)**	**1 (n=173) No. (%)**	**2-4 (n=287) No. (%)**	**5-9 (n=475) No. (%)**	**10-15 (n=504) No. (%)**	**ALL (n=1553) No. (%)**
Fall	49 (43)	120 (69.4)	180 (62.7)	210 (44.2)	142 (28.2)	701 (45.1)
Fall from bicycle	0	1 (0.6)	6 (2.1)	50 (10.5)	32 (6.3)	89 (5.7)
Fall from horse	0	0	0	5 (1.1)	14 (2.8)	19 (1.2)
RTA pedestrian	0	0	34 (11.8)	63 (13.3)	101 (20)	198 (12.7)
RTA passenger	1 (0.9)	3 (1.7)	11 (3.8)	16 (3.4)	23 (4.6)	54 (3.5)
RTA cyclist	0	0	0	22 (4.6)	31 (6.2)	53 (3.4)
RTA other	1 (0.9)	0	2 (0.7)	4 (0.8)	16 (3.2)	23 (1.5)
Object	11 (9.6)	22 (12.7)	32 (11.1)	59 (12.4)	58 (11.5)	182 (11.7)
Assault	0	0	2 (0.7)	13 (2.7)	40 (7.9)	55 (3.5)
Non accidental*	10 (8.8)	15 (8.7)	5 (1.7)	1 (0.2)	3 (0.6)	34 (2.2)
Dropped	34 (29.8)	7 (4)	6 (2.1)	3 (0.6)	1 (0.2)	51 (3.3)
Sport	0	0	1 (0.3)	14 (2.9)	27 (5.4)	42 (2.7)
Unknown	7 (6.1)	4 (2.3)	6 (2.1)	9 (1.9)	13 (2.6)	39 (2.5)
Other	1 (0.9	1 (0.6)	2 (0.7)	6 (1.3)	3 (0.6)	13 (0.8)
Total	114 (100)	173 (100)	287 (100)	475 (100)	504 (100)	1553 (100)

*recorded non accidental injuries, this may be an underestimate

Table 3: Number of TBI admissions per full calendar year

YEAR	No. of Admissions	Percent
1993	250	16.4
1994	238	15.6
1995	274	18.0
1996	292	19.1
1997	266	17.4
1998	206	13.5
Total	1526	100

Table 4 Cause of brain injury by calendar year

Cause of Injury	1993 (n=250) No. (%)	1994 (n=238) No. (%)	1995 (n=274) No. (%)	1996 (n=292) No. (%)	1997 (n=266) No. (%)	1998 (n=206) No. (%)
Fall	111 (44.4)	102 (42.9)	132 (48.2)	120 (41.1)	130 (48.9)	92 (44.7)
Fall from bicycle	15 (6)	10 (4.2)	12 (4.4)	26 (8.9)	12 (4.5)	14 (6.8)
Fall from horse	2 (0.8)	2 (0.8)	4 (1.5)	9 (3.1)	1 (0.4)	1 (0.5)
RTA pedestrian	35 (14)	37 (15.5)	29 (10.6)	38 (13)	26 (9.8)	26 (12.6)
RTA passenger	9 (3.6)	7 (2.9)	14 (5.1)	11 (3.8)	5 (1.9)	8 (3.9)
RTA cyclist	11 (4.4)	12 (5)	11 (4)	8 (2.7)	8 (3)	2 (1)
RTA other	5 (2)	7 (2.9)	3 (1.1)	3 (1)	2 (0.8)	5 (2.4)
Object	10 (4)	21 (8.8)	23 (8.4)	38 (13)	36 (13.5)	22 (10.7)
Assault	2 (0.8)	8 (3.4)	9 (3.3)	16 (5.5)	21 (7.9)	10 (4.9)
Non accidental*	7 (2.8)	3 (1.3)	6 (2.2)	3 (1)	7 (2.6)	5 (2.4)
Dropped	10 (4)	10 (4.2)	11 (4)	5 (1.7)	9 (3.4)	4 (1.9)
Sport	13 (5.2)	6 (2.5)	7 (2.6)	2 (0.7)	1 (0.4)	7 (3.4)
Other	20 (8)	13 (5.5)	13 (4.7)	13 (4.5)	8 (3)	10 (4.9)
Total	250 (100)	238 (100)	274 (100)	292 (100)	266 (100)	206 (100)