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Are boys and girls that different? An analysis of traumatic brain injury in children

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ABSTRACT

Introduction The Phillips Report on traumatic brain injury (TBI) in Ireland found that injury was more frequent in men and that gender differences were present in childhood. This study determined when gender differences emerge and examined the effect of gender on the mechanism of injury, injury type and severity and outcome.

Methods A national prospective, observational study was conducted over a 2-year period. All patients under 17 years of age referred to a neurosurgical service following TBI were included. Data on patient demographics, events surrounding injury, injury type and severity, patient management and outcome were collected from 'on-call' logbooks and neurosurgical admissions records.

Results 342 patients were included. Falls were the leading cause of injury for both sexes. Boys' injuries tended to involve greater energy transfer and involved more risk-prone behaviour resulting in a higher rate of other (non-brain) injury and a higher mortality rate. Intentional injury occurred only in boys. While injury severity was similar for boys and girls, significant gender differences in injury type were present; extradural haematomas were significantly higher in boys ($p=0.014$) and subdural haematomas were significantly higher in girls ($p=0.011$). Mortality was 1.8% for girls and 4.3% for boys.

Conclusions Falls were responsible for most TBI, the home is the most common place of injury and non-operable TBI was common. These findings relate to all children. Significant gender differences exist from infancy. Boys sustained injuries associated with a greater energy transfer, were less likely to use protective devices and more likely to be injured deliberately. This results in a different pattern of injury, higher levels of associated injury and a higher mortality rate.

INTRODUCTION

In industrialised countries injury is the leading cause of death in childhood, accounting for 40% of all childhood deaths between the ages of 1 and 14 years.¹ In the EU, every day 14 children die, 2240 are admitted to a hospital and 28 000 attend an emergency department as a result of injury.² For children under the age of 5 years, the majority of fatal and non-fatal injuries occur in the home.³ Children's risk of injury varies by a range of factors including age, gender and various socio-economic parameters, with boys having more frequent and more serious injuries.^{1 4 5} The gender gap is such that it has been estimated by the Organisation for Economic Cooperation and Development that if boys had the same injury

mortality rate as girls then up to 5000 lives could be saved per year.¹

Of all injury outcomes, brain trauma is considered severe and impacts significantly on mortality.⁶ A report on traumatic brain injury (TBI) in the Republic of Ireland⁷ found that men were three times more likely to sustain a significant TBI than women and that these gender differences were present from a very young age. Brain trauma injury among children contributes significantly to the burden of injury in society and to a large number of disability-adjusted life-years.¹

While previous studies have demonstrated gender differences in injury prevalence and fatalities,¹ little has been done to investigate gender differences in TBI in young children. Therefore, this study aimed to determine the age at which gender differences in TBI start to emerge and to examine TBI-related gender differences in the mechanism and circumstance of injury occurrence, injury severity, the types of injury sustained and injury-related mortality, using TBI data from the two neurosurgical units (NSU) in Ireland over a 24-month period.

METHODS

Data on TBI were collected from all patients referred to the two NSU in the Republic of Ireland; the national neurosurgical centre in Beaumont Hospital, Dublin and the NSU in Cork University Hospital, Cork. Prospective data were collected over a 24-month period from April 2002 to April 2004 from Beaumont Hospital and over a 12-month period from November 2003 to November 2004 from Cork University Hospital.

Referrals to the neurosurgical service were initially made by telephone to the 'on-call' team and CT images were electronically linked. The case and imaging were reviewed and a decision was made either to transfer the patient to the neurosurgical centre for admission or to treat the patient in the referring hospital with management advice. Data were collected by members of the TBI research group from the NSU admissions records and from the 'on-call' telephone logbooks, inputted onto a Microsoft EXCEL database and analysed using Stata 9.⁸ Preliminary results on the adult population revealed large gender variations.⁷ This paper presents further statistical analysis of the paediatric data examining gender differences in TBI. Statistical analysis was largely descriptive and tests of significance were performed when appropriate.



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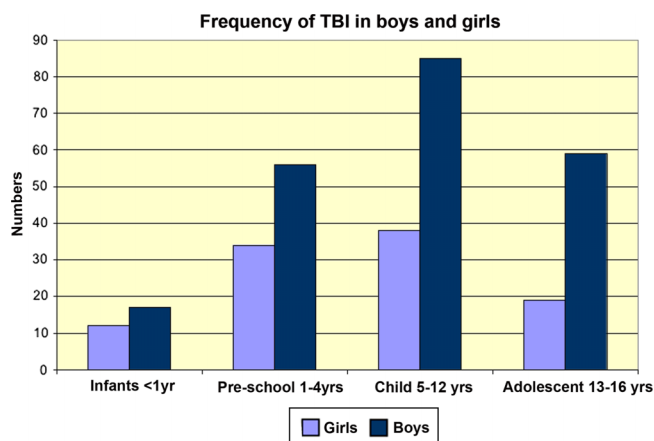


Figure 1 Age distribution by gender for traumatic brain injury (TBI) in a paediatric population. Access the article online to view this figure in colour.

RESULTS

There were 2095 patients registered on the TBI database, of which 342 patients were under 17 years of age and were included in this study. Of these, 235 (69%) were boys. The mean age was 7.6 years, the median age was 8 years (95% CI 6 to 8 years).

Gender differences in incidence began in infancy, persisted and widened into adolescence. The age-gender distribution is shown in figure 1.

Falls were the leading cause of TBI in children (56% in total) with higher rates in girls (66%) than boys (51%). Boys were more likely to be injured on the roads (30% of all boys injured) or by being struck by or against an object (17% of all boys' injuries). These gender differences are statistically significant ($p < 0.005$, Mann-Whitney U test) and are shown in figure 2.

Falls

Over half (56%) of TBI sustained by children was as a result of a fall. Girls were statistically more likely to sustain a TBI by falling than boys (66% vs 51%, $p = 0.005$). Boys were more likely to fall from a height than girls ($p = 0.024$); 27 boys (29%) fell more than 2 m or 10 steps compared with seven girls (12%). There was no statistically significant gender difference in the type of surface (hard or soft) that the children fell onto ($p = 0.52$), nor in injury severity ($p = 0.69$). Boys were more likely to sustain other injuries associated with the fall; five boys who fell more than 2 m had other injuries, while there

were no documented significant other injuries among the injured girls. The numbers involved were small and did not reach statistical significance ($p = 0.052$). Mortality after falling (for children admitted to a NSU) was higher for boys but the number of fatalities was too low to calculate statistical significance (five boys and one girl died following a fall). Our data underestimate mortality, as deaths occurring outside either NSU were not recorded.

Road users

While there was no significant gender difference in the mechanism of road injury, there was a significant difference in the use of protective devices and risk behaviour between boys and girls. Overall, girls were statistically more likely to be secured using an age-appropriate restraint in a car than boys (Mann-Whitney U test $p < 0.05$); eight out of nine girls and five out of 18 boys wore an age-appropriate restraint in a vehicle (table 1). No medical notes recorded any child cyclist wearing a helmet; however, nine cyclists were documented to have had no helmet at the time of injury; eight were boys and the other was a girl.

Circumstances

The home was the most frequent location of injury; half the girls and over one-third of boys were injured there (table 2). Overall, gender differences were found in relation to the location or circumstance of the injury ($p < 0.05$), with girls being significantly more likely to be injured at home ($p < 0.02$) and boys being injured more during 'other' activities ($p < 0.05$) or in 'unknown' circumstances ($p < 0.05$).

Intent

No girl was intentionally injured. Ten boys (4%) were intentionally injured by another person; one infant (<1 year), two children (5–12 years) and seven adolescents (13–16 years). All intentional injuries were caused by striking either with or against an object. Eight of the boys assaulted had an initial Glasgow coma scale (GCS) score between 13 and 15, while the remaining two boys sustained a more severe injury (GCS 3–8). The less severely injured boys sustained cerebral contusions (four), skull fractures (three), extradural haemorrhage (EDH) (two) and an intracerebral bleed. The more severely injured boys had a subdural haemorrhage (SDH), a subarachnoid haemorrhage and cerebral contusions. There was no documented use of alcohol or drugs.

Figure 2 Mechanism of injury by gender in a paediatric population. Access the article online to view this figure in colour.

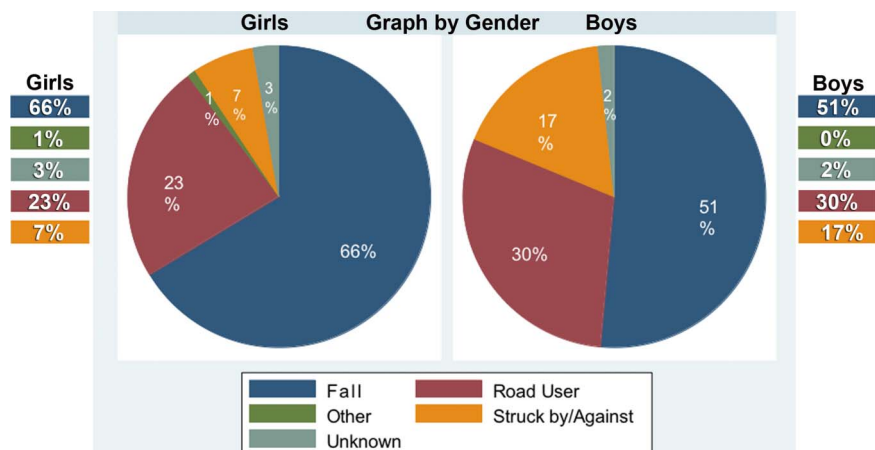


Table 1 Road injury variations by gender

	Boys	Girls	Total
Pedal cyclist	26 (32%)	8 (37%)	34 (36%)
Pedestrian	21 (24%)	6 (30%)	27 (28.5%)
MVC	18 (36%)	9 (26%)	27 (28.5%)
Age-appropriate restraint not worn in MVC			
Age <1 year	2	0	2
Age 1–4 years	1	0	1
Age 5–12 years	5	1	6
Age 13–16 years	4	0	4
Motorcycle collision	5 (8%)	2 (7%)	7 (7%)
Total	70	25	95

MVC, motor vehicle collision.

Injury severity

While all TBI are considered potentially severe injuries, this study also examined the severity level of TBI using the GCS. There was no statistical difference in severity of injury by gender ($p=0.41$). Injuries were categorised as 'mild' (initial GCS 13–15), 'moderate' (GCS 9–12) and 'severe' (GCS 3–8). Two hundred and sixty-one (77%) children had a 'mild' TBI, 33 (10%) had a 'moderate' TBI and 43 (13%) had a 'severe' TBI.

Injury pattern

There were significant gender differences in injury pattern (table 3), with boys statistically more likely to sustain an extradural haematoma ($p=0.014$) and girls more likely to sustain a subdural haematoma ($p=0.011$). Skull fractures, cerebral contusions, subarachnoid haemorrhage and intracerebral bleeds did not show any gender variation. Two-thirds (28 out of 42) of the patients with an EDH had a skull fracture. The major mechanism of injury for girls sustaining a SDH was falls less than 2 m (table 4), while EDH in boys were caused by a mix of falls (51%), road collisions (26%) and being either struck by or against an object (23%). Almost half the falls causing SDH and EDH occurred in the home.

Outcome

Twelve of the 174 patients admitted to a NSU died during their stay there. Deaths outside the NSU and deaths for patients treated in the referring hospital were not recorded. The NSU mortality rate was 7% but when gender was considered this changed to 9% (10 out of 117) and 4% (two out of 57) for boys

Table 2 Circumstance of injury

Circumstance	Girls	Boys	p Value*
Home	53 (50%)	84 (36%)	$p<0.02$
Sport	9 (8%)	27 (11%)	$p>0.1$
Commuting	10 (9%)	26 (11%)	$p>0.1$
Recreation	13 (12%)	15 (6%)	$p>0.05$
Other†	4 (4%)	24 (10%)	$p<0.05$
Education	5 (5%)	7 (3%)	N/A
Occupation/industry	1 (1%)	4 (2%)	N/A
Unknown	12 (11%)	48 (20%)	$p<0.05$
Total	107	235	$p<0.05$

*p Values were calculated for all circumstances and individual circumstances. The number of children injured in education and occupation were too low for meaningful analysis.

†Other includes the categories 'struck by or against' and known, but unclassifiable circumstances.

Table 3 Pattern of traumatic brain injury sustained by gender (n=342)

Brain injury pattern	Total	Boys	Girls	Mann–Whitney U test
Extradural haematoma	42	36 (86%)	6 (14%)	$p=0.014$
Subdural haematoma	22	10 (45%)	12 (55%)	$p=0.011$
Subarachnoid haemorrhage	25	18 (72%)	7 (28%)	$p=0.78$
Intracerebral bleed	20	14 (70%)	6 (30%)	$p=0.97$
Cerebral contusion	132	95 (72%)	37 (28%)	$p=0.36$
Skull fracture	108	77 (71%)	31 (29%)	$p=0.62$
Midline shift	15	8 (53%)	7 (47%)	$p=0.42$
Total*	364	258	106	

*Patients may have more than one injury type (so total may exceed n=342).

and girls, respectively, but did not reach statistical significance ($p=0.22$).

DISCUSSION

The aim of this study was to identify gender differences in paediatric TBI. The key findings of the study are that falls are responsible for the majority of TBI in children. A higher proportion of TBI in girls was caused by a fall. The home is the most frequent location of injury for both sexes. Significant gender differences exist, are evident from an early age, and are present throughout childhood and adolescence. Boys sustain injuries associated with a greater energy transfer (falls greater than 2 m), are less likely to use protective devices and are more likely to be injured deliberately. This results in a different pattern of injury, with potentially higher levels of associated injury and mortality.

Road-related injuries and falls are the main causes of severe trauma in children, with head injuries being the main cause of death.^{6 9 10 11} Our findings suggest that while falls occur more frequently in girls; boys' falls tend to be more severe. This finding is supported by the differences in fall mechanism, with boys more likely to fall from height compared to girls. Similarly, more boys who were admitted with TBI were injured in a motor collision compared to girls, with a much higher proportion of boys across the age groups not using appropriate restraints. Some studies have previously addressed gender differences in risk perception,^{10 11} some specifically in relation to traffic.^{12 13} Our findings demonstrate that inappropriate restraint is evident at a much earlier age, a time when guardians are responsible for ensuring the safety of child passengers. Graine¹³ has demonstrated that gender differences in obeying rules in adolescence are very much determined by perceived sex stereotypes more than the biological sex. However, our findings suggest that such stereotypes may exist in guardians, who may be more tolerant (or even encouraging) towards risk-prone

Table 4 Mechanism of injury for patients with an extradural haemorrhage and subdural haemorrhage

Mechanism of injury	Girls (n=18)		Boys (n=46)	
	Extradural	Subdural	Extradural*	Subdural
Fall				
Less than 2 m	3 (50%)	10 (83%)	12 (34%)	3 (30%)
More than 2 m	1 (17%)	0	6 (17%)	3 (30%)
Road user	2 (33%)	1 (8%)	9 (26%)	1 (10%)
Struck by or against	0	1 (8%)	8 (23%)	3 (30%)
Total	6	12	35*	10

*Mechanism of injury for one boy with an extradural haemorrhage was unknown.

behaviour among boys, such as climbing heights, and may be more lenient towards boys who refuse to use restraints while in the car.^{14 15} The gender differences demonstrated in relation to car restraint devices is of particular importance given that in some studies almost half of all TBI result from road collisions.^{9 10} Studies have demonstrated that being an unrestrained occupant, injury to the head and a young age were all associated with a more severe outcome following a road collision.¹¹

Girls were not reported to have been injured intentionally in this study. The current study found that 4% of boys were intentionally injured and the risk is greatest for adolescent boys. The intentional injuries in this paper were assaults and no intentional self-harm was reported. Data from the Trauma Audit Research Network in England⁶ found that 1.9% of all severe trauma in children was intentional. A Scottish study of paediatric mortality from trauma⁹ found that the incidence of assault and suicide was higher in boys. In a further paper by the same authors¹⁶ they state that intentional injury poses a greater threat to child health than any single cause of unintentional injury.

The rates of non-operable TBI (parenchymal bleeds and contusions) were similar in boys and girls. However, for operable TBI (EDH and SDH), statistical gender differences exist with boys more likely to sustain an EDH and girls more likely to have a SDH. The major mechanism for both EDH and SDH is falls and up to 50% of these significant falls occur at home. This has not been described in the literature to date.

Limitations

The current study is based on 24-month data collected in the two neurosurgical centres in Ireland. All cases that were admitted for TBI were logged and the data present a high level of completeness. Yet, for those under 17 years the number of cases is still relatively low and limits the ability to conduct statistical testing. Although the majority of the TBI cases in Ireland will be admitted to these centres, results should be interpreted with caution. The mortality rates in this study only record the deaths that occurred within the NSU. Reliable data on mortality were not available for children who were not admitted to the NSU or who were discharged from the unit and subsequently died.

CONCLUSIONS

Boys and girls are indeed different, and this is evident from infancy onwards. Boys are more likely to fall from a greater height, be assaulted, and tend to sustain other injuries. They are less likely to use protective devices. Whether or not the reason for such differences is sex stereotyping, it is clear that guardians should be guided to care for boys in the same manner as girls. This includes restricting the height to which they are allowed to climb, and ensuring that they are appropriately restrained when in vehicles.

Contributors NCC: researcher, data interpretation and primary author; MM: author; PC: database creation and statistical analysis; LME: primary researcher, data collection and data interpretation; LG: researcher, data interpretation. JPP: intellectual property for study, researcher and data interpretation. AJN: author.

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Competing interests None.

Ethics approval The Ethics Committee of Beaumont Hospital granted ethics approval for the study. The need for informed consent was not required as it was an observational study.

Provenance and peer review Not commissioned; externally peer reviewed.

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