A population-based study of potential brain injuries requiring emergency care

Research

Recherche

From the Departments of *Emergency Medicine and †Community Health and Epidemiology, Queen's University, Kingston, Ont.

This article has been peer reviewed.

CMAJ 2001;165(3):288-92

William Pickett,*† Christopher Ardern,† Robert J. Brison†

Abstract

Background: Brain injury is an important health concern, yet there are few population-based analyses on which to base prevention initiatives. This study aimed, first, to calculate rates of potential brain injury within a defined Canadian population and, second, to describe the external causes, natures and disposition from the emergency department of these injuries.

Methods: We studied all cases of blunt head injury that resulted in a visit to an emergency department for all residents of Greater Kingston during 1998. We used data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) and augmented this by examining all records of emergency or inpatient care received at all hospitals in the area.

Results: In 202 (27%) of 760 cases of head injury, there was potential for brain injury. Annual rates of potential brain injury were 16 and 7 per 10 000 population for males and females respectively. CT was performed on 114 (56%) of 202 cases, of which 60 (53%) demonstrated an intracranial pathology, with 11 (10%) showing a diffuse axonal injury pattern on the initial scan. Falls from heights accounted for 14 (47%) of 30 injuries observed in children aged 0–9 years. Individuals aged 10–44 years sustained 32 (63%) of 51 motor vehicle injuries, 15 (88%) of 17 bicycle injuries, 22 (100%) of 22 sports injuries and 8 (89%) of 9 fight-related injuries. Falls accounted for 15 (71%) of 21 injuries among adults aged 65 years or more.

Interpretation: The results indicate the relative importance of several external causes of injury. The findings from our geographically distinct population are useful in establishing rational priorities for the prevention of brain injury.

Blunt head injury is a leading cause of death[1] and disability;[2] it can affect the activities of daily life[3] and the risk of readmission to hospital[4] and subsequent death,[5] and it can lead to ongoing neuropsychological deficits.[6] About 18 000 patients are admitted to hospital with brain injuries in Canada annually,[7] leading (by extrapolation) to at least $1 billion in societal costs. In the United States, 1.5 million people sustain a head injury annually,[8] resulting in 50 000 deaths,[9] 80 000 disabling injuries,[2] US$346 million in emergency care costs[10] and US$54 billion in associated hospital care costs.[11] Rehabilitative therapies are often lengthy and costly.[12]

The published incidence rates of blunt head injury in emergency department settings range from 180[1] to 444[10] per 100 000 population, with an overall male bias and a peak incidence in those aged 15–24 years.[1] A disproportionate number of severe head injuries result from traffic-related accidents in this age group,[13] whereas falls account for larger percentages of head injuries among young children and elderly adults.[13] In terms of the acute prognosis, head injuries are typically classified as "minimal," that is, with no loss of consciousness, amnesia or disorientation, or, in the presence of one of those clinical signs, "minor" (Glasgow Coma Scale [GCS][14] score 13–15), "moderate" (GCS 8–12) or "severe" (GCS < 8) head injuries.[15]

The modern scientific literature contains few Canadian studies of blunt head injury and none that describe the experiences of a geographically isolated population. Our own research setting in Kingston, Ont., is a population-based site of the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP).[16] In this context, we conducted a study of potential brain injuries for a geographically distinct Canadian population. Our objectives were, first, to calculate rates of blunt head trauma and, thus, potential brain injuries within our defined population and, second, to describe the external causes, natures and disposition from the emergency department of these potential brain injuries.

Methods

Kingston has participated in the national CHIRPP program since 1993. Its hospital-based emergency departments serve a population of 176 000, with a 65:35 urban:rural split. The Kingston site is unique in the CHIRPP program because of its complete community coverage. It was possible to crossreference the CHIRPP database and a separate hospital encounter database to identify all head injuries experienced by the Kingston population presenting for emergency medical care.

Computerized injury records were identified for 1998 from the CHIRPP surveillance system and from the hospital encounter database. The present analysis focused on blunt head trauma with the potential for intracranial involvement. Case identification involved the following 2-stage process.

Stage 1

Injuries with the following CHIRPP codes were included: "minor head injury," "concussion," "intracranial injury," "skull fracture" and "multiple injury with associated head injuries." Records from the hospital encounter database that included diagnoses of "skull fracture" or "intracranial injury" were added if they had not been identified by CHIRPP. Patients with injuries to the eyes, facial fractures, dental injuries or isolated facial lacerations were excluded, as were patients whose residence was outside the hospital catchment area. Additional descriptive information was available from 2 sources: from an ongoing investigation of minor head injuries (the Canadian CT Head Study[15]) for 219 cases and from hospital separation records for 81 admissions.

Stage 2

The case series was further separated into 2 categories: potential brain injuries (of at least "minor" severity) and "minimal" head injuries. The following were considered to be potential brain injuries: blunt head trauma resulting in a witnessed loss of consciousness, amnesia or disorientation;[15] skull fracture; head injury for which the patient was admitted to hospital; and intracranial injury recorded on the CHIRPP record. Penetrating wounds were excluded because of their relative scarcity and disparate external causes.

Counts and annual rates per 10 000 population of head injury were calculated by age group and sex. Potential brain injuries were further described by age group, ICD-9 codes for classifying external causes of injury (E codes),[17] diagnosis, activity and treatment.

Results

Overall, males experienced a rate of potential brain injury (16/10 000 population per year) that was approximately twice that of females (7/10 000 population per year). The disparity in rates between males and females was highest for those aged 10–19 years (Table 1).

Falls from heights accounted for 14 (47%) of the 30 injuries observed in children aged 0–9 years, followed by vehicle-related accidents (9/30, 30%) (Table 2). People aged 10–44 years accounted for 32 (63%) of 51 motor vehicle injuries, 15 (88%) of 17 bicycle injuries, 22 (100%) of 22 sports injuries and 8 (89%) of 9 fight-related injuries. Falls also accounted for 15 (71%) of 21 injuries among adults aged 65 years and more.

The contexts in which potential brain injuries occurred (Table 3) were consistent with the observed external causes. For children aged 0–9 years, 10 (33%) of the 30 head injuries occurred during transportation and 8 (27%) occurred during play. Among those aged 10–44 years, leading contexts were transportation (43/119, 36%) and then sports and physical recreation activities (33/119, 28%). Among the 37 cases attributed to sports injury, 14 (38%) occurred during ice skating and 11 (30%) during ice hockey.

CT was performed for 114 (56%) of 202 cases and showed abnormalities in 60 (53%), including brain contusion with or without skull fracture (n = 23), subdural hematoma (n = 15), epidural hematoma (n = 8), skull fracture (n = 7) and subarachnoid bleeding only (n = 3). Eleven of these cases showed diffuse axonal injury patterns on the initial scan, which is evidence of major intracranial injury. The remaining cases were either normal on the CT scan (54/202, 27%), or CT was never performed (88/202, 44%). Of the 202 patients with recorded cases of head injury, 90 (45%) were admitted to hospital (Table 4), and the admission rate was highest for children aged 0–9 years (22/30, 73%).

Table 1: Population-based rates of head injury and potential brain injury per 10 000 in Kingston, Ont., and area, by age and sex, 1998

Type of injury; age group, yr	Males, no. and rate of injury (and 95% CI)			Females, no. and rate of injury (and 95% CI)		
Total head injuries (n = 760)						
All ages	479	55	(50–60)	281	32	(28–35)
≤ 9	130	115	(95–134)	79	72	(57–88)
10–19	141	122	(102–142)	57	52	(38–65)
20–44	146	42	(35–49)	82	24	(19–29)
45–64	37	19	(13–26)	34	18	(12–23)
≥ 65	25	25	(15–34)	27	19	(12–27)
Potential brain injuries (n = 202)						
All ages	141	16	(14–19)	61	7	(5–9)
≤ 9	17	15	(8–22)	13	12	(5–18)
10–19	46	40	(28–51)	10	9	(3–15)
20–44	45	13	(9–17)	18	5	(3–8)
45–64	22	12	(7–16)	10	5	(2–8)
≥ 65	11	11	(4–17)	10	7	(3–12)

Note: CI = confidence interval.

Interpretation

This study provides information about the external causes, natures and demographic patterns of potential brain injury in a defined Ontario population and about the sequelae of acute injury. The study shows that about 30% of patients with blunt head injury presenting to the emergency department had signs consistent with brain injury. Of these, 56% received a CT scan, and 53% of those scanned had evidence of a brain injury, whereas 10% had evidence of a major intracranial injury. Leading external causes of potential brain injury were falls from heights in young children; motor vehicle injuries, bicycle injuries, sports injuries and fight-related injuries in individuals aged 10–44 years; and falls (all types) in those over the age of 65 years. Males had a rate of head injuries and potential brain injuries that was approximately twice that of females, and both injury rates peaked in boys and young men.

Although head trauma has been recognized as a serious health issue, there are few Canadian epidemiological stud-

Table 2: Causes of potential brain injury, by ICD-9 E code

ICD-9 E code	Description	Total *n* = 202	Age group, yr; no. of patients				
			≤ 9	10–19	20–44	45–64	≥ 65
E810–825	*Motor vehicle injuries*	*51*	*7*	*14*	*18*	*9*	*3*
812, 815	Highway collision	8	2	1	4	1	0
816	Loss of control, not involving highway collision	20	0	6	8	4	2
.6 suffix	Pedal cycle collision	4	0	3	1	0	0
820–21	Nontraffic collisions involving recreational vehicles	9	1	2	3	2	1
814	Collision with pedestrian	6	2	2	1	1	0
	Other	4	2	0	1	1	0
E826–829	*Other road vehicle accidents*	*16*	*2*	*10*	*4*	*0*	*0*
826	Pedal cycle collision	13	2	7	4	0	0
828.2	Animal ridden	3	0	3	0	0	0
E880–888	*Accidental falls*	*71*	*16*	*8*	*19*	*13*	*15*
880	Fall on or from stairs or steps	12	1	1	4	3	3
881–884	Falls from height	25	13	2	4	3	3
885	Falls on same level, tripping	11	2	2	3	4	0
888	Falls of an unspecified nature	22	0	3	7	3	9
	Other	1	0	0	1	0	0
E917	*Struck against or by object*	*32*	*1*	*17*	*11*	*3*	*0*
917.0	Struck in sport	22	0	16	6	0	0
	Other	10	1	1	5	3	0
E960	*Unarmed fight or brawl*	*9*	*0*	*3*	*5*	*1*	*0*
All other E codes		*23*	*4*	*4*	*6*	*6*	*3*

Note: ICD-9 E code = International Classification of Diseases, ninth revision (ICD-9), codes for classifying external causes of injury.[17]

Table 3: Contexts of potential brain injury, by CHIRPP classification code

CHIRPP description of context	Total *n* = 202	Age group, yr; no. of patients				
		≤ 9	10–19	20–44	45–64	≥ 65
Transportation	66	10	23	20	11	2
Sports and physical recreation	37	0	22	11	3	1
Leisure or recreation	22	8	4	7	0	3
On duty at work	7	0	0	4	2	1
Miscellaneous household activities	4	0	0	0	2	2
Maintenance	4	0	0	1	3	0
Quarrel, aggression, fight, riot	8	0	2	5	1	0
Other events*	37	9	2	12	5	9
Missing data	17	3	3	3	5	3

Note: CHIRPP = Canadian Hospitals Injury Reporting and Prevention Program.[16]
*These include walking, running, crawling, sitting, standing, loss of temper and events not classified elsewhere.

Table 4: Disposition of cases of potential brain injury, by CHIRPP classification code

CHIRPP description of disposition	Total *n* = 202	Age group, yr; no. of patients				
		≤ 9	10–19	20–44	45–64	≥ 65
Advice only	4	0	2	2	0	0
Treated, follow-up as necessary	39	1	15	16	3	4
Treated, follow-up required	43	4	9	14	10	6
Short stay, observation in emergency	25	3	11	9	1	1
Admitted	90	22	19	21	18	10
Missing data	1	0	0	1	0	0

ies of this issue that include population-based rates, and no studies have comprehensively examined the full spectrum of blunt head traumas seen at emergency departments. Existing studies have been conducted with large, but selected, populations of children[18] or adults[19] only, whereas others have examined admissions to hospital[20] and rehabilitative[21] services.

The increased frequency of head injuries observed in males is consistent with the existing literature, and the peak ratio of 4:1 of head injuries in males compared with females seen among those aged 10–19 years was similar to that reported nationally from US emergency department data.[10] The male predominance is probably attributable to differential exposure to risks in certain age groups. Although some studies have identified incidence peaks in teenagers and young adults,[13] others have reported higher rates in children aged less than 5 years,[1] which are mainly attributable to falls from heights. The peak in injuries from falls among elderly people that has been reported elsewhere,[13] and is to some extent reflected in our data, is indicative of the intrinsic risks associated with aging.

We observed that motor vehicle injuries and sports injuries were concentrated in young people, which has been recorded elsewhere.[20] Past research has indicated the importance of contact surfaces as a predictor of the severity of injuries,[22] and ice and collisions are clearly causal environmental risk factors in ice skating and contact sports like ice hockey.[23] Although earlier Canadian research found that almost one-third of cases of head injury admitted to hospital were sustained during fights,[20] only 9 cases were identified in our study, almost all of them experienced by young men.

Because of the availability of universal health care coverage in Canada, the observed patterns of injury should not be distorted by differential access to health care, and the present analysis was based in emergency departments that serve the trauma needs of both rural and urban populations. Our study was limited, however, in that there was no standardized protocol for assessing patients. The lack of exact information on the location and context of these injuries also limited our ability to recommend focused alternative preventive measures. Follow-up data on disability and other long-term outcomes were also not available. These can be substantial, because up to 40% of patients with mild traumatic brain injuries remain impaired for at least 1 year,[11] and all individuals who survive these injuries need clinical assessment and follow-up.

In conclusion, brain injuries represent a serious and perhaps underappreciated clinical challenge, and these data reinforce the importance of the many external causes that should be targeted for preventive measures.

Competing interests: None declared.

Contributors: Dr. Pickett developed the idea for this study, designed the analysis and its presentation, and wrote the manuscript. Mr. Ardern performed the analysis and assisted in all other aspects of the manuscript preparation, including drafting some sections of the manuscript. Dr. Brison oversaw all clinical aspects of the case series and its development as Medical Director of the CHIRPP surveillance program in Kingston and edited the manuscript at various stages of preparation. All authors can take full responsibility for the manuscript and its conclusions.

Acknowledgements: We thank Kathy Bowes, Trish Matys and Sarah Pickett for their respective contributions and support. Some case information was obtained from the Canadian CT Head Study, directed by Dr. Ian Stiell.

Funding for this analysis came from the Laboratory Centre for Disease Control, Health Canada (CHIRPP); Emergency Medicine Research, Queen's University (support for Mr. Ardern); the Ontario Neurotrauma Foundation (research unit support); and the Ontario Ministry of Health and Long-term Care (Career Scientist support for Dr. Pickett).

References

1. Kraus JF, Black MA, Hessol N, Ley P, Rokaw W, Sullivan C, et al. The incidence of acute brain injury and serious impairment in a defined population. *Am J Epidemiol* 1984;119(2):186-201.
2. Thurman DJ, Alverson C, Dunn KA, Guerrero J, Sniezek JE. Traumatic brain injury in the United States: a public health perspective. *J Head Trauma Rehabil* 1999;14:602-15.
3. Lescohier I, DiScala C. Blunt trauma in children: causes and outcom head versus extracranial injury. *Pediatrics* 1993;91:721-5.
4. Cifu DX, Kreutzer JS, Marwitz JH, Miller M, Hsu GM, Steel RT, et al ology and incidence of rehospitalization after traumatic brain injury: a multicenter analysis. *Arch Phys Med Rehabil* 1999;80(1):85-90.
5. Strauss DJ, Shavelle RM, Anderson TW. Long-term survival of childre adolescents after traumatic brain injury. *Arch Phys Med Rehabil* 1998;79:1095-100.
6. McAllister TW. Neuropsychiatric sequelae of head injuries. *Psychiatr North Am* 1992;15:395-413.
7. Albert T, Cloutier E. *The economic burden of unintentional injury in Ca* Toronto (Ont): SMARTRISK Foundation; 1999.
8. Sosin DM, Sniezek JE, Thurman DJ. Incidence of mild and moderate injury in the United States, 1991. *Brain Inj* 1996;10:47-54.
9. Sosin DM, Sniezek JE, Waxweiler RJ. Trends in death associated with matic brain injury, 1979 through 1992. *JAMA* 1995;273:1778-80.
10. Jager TE, Weiss HB, Coben JH, Pepe PE. Traumatic brain injuries eval in U.S. emergency departments, 1992–1994. *Acad Emerg Med* 2000;7:134-40.
11. Max W, MacKenzie EJ, Rice DP. Head injuries: costs and consequen *Head Trauma Rehabil* 1991;6:76-91.
12. Bennett BR, Jacobs LM, Schwartz RJ. Incidence, costs, and DRG-base imbursement for traumatic brain injured patients: a 3 year experience. *J Trauma* 1989;29:556-65.
13. Kraus JF, McArthur DL. Epidemiologic aspects of brain injury. *Neuroepi ology* 1996;14:435-50.

14. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. *Lancet* 1974; 2:81-4.
15. Stiell IG, Wells GA, Vandemheen K, Laupacis A, Brison R, Eisenhauer MA, et al. Variation in ED use of computer tomography for patients with minor head injury. *Ann Emerg Med* 1997;30(1):14-22.
16. Mackenzie SG, Pless IB. CHIRPP: Canada's principal injury surveillance program. Canadian Hospitals Injury Reporting and Prevention Program. *Inj Prev* 1999;5(3):208-13.
17. *International classification of diseases, 9th revision (clinical modification).* 5th ed. Washington: US Department of Health and Human Services; 1996. Cat no 86-72897.
18. Hendrick EB, Harwood-Hash MB, Hudson AR. Head injuries in children: a survey of 4465 consecutive cases at the Hospital for Sick Children, Toronto, Canada. *Clin Neurosurg* 1964;11:46-65.
19. Snow WG, Macartney-Filgate MS, Schwartz ML, Klonoff PS, Ridgley BA. Demographic and medical characteristics of adult head injuries in a Canadian setting. *Can J Surg* 1988;31:191-4.
20. Parkinson D, Stephensen S, Phillips S. Head injuries: a prospective, computerized study. *Can J Surg* 1985;28:79-83.
21. Wong PP, Dornan J, Schentag CT, Ip R, Keating AM. Statistical profile of traumatic brain injury: a Canadian rehabilitation population. *Brain Inj* 1993;7:283-94.
22. Mowat DL, Wang F, Pickett W, Brison RJ. A case-control study of risk factors for playground injuries among children in Kingston and area. *Inj Prev* 1998;4:39-43.
23. Kelly JP, Nichols JS, Filley CM, Lillehei KO, Rubinstein D, Kleinschmidt-DeMasters BK. Concussion in sports. Guidelines for the prevention of catastrophic outcome. *JAMA* 1991;266:2867-9.

Correspondence to: *Dr. Robert J. Brison, Department of Emergency Medicine, Angada 3, KGH, Queen's University, Kingston General Hospital, 76 Stuart St., Kingston ON K7L 2V7; fax 613 548-1381; brisonr@kgh.kari.net*