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NEUROEPIDEMIOLOGY

Epidemiology of head injury

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In western countries injuries are the leading cause of death under the age of 45 years, and in several Third World countries that applies also for ages 5–45 years. Because many injury victims are young, more years of life are lost in males below the age of 65 from trauma than from cardiac and cerebrovascular disease, or from cancer, in the United States, Japan, and several European countries.[1] Up to half of trauma deaths are due to head injuries but these account for most cases of permanent disability after injury.[2] Recognition that head injury is a major health problem has led to several studies over the past decade to produce epidemiological data in order to devise effective preventive measures, and to plan the most appropriate health care provision both for acute care and the rehabilitation of disabled survivors.

Limitations of available data

Reliable statistics are difficult to discover from routinely collected data. International comparisons of deaths from injury do not identify head injuries, although their incidence reflects geographical differences and trends over time in the frequency of trauma deaths as a whole. There are wide differences between countries in how many deaths are attributed to injuries, and how many injury deaths are due to motor vehicle or road deaths (table 1). The best time trend data are for road deaths and these have been falling for some years in many developed countries (table 2). This is believed to be mainly due to preventive measures such as seat belts, motorcycle helmets, enforcing laws on alcohol limits for drivers, speed limits, and improved car and road design. For example, in Great Britain the number of motorists tested for alcohol level in 1994 was 80% higher than the average for 1981–5, whereas the absolute number testing positive was halved; fatalities associated with drink driving were reduced by 70%.[5] Rates for road deaths are much higher in developing countries where such measures have not been taken (table 3), and are believed to be rising in such countries as vehicles become more common. In Taiwan deaths due to vehicle accidents rose from 31 per 100 000 population in 1977 to 37 per 100 000 in 1987[7]—higher than in any of the countries in table 2.

Data on hospital discharges and on deaths at national or local level do allow head injuries to be identified by the codes of the International Classification of Diseases (ICD) that specify location of injury. However, there are several difficulties in using these that limit the accuracy of data not only in routine statistics but also in research surveys that rely on ICD coding alone for case ascertainment. In the current (9th) edition of these codes[8] head injuries are covered by no less than 10 rubrics (table 4); moreover these are based on pathological rather than clinical criteria, and they are not mutually exclusive. For example, intracranial haematoma, the commonest treatable complication causing death and disability, is associated with skull fracture in 75% of cases, yet it is classified by a rubric that seems to exclude skull fracture. Severity of injury is also difficult to identify reliably from ICD codes. In particular the three digit codes make

Table 1 Deaths from injury in different countries in 1985[3]

	Injuries as % of all deaths	Motor vehicle as % of injury deaths
France	7	30
Australia	5	51
United States	5	48
Canada	5	42
Japan	4	42
The Netherlands	3	41
Scotland	3	30
England	2	36

Table 2 Road deaths per 100 000 population[4]

	1980	1985	1993
France	21	20	17
Australia	24	18	—
USA	23	19	16
Canada	23	16	—
Japan	10	10	11
The Netherlands	13	11	8
Great Britain	11	9	7

Table 3 Road deaths per 1000 million vehicle km

	1985[6]	1993[4]
United States	15	9
United Kingdom	18	5
Japan	22	15
South Korea	540	—
Cameroons	530	—
Kenya (1984)	390	—
S Africa (1984)	180	—

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Table 4 International Classification of Diseases[8]

Three digit categories:	
Fracture of skull, spine, and trunk (N800–N09)	
N800	Fracture of vault of skull
N801	Fracture of base of skull
N802	Fracture of face bones
N803	Other and unqualified skull fractures
N804	Multiple fractures involving skull or face with other bones
Intracranial injury (excluding those with skull fracture):	
N850	Concussion
N851	Cerebral laceration and contusion
N852	Subarachnoid, subdural, and extradural haemorrhage after injury (without mention of cerebral laceration or contusion)
N853	Other and unspecified intracranial haemorrhage after injury (without mention of cerebral laceration or contusion)
N854	Intracranial injury of other and unspecified nature

no reference to the duration or degree of impaired consciousness, the universally recognised clinical criterion of severity. More recently an expanded five digit clinical modification (ICD 9-CM) has been introduced which deals with the anomalies of fractures and haematomas and in a fifth digit registers duration of unconsciousness,[9] and this is now used in some United States hospitals. Another problem is the variation in the use of codes between hospitals when recording similar injuries, as well as simple coding errors. In one United States survey nearly two thirds of head injuries selected by ICD codes were excluded when the medical records were reviewed.[10] Therefore higher incidence rates will be reported from surveys based on routine coding than when case records are reviewed. For example, Lyle *et al*[11] have suggested that the rate of 392 admissions per 100 000 population in New South Wales reported by Selecki *et al*[12] should be reduced to 266, to take account of the experience of Klauber *et al* in San Diego.[13] Incidence rates based on admissions (or discharges) may also be inflated by the double counting of patients transferred between acute hospitals (for example, from primary surgical wards to neurosurgical units and perhaps then back to primary surgical wards), and also by the inclusion of late admissions with delayed complications. Each of these has been estimated to account for 2% of recorded admissions for head injury.

Reports about head injuries from clinicians are of limited value. The several different specialists who are responsible for head injuries of different severities, together with varying admission and transfer policies in different places, make it difficult to put these reports into an epidemiological setting. The catchment population is often unknown, and the factors affecting the selection for treatment by a particular clinical unit are unlikely to be recognised, unless there are explicit policies. Most head injuries admitted to hospital are mild, but many clinical reports are from neurosurgeons who focus only on the 5%–10% of severe or complicated injuries that are transferred to them. Two large sets of data about severe injuries prospectively collected according to strict protocols from several centres are, however, now available. The international study of severe injuries that began in the Institute of Neurological Sciences in Glasgow in 1970 accumulated data from the Institute there and from centres in The Netherlands and California.[14,15] The United States National Coma Data Bank began 10 years later, collecting from four centres.[16,17] These two studies provide invaluable information about the minority of head injuries that are severe, but little about the population of head injuries from which they were selected or about the catchment populations. Reports from pathologists likewise focus on selected injuries, those from forensic laboratories including many victims who died instantaneously or very soon after injury. Such deaths that occur before admission to hospital account for two thirds or more of deaths from head injury in the United States and Australia and 45% of those in the United Kingdom. Reports from neuropathologists, by contrast, deal mostly with cases that survived long enough to be referred to specialist clinical centres, with very early deaths underrepresented.

Definition of head injury: grading severity

Head injury covers a wide range of severity from patients who die before admission to hospital to those with head injuries so mild that they do not even attend hospital. In between are those in coma, either initially or as a result of complications, those who are less serious but are admitted to hospital, and the much larger number who attend hospital but are sent home. Much of the difficulty in comparing different reports about the features and frequency of head injury stems from differing criteria for the minimum degree of severity required for classification as a head injury.

Most reports depend on administrative categories based on management or process, rather than on clinical criteria or outcome. The assumption is that cases admitted to hospital were more severe than those sent home, and that those transferred to a neurosurgical unit were more severe again. However, management policies, whether implicit or explicit, vary so much that the case mix of severity can vary widely from place to place. Policies can influence not only whether or not patients are admitted to hospital but also when they are discharged, so that duration of stay can be misleading as a measure of severity. Associated extracranial injuries can also distort the data by determining the admission, and prolonging the stay, of some patients. Social factors may have a similar influence—for example, for elderly patients and those who are injured far from home.

Clinical evidence of damage to the head is the most reliable way to recognise that a head injury has occurred, but all definitions exclude injuries confined to the face and foreign bodies in the nose or ears. Scalp, skull, or brain may each be injured independent of the other. Only 2% of attenders at Scottish accident departments for recent head injury have a skull fracture, but 15%–20% of severe and fatal injuries have no fracture.[18] Almost half of all attenders with head injuries in Scotland have a scalp laceration, but few have any evidence of brain damage by the time they arrive in hospital.[19,20] This applied to both adults and children and similar proportions have recently been found for a series of children in an American emergency room (personal communication). Some patients who are fully alert and oriented do, however, have a period of amnesia for some minutes after the injury. Most of the patients with head injuries admitted to hospital in Britain and the United States are only mildly injured. But a small minority of these patients develop complications—brain swelling or intracranial haematoma or infection. Moreover CT and MRI have recently confirmed what clinicians and psychologists have long suspected, that there is structural brain damage in some patients whose injuries seem to have been mild and who have not developed clinical complications.[21]

It has been suggested that patients who do not have either altered consciousness of a certain degree or duration, or neurological signs, should be excluded from estimates of incidence because they do not have *brain* injury.[22] In the light of the above clinical and imaging evidence the concept of "non-neurological" head injury seems to be unjustified on logical grounds, whereas it is certainly unwise from the standpoint of clinical management, as Fife[23] has also pointed out. These mild injuries are so frequent that they make considerable demands on the healthcare system, and they cause concern because of the small proportion who develop serious early complications, and the larger number who develop postconcussional symptoms. They are important also when exploring the pattern of causation of head injuries as a basis for devising strategies for prevention—because most mild injuries might well have been more severe, given only slightly different circumstances.

When milder injuries are included, as they are in most surveys, the incidence rates based on admissions are considerably higher than when only those with actual as distinct from potential brain damage are counted. Thus Kraus *et al*[22] recorded only 180 cases of traumatic brain injury per 100 000 population in San Diego in 1981 compared with an estimate of 295 in 1978 in a study that included milder cases.[13] Similarly, Lyle *et al*, applying the same exclusions to data from New South Wales, reduced the incidence from 266 to 180–200 per 100 000 population.[11]

Trauma centres now commonly use the abbreviated injury score (AIS) to define severity for trauma in general.[24] A conversion programme for deriving the AIS from the ICD 9-CM codes has been devised giving 5 severities: 1/2 minor, 3 moderate, 4 serious, 5 severe.[25] However, it proved much more difficult to convert the 519 possible combinations of head injury codes reliably to the five AIS categories than it did for injuries in other locations. The most common severity classification is by the Glasgow coma scale,[26] considering a score of 13–15 as mild, 9–12 as moderate, and 3–8 as severe. Others have used duration of unconsciousness or post-traumatic amnesia, but as post-traumatic amnesia is commonly as much as four times as long as the duration of coma these alternative definitions allow a wide latitude of severity. So also do the durations of altered consciousness used by different authors to distinguish mild from severe injuries. Durations of less than 15 or 30 minutes or 24 hours can count as mild, with severe defined as more than six or 24 hours of altered consciousness *or* evidence of brain contusion or intracranial haematoma. Classifications based on CT or MRI findings are suited only for the more severe injuries admitted to neurosurgeons.

Population based surveys in various countries

UNITED KINGDOM

Data for all deaths and for a 10% sample of admissions by ICD codes, and duration of inpatient stay have been published annually for many years in Britain, and these data for head injuries in England and Wales up to 1972 have been reviewed.[27] More detailed data for a stratified sample of injuries of all severities in Scotland in 1974 and 1985 have been analysed by an epidemiological team in Glasgow.[19 20 28–30] These studies included deaths before reaching hospital and attenders at emergency rooms sent home, as well as admissions to general hospitals and to neurosurgical units. The admissions included many patients without definite evidence of brain damage.

UNITED STATES

Data on admissions for head injury are not routinely collected on a national basis in the United States, but discharges after head and spinal cord injury were reported from a sample of hospitals throughout the country during 1970–4.[31] Some local surveys have been reported since then and these have been reviewed by Jennett and Frankowski[32] and by Kraus.[2] A report of head injuries in Olmsted County, Minnesota from 1935–74 included deaths, admissions, and attenders but only those with loss of consciousness, amnesia, or neurological signs.[33] A survey in Bronx County in 1980 included admissions within 24 hours of an injury associated with unconsciousness of at least 10 minutes or skull fracture, neurological signs, or seizure.[34] Two surveys in San Diego identified cases by different criteria for 1978[13] and 1981.[22] The second was based on admissions with medically confirmed concussion or contusion and haemorrhage or laceration of the brain, and included prehospital deaths. A Chicago study compared two socioeconomically distinct communities: inner city and suburban; it included admissions within seven days of a blow to the head and all deaths were included.[35] A study of residents admitted to Rhode Island hospitals excluded early fatal injuries,[36] and the same went for a statewide study in Maryland.[37] Almost all these studies included cases of skull fracture without evidence of brain damage. A review of routinely collected mortality data from 1979–86 in the United States as a whole by the Centre for Disease Control identified deaths associated with head injury related to

Table 5 Head injury admissions and deaths

Place and reference	*Year of study*	*Admissions/ 100 000*	*Deaths/ 100 000*	*Case fatality rate (%)*
USA National[31]	1970–4	200	25	12·5
Olmsted[33]	1935–74	193	22	11·3
Bronx[34]	1981	249	28	10·8
San Diego[13]	1978	295	22	7·5
San Diego[22]	1981	180	30	16·6
Chicago[35]	1980			
City black		403	32	7·9
Suburban black		394	19	4·8
Suburban white		196	11	5·6
Australia[12]	1977	392	25	6·3
Australia[11]	1977	180–200	25	14–15·6
England[27]	1972	270	10	3·7
Scotland[20]	1974–6	313	10	3·2
Johannesburg[46]	1986	316	81	25·6
France[43]	1986	281	22	7·8
Spain[44]	1988	91	20	21·9
Northern Sweden[42]	1984	249	17	6·8

age, sex, race, cause, and region,[38] but acknowledged that these might have been underestimated by as much as 23%–44%—again indicating the limitation of routine statistics.

OTHER COUNTRIES

The epidemiology of neurotrauma (head, spine, and peripheral nerves) was studied in New South Wales, South Australia, and the Capital Territory of Australia in 1977 based on admissions and death records.[12 39] In Norway admissions after head injury to a regional hospital in 1979–80 have been reported[40] and also to a county hospital near Oslo for 1974–5.[41] A study in northern Sweden was limited to persons aged 16–60 years who had impaired brain function; it included early deaths.[42] In the region of Aquitaine in France all admissions and deaths after head injury were surveyed for the year 1986.[43] A study in Cantabria, Spain for 1988 was limited to admissions with loss of consciousness, skull fracture, or neurological signs, but excluded early deaths, which accounted for 92% of all deaths.[44] A study in Johannesburg was limited to admitted patients aged 15 years or over who had altered consciousness or evidence of contusion or laceration of the brain, excluding prehospital deaths.[45 46]

Variations in frequency of head injuries

Calculations of incidence vary according to whether the numerator is deaths, admissions, or attenders. They also depend on how well defined is the population denominator. Patients who were not local residents were excluded from some studies, but other reports suggested that they be included on the basis that they would be balanced by injuries sustained by local residents who were injured elsewhere during the same period.

DEATHS

In several United States locations and in Australia, France, and Spain death rates from head injury are two to three times those in Britain (table 5). That for adults in Johannesburg is eight times greater than in Britain for all ages. The only reported rate that approached the low British level is that from a small sample of white patients in suburban Chicago.[35] In Britain the death rate from head injury has been falling since 1968[20] and was estimated to be only seven per 100 000 in 1994; a similar trend is reported from the United States.[38] Age specific mortality graphs are similar in Britain and one United States study (fig 1), but set at a higher level in the United States.[22] As in most countries for ages 15–60 years male rates are about twice those for females; the peak incidence is in males in the 15–30 age group.

The case fatality rates for those studies with population based rates for both admissions and deaths vary between 25·6% for Johannesburg to 3·2% for Scotland. They are higher when admissions are limited to cases with definite brain damage, when early death is excluded from incident rates based on admission, and when a large proportion of all deaths occur before hospital admission. Because many deaths occur before admission the in hospital case fatality rates are much lower (1%–6%) and are available for some studies that do not have population based mortality rates (table 6). The case fatality rates in clinical series of more severe injuries are much higher—14% for a regional neurosurgical unit in Virginia,[48] 15% for Scottish neurosurgical units,[30] and 33%[17] and 50%[15] for admissions in coma.

ADMISSIONS TO HOSPITAL

Admission to hospital is a less reliable indicator of the incidence of head injuries because policies for admission vary widely even within one country, but they are an important indica-

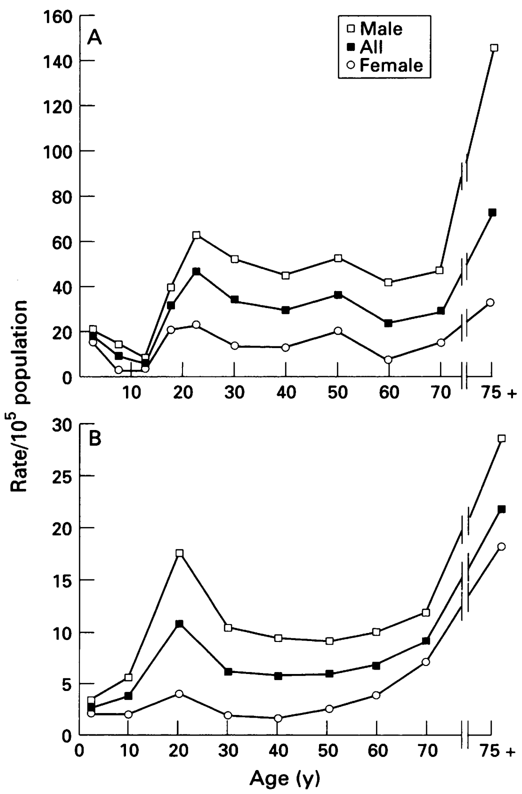

Figure 1 Age specific mortality rates for head injury. (A) San Diego 1981[22] (with permission); (B) England and Wales 1985.[47] Note the similarity in age distribution, with peaks in young adults and elderly people. The rates for San Diego are much higher at all ages than in England and Wales.

Table 6 In hospital case fatality rates (CFRs)

Place and reference	*Study year*	*Admission rate per 100 000*	*CFR (%)*
San Diego[13 22]	1978	295	< 3
	1981	180	6
Maryland[37]	1986	132	4
Rhode Island[36]	1980	152	4·9
Norway[41 40]	1974–5	236	1·3
	1979–80	200	2·8
Sweden[42]	1984	249	1·3
France[43]	1986	281	2
Spain[44]	1988	91	1·7
Scotland[28]	1974	313	1·0

tor of the impact of local injuries on hospital resources. The age specific admission rates are very similar in Britain and the United States (fig 2) with a less dramatic rise in elderly people than in the mortality rates (fig 1). In Britain the regional range is 210–404 per 100 000 and for other countries 91–403 per 100 000 (table 5). However, most estimates are in the range of 200–300 per 100 000 despite differences in the criteria of severity used for case ascertainment, and the much wider variations in death rates. Moreover, despite these differences some 80% of admissions for head injury in most places are categorised as mild and only 5%-10% as severe. The mild cases are patients who were presumably admitted as a precaution against the development of serious complications. Thus two thirds of admissions to primary surgical wards in Scotland in 1974 had no skull fracture or evidence of brain damage and did not have an extracranial injury to account for admission. About 60%–70% of all admissions in United Kingdom hospitals were discharged within 48 hours. Publication of guidelines for admission triage in Britain[50 51] has led to some reduction in the proportion of attenders at accident and emergency departments that are admitted.[19] That fewer patients are admitted in the United States despite higher population mortality rates may be accounted for by there being access to neurosurgical advice in many more hospitals, giving other clinicians the confidence to send mildly injured patients home.

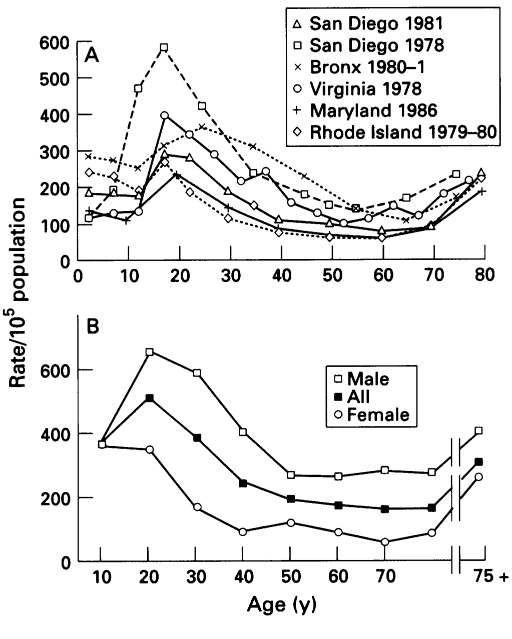

Figure 2 Age specific incidence rates (admissions) for head injury. (A) Various USA studies[2] (with permission); (B) Scotland.[49] The age distribution is similar in the two countries, and the rates are less different than for mortality.

Table 7 Attenders at accident/emergency departments after head injury: age specific rates per 100 000 population per year (Scotland 1985)[19]

	Children	*Adults*	*All*
All causes:			
All	4011	1473	1967
Males	5340	2180	2832
Females	2613	831	1158
Falls:			
All	2280	459	813
Males	2924	544	1035
Females	1603	381	605
Assaults:			
All	230	399	366
Males	350	677	610
Females	99	147	138
Road traffic accident:			
All	364	222	249
Males	486	306	343
Females	235	144	161

PATIENTS WITH HEAD INJURIES NOT ADMITTED TO HOSPITAL

Many patients with mild injuries either seek no medical attention or they attend hospital and are sent home after assessment. Data about such cases depend on specific surveys because no country keeps routine records of these cases. In 1974 about 20% of attenders with head injury in Scotland were admitted,[29] somewhat less than that a decade later.[19] This is very similar to a report of 20 years ago from Vancouver,[52] and recent findings for Rhode Island.[23] This last study estimated that during the years 1977–81 only 11%–22% (95% confidence interval) of head injured persons who were medically attended, or who reported at least one day of disability due to acute injury, were admitted to hospital. This indicated that cases not admitted to hospital accounted for 82% of all medically attended patients with head injuries in the United States, and for about half of all disability days due to head injury.

Some patients with minor head injuries may deliberately minimise or conceal their injuries. Sportsmen may worry that doctors will advise prolonged rest from their sport, and injuries associated with assault carry the risk of police investigation if a hospital becomes involved. Local geography and ease of access to medical care also influence whether or not mildly injured patients seek attention. These various

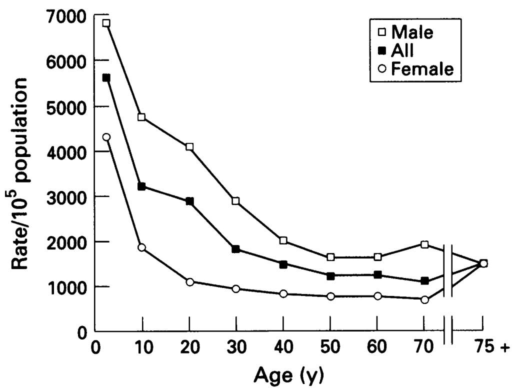

Figure 3 Age specific attendance rates for head injuries at Scottish accident and emergency departments for 1985[19] (with permission). About half the attenders are under 15 years, hence the earlier age for the peak of incidence rates than for deaths or admissions.

Table 8 Attenders with evidence of brain damage: age specific rates per 100 000 per year (Scotland 1985)[19]*

	Children	Adults	All
All causes:			
All	290	341	331
Males	395	537	508
Females	180	163	166
Falls:			
All	130	118	120
Males	165	168	167
Females	94	73	77
Assaults:			
All	6	147	78
Males	8	171	137
Females	4	26	22
Road traffic accident:			
All	99	70	76
Males	141	77	112
Females	55	39	42

*Brain damage = any evidence of altered consciousness either before or after reaching hospital, or neurological signs.

Table 9 Distribution (%) of causes in different places (based on admission ± early deaths)

Place and reference	Road traffic accidents	Falls	Assault
USA[31]	49	28	NI
Olmsted Co[33]	47	29	4
Bronx[34]	31	29	33
Sand Diego[22]	48	21	12
Rhode Island[36]	39	35	9
Chicago[35]			
City black	31	29	40
Suburban black	32	21	26
Suburban white	39	31	10
Maryland[37]	49	26	11
Australia[12]	53	28	NI
Scotland	24	39	20
France[43]	60	32	1
Spain[44]	60	24	NI
Taiwan[7]	90	5	NI
Johannesburg[46]	M 35	4	45
	F 39	3	38

NI = no information.

factors combine to limit the accuracy of estimates of the incidence of head injuries as a whole. Indeed they can only be reliably counted when they impinge on the hospital system, or on the coroner or medical examiner. The number of patients who present at hospital after injury is, however, probably the best guide to the incidence, because this is least likely to be influenced by differences between health care systems, or local admission policies.

Incidence rates for attenders in Scotland in 1985 have been calculated on the basis of a countrywide survey (table 7). About half the attenders were children (under 15 years) giving an earlier peak incidence than for deaths or admissions (fig 3). Only about 20% of adults and 9% of children had any evidence of brain damage—either impairment of consciousness on arrival, or a history of brief post-traumatic amnesia or witnessed impairment of consciousness. In both adults and children 40% had a scalp laceration, which is more often found in those without brain damage. Incidence rates for those with brain damage were naturally much lower than for all attenders (table 8).

DISABILITY AND PREVALENCE

A significant proportion of survivors of head injury are left with disability which may be both considerable and prolonged and it is of some importance to estimate the incidence and prevalence of such cases. Kraus[2] emphasises that even patients with mild injuries may be left with some disability for some months, and he calculated that the number of new cases of disability from head injury per year in the United States varies from 33–45 per 100 000 according to whether 10% or 18% of patients with mild injuries are estimated as having some disability. Lyle *et al*[11] estimate on the basis of the San Diego study[22] that there are two per 100 000 new cases of severe disability and four per 100 000 of moderate disability per year there; he made a similar estimate for New South Wales. Because disability can persist for years the prevalence rates are much higher—one estimate for the United States was 439 per 100 000.[31] However, Moscato *et al*[53] in a household survey in Canada estimated 54 per 100 000 having at least six months of disability as a prevalence rate. The disability had lasted for more than five years in 65% of respondents and for more than 10 years in 45%. In a similar household survey in Scotland Bryden[54] found a prevalence rate of 100 per 100 000 for considerable disability, compared with an incidence rate of two per 100 000 of such newly disabled survivors.

Causes of head injury

All reports show that the main causes of head injury are road accidents, falls, and assaults. There is, however, considerable variation from place to place, with the proportion of admissions due to road accidents ranging from 24% in Scotland to 90% in Taiwan (table 9). Similarly the proportion due to assault ranges from 1% of males in France to 45% of males in Johannesburg; in the United States the range is from 40% for inner city black persons in Chicago to 4% in Olmsted. The distribution of causes also varies greatly with the severity of injury, with road accidents the dominant cause only for severe and fatal injuries (table 10). Within a given severity there is also a pronounced difference in the distribution of causes according to age and sex (tables 7, 8, and 11).

Among those with fatal head injuries from *road accidents* in the United States two thirds are vehicle occupants compared with only 40% in Britain, where pedestrians are often the victims. Pedestrians are apt to be more severely injured than occupants and injuries to pedestrians are particularly common in young children and elderly people. In Taiwan 62% of admissions with head injury from road accidents were motor cyclists, 33% were pedestri-

Table 10 Main causes of head injury according to severity

	A and E attenders	PSW admissions	NSU transfers	NSU severe	Deaths
Year	1985	1985	1985	1984–6	1985
n	5242	1130	572	391	4100
Falls (%)	41	39	37	27	25
Assaults (%)	20	20	15	12	2
Road accidents (%)	13	24	32	50	58
Pedestrians as % of road traffic accidents (%)	29	39	46	50	

A and E = Accident and emergency department (Scotland); PSW = Primary surgical ward (Scotland); NSU = neurosurgical unit (Glasgow); Severe = coma > 6 hours (Glasgow). Deaths includes deaths at scene (England and Wales).

Table 11 Causes of head injury in admissions according to age and sex (Scotland 1985)

	< 15 y	15–64 y	> 65 y	Males	Females	All
n	351	653	117	785	336	1121
Falls (%)	55	27	40	35	49	39
Assaults (%)	5	32	3	34	12	20
Road accidents (%)	23	24	23	24	23	24
Pedestrians as % of road traffic accidents (%)	63	24	52	34	49	39

ans, and only 5% were vehicle occupants. Clearly recommendations for preventive measures must take account of local conditions. There is increasing awareness of the importance of bicycle accidents, which are particularly common in children.[55-57] Most of the childhood accidents result from falls rather than collisions, and are often sustained off the road. It is often unclear whether they are included in road accident statistics or come under recreational activities.

Falls are a significant cause of head injury, particularly in young children and elderly people. Many falls in adults are related to alcohol and others result from assault, so that falls are likely to be underreported and the details are often inaccurate.

Assault is a common cause of head injury in some places, particularly in economically depressed and densely populated urban areas. In the Bronx[34] and inner Chicago[35] assault was the leading cause of head injury, but overall in the United States it accounted for only 10%. Within Rhode Island[36] and San Diego[58] rates of admission to hospital for head injury due to assault varied fivefold with deciles of median income. The frequency of gunshot wounds of the head in the United States is unique to that country, but there are wide regional variations there. There were 31 764 firearms related deaths in the United States in 1986, half of which were suicides and a third homicides; in some places gunshot wounds of the head account for half of all suicides and homicides.[59] Only 3%–6% of all admissions for head injury in the United States were due to firearms; they accounted for 20%–40% of all deaths from head injury in some local studies but for only 14% in the national deaths review.[38]

Alcohol is an important contributory cause of injury and its influence is best documented for road accidents, and especially for drivers. However, studies in New York city[60] and Glasgow[61] both showed that pedestrian victims of head injury were more often intoxicated than injured drivers. In San Diego over half the brain injured cyclists over the age of 15 were intoxicated.[55] Alcohol is also a common feature of victims of assaults, of falls, and of suicides. In admissions for head injury in Scotland alcohol featured four times more often after falls and assaults than after road accidents; in the latter pedestrians were affected twice as often as vehicle occupants.

Almost any *sport or recreational activity* can result in head injury. It is seldom clear from reports whether injuries ascribed to sport were limited to organised games, or also included informal recreational play. However, the importance of informal play as a cause of head injury in the young is highlighted in a recent report of 58 000 such injuries in United States emergency rooms.[62] Playground equipment and childrens' vehicles (excluding bicycles) were the main causes. In various United States studies some 10% of admissions for head injury were related to sport or recreational activities; in the Scottish survey 12% of new head injuries coming to emergency departments were attributed to sport.

Practical value of epidemiological data

Programmes directed towards reducing the number of head injuries, and minimising the damage to the brain when an accident does occur, have already had some impact. A strategy of prevention is, however, unlikely to realise its full potential unless there are reliable data about the incidence, demography, and geography of injuries in different places. Neither can the provision of medical services be planned appropriately without this knowledge. There is evidence that mortality can be reduced if there is a coherent scheme for the care of head injuries of all severities, but that most impact is made on less severe injuries.[63] Because mild injuries are so much more common, and among them are some patients who will develop serious but remediable complications, it is essential to have guidelines for the various specialties involved, to ensure that appropriate triage is carried out.[64] This is all the more essential in those countries where CT and neurosurgical services are provided on a regional basis. In those places secondary referral of serious injuries, and of mild injuries at risk of complications, is an essential component of good care for the community as a whole. Monitoring or audit of the care received and of the outcome depends on having reliable denominators. With increasing emphasis in all countries on the quality of care and on cost effectiveness it is important to ensure that reliable data are routinely collected about head injuries of all severities, their causes, and their outcomes.

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