Phillips Report

National Report on Traumatic Brain Injury in the Republic of Ireland 2008

TBI

Traumatic Brain Injury Research Group

Foreword

For decades neurosurgeons have battled to reduce the mortality and morbidity caused by Traumatic Brain Injury (TBI). Modern concepts and a better understanding of the neuro-physiology and biochemical mechanisms of brain cell death, together with advances in critical care, have reduced mortality rates. Unfortunately, improved hospital survival figures mask the greater tragedy of those who survived their injuries, sometimes desperately disabled for the rest of their lives.

With greater urgency than ever we turn to the concept of injury prevention. Modern media graphically reports the carnage following road traffic collisions on Irish roads and dominates the headlines. However, little is said of the other silent epidemic – falls and injuries in the home. These accidents increasingly involve our aging population and result in significant disability and death. Why, where and how do these injuries occur; who is affected? No single national study in the Republic of Ireland has yet succeeded in answering these questions.

The epidemiology and demographics of traumatic brain injury are the subject matter of this study. It is a two year snap shot of TBI in Ireland. Our aim is to inform discussion and promote change.

Improvements in service provision must be targeted towards areas where improvements are both needed and possible. This report asked specific questions; who was most vulnerable to injury, what were the events surrounding injury and what was the nature of the injury sustained as different injury requires different treatment. This information is needed before reforming service provision.

We would like to thank all those involved in sharing the responsibility of TBI in Ireland many of whom are often unacknowledged; the patients living with the consequences, the supportive families and communities who are the backbone of all care, the frontline healthcare workers who put the patients' best interests first and the advocacy groups who champion their cause.

We hope that this report and its recommendations will encourage debate. Now is the time to address the devastation of this disease.

Jack Phillips

Consultant Neurosurgeon

Acknowledgements

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Executive Summary

Traumatic Brain Injury (TBI) is a major cause of premature death and disability in the Republic of Ireland. This two year national audit of over two thousand patients with significant TBI identifies causation, injury detail, management, contributory factors and outcome.

The study was funded by a grant from the Department of Health and Children to Professor Jack Phillips, Consultant Neurosurgeon. The research group was composed of clinicians from neurosurgery, emergency medicine and public health medicine, nursing researchers and medical informatics.

All TBI cases referred to the Neurosurgical Services in Beaumont Hospital, Dublin and Cork University Hospital were included. Cases were identified either following admission to the unit (NSU) or from the national telephone based advisory service log (NAS). Case report forms were generated and entered onto the project database. Data was collected as per guidelines set out by the Good Clinical Practice for Clinical Trials.

Summary:

Who? Men were three times more likely to be injured than women. One in six patients was aged between 16-24 years in this study. The median age has increased over the past two decades.

How? The incidence of TBI amongst road users has decreased in the past decade.
Falls were responsible for 3 of every 5 TBI in Ireland.

Where? Half of the females and a third of the males in this report were injured at home.

Why? 88% were unintentional; 1% was self-harm; 11% were assaults. There was a strong association between assault and alcohol consumption. The number of assaults causing TBI is increasing.

Management?
Two in 5 patients with a severe TBI were treated in a NSU in Ireland; 3 of 5 did not gain access.
Two-thirds of patients required inter-hospital transfer; 40% travelled > 100km, 45% were intubated.
Forty percent of patients admitted to the NSU required surgery, irrespective of the severity of injury.
Severely injured patients required a combination of both operative and non-operative care.

Outcome?
The mortality rate within the NSU was 12%. The mortality rate after discharge from the NSU and the mortality rate for patients not admitted to the NSU were unknown.

Other
Alcohol use was reported for 1 in 4 TBI in Ireland. Four in every five assaults involved alcohol. Alcohol was associated with a greater incidence of severe injury.
One in 7 patients injured in the home was using aspirin and 1 in 10 was taking warfarin. They were at greater risk of complication.
Protective devices: 50% of patients in MVC were not wearing a seat belt, 50% pedal cyclists and 33% of motorcyclists were not wearing helmets.

Recommendations:

Injury prevention

- Implementation of a national “fall and fracture prevention strategy”.
- Participation in the EU Injury Database and establishment of an injury surveillance register.
- Creation of a national injury prevention authority.
- Education: Highlight the strong associations between alcohol and drugs with injury.
- Establish a working party to explore the risk factors and impact of assaults in our community.
- Studies of risk behaviour (risk perception, influences on judgement and populations who under-estimate potential risk) to improve use of protective devices.

Provisions of appropriate services

- Emergency Department: 24 hour CT access; scans performed and reported within 60 minutes.
- Inter-hospital Transfers: A poly-trauma patient should only be transferred when haemodynamically stable. Provision of a 24-hour National Retrieval Service for critically ill patients.
- Neurosurgical management: Provision of sufficient neuro-critical care facilities in Ireland so that all patients with a severe TBI (GCS 3-8) can be treated in a neurosurgical unit in line with international best practice, irrespective of their need for operative intervention.
- Performance assessment: Development of a national trauma registry.

An important limitation of this report was that is only studied part of the patient journey; key areas such as pre-hospital care, emergency department resuscitation and rehabilitation were not studied. A national trauma audit system would provide information on the outcome of patients who did not gain access to the NSU.

The findings of this report demand attention. Injury, including TBI, is a silent epidemic. The level of care being provided to some patients at times is less than optimal. Future TBI management strategies must address both the prevention of injury and the provision of appropriate services in line with international best practice.

We have learned a great deal from this project. We conclude that there is a pressing need to establish a national injury surveillance register and a national injury prevention body with similar powers to the Road Safety Authority and Health and Safety Authority to deal with injury prevention. Finally, a national trauma registry is required to provide on-going monitoring of national service provision.

Introduction

1. Introduction

Traumatic brain injury (TBI) is the leading cause of death and disability among young individuals in high-income countries[1,2]. Trauma is the fourth most frequent cause of overall mortality in this country and is the leading cause of death in the Irish population under the age of 45 years[3]. Head trauma accounts for the majority of trauma deaths[4],[5]. For every traumatic brain injury death at least two other people survive with permanent disability[6]. Data from the Traumatic Coma Databank[7] state that death is expected in one third of patients with a severe TBI and another 40% will have a moderate to severe disability. Disability from TBI in Ireland has unmeasured personal, societal and economic consequences.

The true incidence of traumatic brain injury (TBI) in the Irish population is unknown and in general there is minimal data for all types of trauma available from Ireland[8]. Significant variation in the estimated incidence of TBI in Europe exists due to local interpretation of injury severity and different methods of case identification. Current international literature estimates TBI incidence to be somewhere between 150 and 300 per 100,000 persons per year in Europe[9] and 403 per 100,000 emergency department presentations and 85 per 100,000 hospital admissions in the US[10]. In England and Wales, trauma patients with a traumatic brain injury had a ten fold higher mortality rate than patients without head injury (1989-2003) and improvements in trauma care have delivered greater benefit to patients without brain injury[11].

There is a deficit of trauma data collecting systems in Ireland. Some local collection methods exist; selected hospitals have general trauma data from TARN databases[12], ICU data collection from the Critical Care Trials Group[13] and local audit. Other data comes from the Central Statistics Office, the Road Safety Authority, the Coroners' Offices and EU Injury Database[14] (a successor to EHLASS). However, no national mechanism exists for capturing the incidence, management and outcome of TBI presenting to the Irish health care system. Aetiology, incidence and estimates of disability are inferred from international data, which may not be representative of the Irish population.

Improvements in patient care require knowledge of the "at risk" populations, the mechanism and circumstance of the injury, the injuries sustained and their management. This audit was devised to gather baseline information in these key areas and subsequently facilitate targeted provision of resources to both prevent and minimise the morbidity and mortality associated with TBI. It is envisaged that the findings of this report will inform future TBI service development in the Ireland.

The report focuses primarily on acute hospital services but it is anticipated that this knowledge will be relevant to all multidisciplinary health service professionals involved in the provision of care to TBI patients, to health promotion and rehabilitation providers, to patients, their family and carers.

TBI Research Group

2. TBI Research Group

TBI Research Group

The Beaumont Hospital TBI Research Group was established in Beaumont Hospital in 2002. Group members included the following disciplines - neurosurgery, emergency medicine, public health medicine, nursing research and development and medical informatics.

The group were tasked with the establishment and administration of a database for all patients with a significant TBI[i] in the Republic of Ireland. Collected material would provide the information necessary to compile a national report on traumatic brain injury.

Funding Body

This report was funded by the Department of Health & Children through a grant to Professor Phillips. The work was undertaken by a partnership of acute care service providers and key personnel in the following areas: public health, research and development and medical informatics.

Ethical Approval

This study was designed to audit current practise and no interventions in patient care were made. Ethical approval was given by the Hospital's Ethics Committee.

Competing Interests

No financial or competing interests were declared by any members of the TBI Research Group.

Supplementary projects were undertaken by members of the TBI Research Group, in addition to the work identified above. The majority of supplementary work undertaken by members of the TBI Research Group was closely aligned to, and in most instances dependant upon, the TBI registration and recording systems established and described in this report.

[i] The study did not include every patient presenting to an Emergency Departments in Ireland but included those that the treating physician deemed sufficiently serious to warrant neurosurgical opinion.

Neurosurgical services in the Republic of Ireland

3. Neurosurgical services in Republic of Ireland

Neurosurgery is the surgical discipline focussed on treating those central, peripheral nervous system and spinal cord diseases amenable to surgical intervention. Conditions may be traumatic (TBI) and non-traumatic including brain tumours, spontaneous intra-cranial haemorrhage and aneurysms.

There are two neurosurgical units (NSU) in the Republic of Ireland; the national unit is located in Beaumont Hospital (BH), Dublin and the second is located in Cork University Hospital (CUH), Cork. Each centre provides in-patient care and a telephone based neurosurgical advice service (NAS) for both traumatic and non-traumatic illness. This report focuses on the sub-section of neurosurgical patients that have sustained a traumatic brain injury (TBI).

TBI referrals to the neurosurgical unit are made either via the emergency department (ED) of that hospital or as a tertiary referral from another hospital. Initial contact is usually made by telephone to the neurosurgical registrar 'on call' who records the details of the referral in a specific log book. CT imaging of the patient, when appropriate, is sent by an electronic image link from the radiology department, or as a hard copy by taxi, to the NSU. The neurosurgical registrar 'on call' reviews the case and imaging with the neurosurgical consultant 'on call' and a treatment decision is made. The referring hospital is contacted by telephone and, if appropriate, a decision to transfer the patient to the NSU for assessment or admission is made. Alternatively, advice on patient management is given (NAS) with the proviso to contact the NSU again if the patient's clinical condition changes. Both centres offer a 24 hour service.

3.1 Beaumont Hospital

Beaumont Hospital is a large tertiary referral centre, located on the northern periphery of Dublin city, providing acute care services across fifty-four medical/surgical specialities[ii]. The hospital is the main teaching hospital for the Royal College of Surgeons in Ireland. It has a total compliment of 620 acute care beds and is the national referral centre for neurosciences in Ireland. The National NSU has two academic positions affiliated to the Royal College of Surgeons in Ireland[iii].

It provides neurosurgical services for a population of approximately 3.4 million people (22 counties). There are 81 protected neurosurgical beds, including a 10 bed neurosurgical intensive care unit. There are currently 7 consultant neurosurgeons (including two paediatric neurosurgeons), and seventeen non-consultant hospital doctors within the neurosurgical service. There are three designated neurosurgical operating theatres and 116 whole-time equivalent nursing staff in four neurosurgical wards. An additional 18 allied health professionals provide dedicated service to neurosurgical patients.

[ii] Beaumont Hospital is working at almost 100% capacity. In 2005 there were 21,010 in-patient admissions; 123,792 out-patient attendances; 47,952 Emergency Department attendances; 37,258 day-case procedures and 31,557 renal dialysis sessions.

[iii] Professor Ciaran Bolger is a Consultant Neurosurgeon and Professor of Neuroscience at RCSI. Professor Jack Phillips is a Consultant Neurosurgeon and Associate Professor of Surgery.

There is one neurosurgeon for every 470,000 people. In any year, a consultant neurosurgeon provides out-patient services for approximately 750 new and 2,900 return patients. There are over 2,000 in-patient neurosurgery discharges per year, with an average length of stay of 12.4 bed days.
More than seventy percent of all admissions to the National Neurosurgical Centre are emergencies, and include a large proportion of patients with head injuries. The volume of truly elective admissions to the NSU in Beaumont Hospital is restricted by the exceptional demand for emergency and urgent elective care.

The NSU is supported by the allied clinical services in neurology, neuro-anaesthesia, neuro-radiology, neuro-physiology, neuro-psychology and neuro-pathology and non-neuroscience specialities including endocrinology, oncology, plastic surgery, maxillary facial surgery, radiotherapy and rehabilitation. The neurosurgery team also relies heavily on a range of other clinical services typically provided within the framework of an acute hospital.

3.2 Cork University Hospital

CUH is the major tertiary referral hospital in the South-West of Ireland and is the teaching hospital of University College Cork. NSU CUH serves approximately 1 million people (4 counties). The hospital has 556 acute in-patient beds. The service in CUH is provided by 3 consultant neurosurgeons and 8 non consultant hospital doctors (including 2 specialist registrars)[15]. Each consultant performs both adult and paediatric procedures. The NSU CUH has 25 neurosurgical in-patient beds and no dedicated ICU beds. There is one dedicated neurosurgical theatre and general theatres are used in emergency. In 2004 there were 1357 neurosurgical in-patient discharges from CUH of which 770 (57%) were elective and 587 (43%) were emergency. 1327 neurosurgical procedures were undertaken.
They are supported by 2 consultant neuro-radiologists, 2 consultant neuro-pathologists, 2 consultant neurologists and 1 consultant neuro-physiologist. Neuro-anaesthesia is a core module in anaesthetic training in Ireland and several anaesthetists provide significant commitment to neurosurgery.

Patient registration, data collection & analysis

4. Patient registration, Data collection & analysis

4.1 Case Definition

The TBI Research Group adopted the definition of Traumatic Brain Injury (TBI) employed by the Oxford Head Injury Service[16]. It defines TBI as follows:

a) Any blow to the head, even if not knocked out;
b) Including the full range of head injury, from minor to very severe;
c) Including head injury sustained as either the main injury, or in conjunction with other injuries;
d) Including cases who have died as a result of their injury.

Traditionally the severity of TBI is categorised as mild, moderate or severe according to the Glasgow Coma Scale or GCS[17] (Appendix 1). This universally accepted descriptive scale was developed in the early 1970's and using a combination of eye opening, verbal response and motor response scores a patient's level of responsiveness from 3 to 15. Injury severity correlates as follows; Mild is 13-15, moderate 9-12 and severe 3-8[iv]. In this study, a category "Irreversible" was used for a GCS 3 with bilateral fixed and dilated pupils.

4.2 Case Identification

All TBI cases were identified via admissions to the neurosurgical units (NSU) and calls logged with the telephone advice service (NAS). Identification and data collection for each TBI case was undertaken by one neurosurgical registrar and the study co-ordinator in each hospital. Patients were identified via the entries in the neurosurgical registrar's "on-call" log book or via the admissions records in the NSU. Case Report Forms (CRF) were generated and completed for each case identified.

Data was collected, cross-checked and forwarded to the project manager for entry into the TBI database. All hard-copy CRFs were kept on-file. Data was collected as per guidelines set out by the Good Clinical Practice for clinical trials[18]. Systems for TBI case identification and recording were piloted for one month prior to commencement of the study.

4.2.1 Neurosurgical Units (NSU)

Patients admitted to the NSU were either referred from the hospital's emergency department (ED) or were transferred from other acute hospitals in the Republic of Ireland. Occasionally, Irish patients were repatriated from abroad or patients from Northern Ireland were referred to the NSU in the Royal Victoria Hospital in Belfast. Information collected related to demographics, injury details, Glasgow Coma Score (GCS) and physiological parameters at time of injury, investigations performed, details of transfer and medical/surgical interventions undertaken. The study co-ordinator monitored each patient's acute hospital stay, notified the project manager of the date/time of discharge (or death)

[iv] A mild injury equates with a patient who may be confused but responds to verbal stimuli while a severe injury refers to a patient that is either unresponsive or responsive at best to painful stimuli.

and the database was updated accordingly. Participant information leaflets were available throughout the NSU and are available on request.

4.2.2 Neurosurgical Advice Service (NAS)

A 24-hour referral and advice service is provided by the 2 neurosurgical services for all acute hospitals in the Republic of Ireland. This service is for all neurosurgical conditions including but not limited to trauma, tumours and intra-cerebral haemorrhages. The NAS is co-ordinated by the neurosurgical registrar or specialist registrar "on-call" for any given 24-hour period, under the direction of the Consultant Neurosurgeon "on-call". All calls from referring hospitals are recorded in the "on-call directory" or log book. Information recorded in the hard-copy "on-call directory" was extracted by the TBI study co-ordinator, transferred onto the CRF and subsequently recorded in the TBI database. This is the source of information for patients included in the "Neurosurgical advice service" (NAS) category. Patients admitted to the NSU were classified as "Admit to neurosurgical unit" (NSU). Patients re-referred to the NAS and subsequently admitted are included in the NSU category (this corresponds with Episode 2).

4.3 Database Development

Data was entered into the local hospital database using the case report forms. Data was collected over a two-year period, commencing on 1st April 2002 and finishing on 31st March 2004 in Beaumont Hospital and over a one year period in Cork University Hospital from 1st Nov 2003 to 31st Oct 2004.. TBI patients registered in the database had a unique identification number for each injury sustained Patients' confidentiality was maintained using the unique patient identification number and access to personal data was limited to TBI group members.

4.4 Statistical Methods

The Excel database files from Beaumont Hospital and CUH were merged, cleaned and coded using Stata 9[19]. The "Do-files" are available on request. The statistical methods are largely descriptive. Data were not available for each item in all cases; available data frequency is reported (as n=) where applicable. Tests of significance were performed using chi^2 testing when applicable.

Results

National Findings

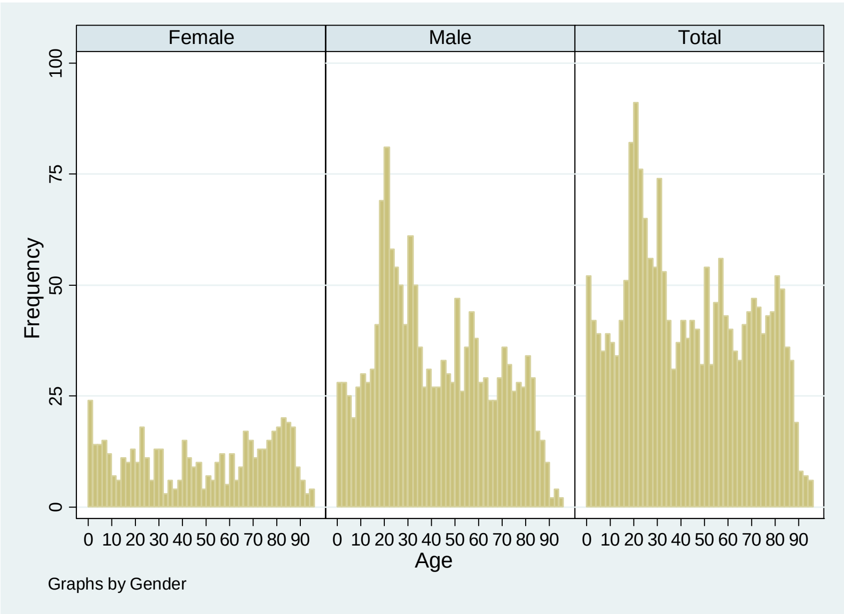
Chapter 5 Results

Two thousand and ninety five patients were registered in total, 1,669 via Beaumont Hospital and 426 via Cork University Hospital. Beaumont, the larger centre collected data for two years and CUH collected data for one year.

5.1 Demographics

Men were three times more likely to sustain a traumatic brain injury than women. Figure 5.1 demonstrates the age distribution of all patients by gender. Female patients show a bimodal distribution of injury with peaks at the extremes of life while male patients demonstrate a dramatic peak in injury for young men aged between 16 and 24 years.

Figure 5.1: Total - age and gender distribution



The overall mean age was 43 years. The median age of men was 40.8 years (CI 39.6-42) and 47.3 years (CI 44.8-49.8) for women. One in three patients (657 patients) were less than 25 years of age; 121 (6%) were under 5, 210 (10%) were aged 5-15 and 335 (16%) were aged 16-24 years. A quarter of patients (524) were greater than 65 years.

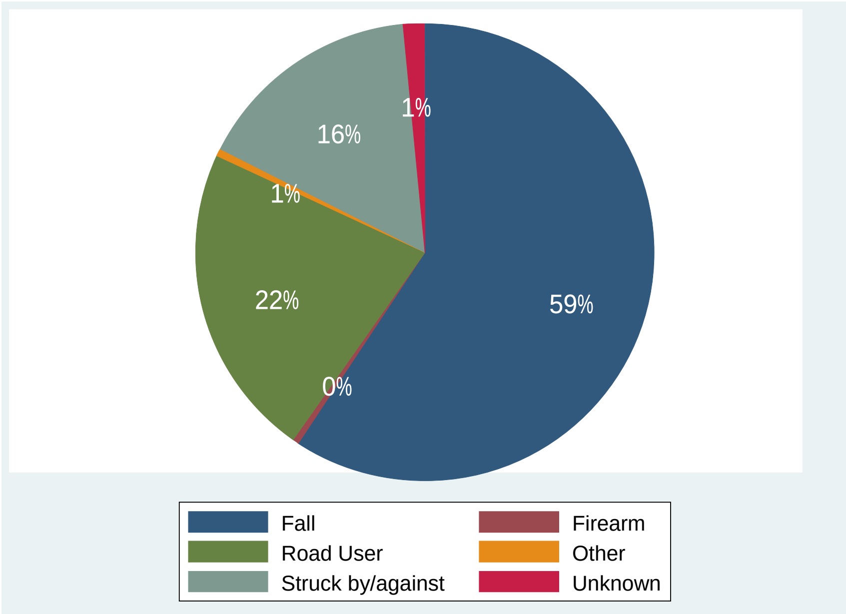
5.2 Cause of TBI

This report looked at three key factors in the occurrence of injury; manner, circumstance and intent. These are standardised terms used to describe the events surrounding an injury[20]. Manner refers to the mechanism of injury, that is, the nature of the force applied. Circumstance refers to the location of injury or the activity performed at the time of injury. Intent examines purpose.

Manner

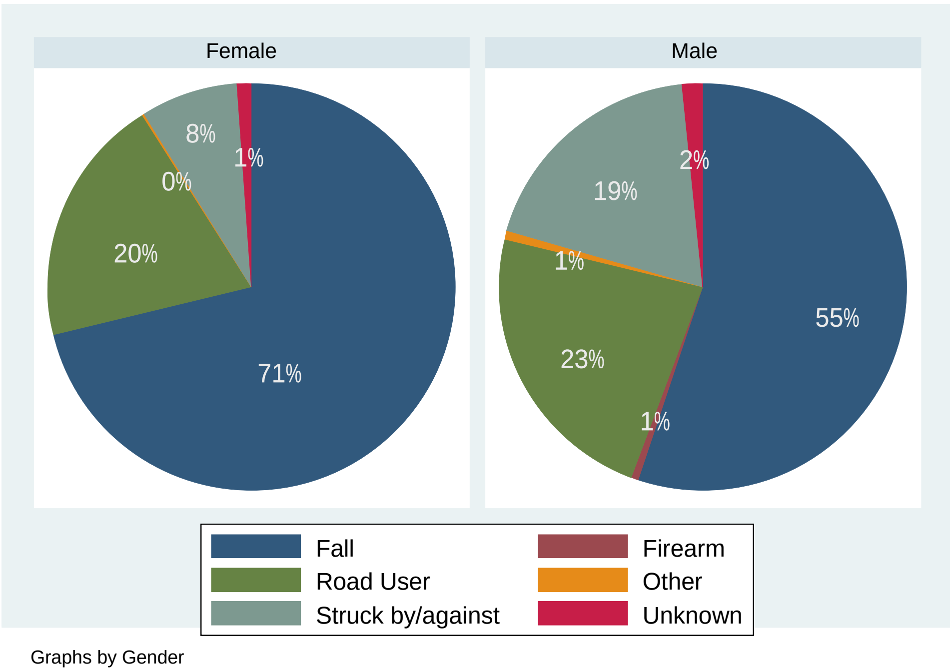
Falls were responsible for the majority of injuries for both male and female patients (1,243 patients or 59%) far outweighing road users (466 patients or 22%) and all other causes (Figure 5.3). Road users include motor vehicles, motor bikes, pedal cyclists and pedestrians. **[n=2,064]**

Figure 5.2: Manner of TBI



Being struck by or against a moving or stationary object is more common amongst men while women are more likely to be injured by falls (Figure 5.4).

Figure 5.3: Gender variation in Manner of Traumatic Brain Injury



Circumstance

The home was the location of over one third of injury). Commuting and recreation[v] were the next most frequent circumstances. Injury during sport, education or employment formed less than 10% of the total injury load. Circumstance of injury differed significantly with gender ($p<0.001$) [n=2,084]

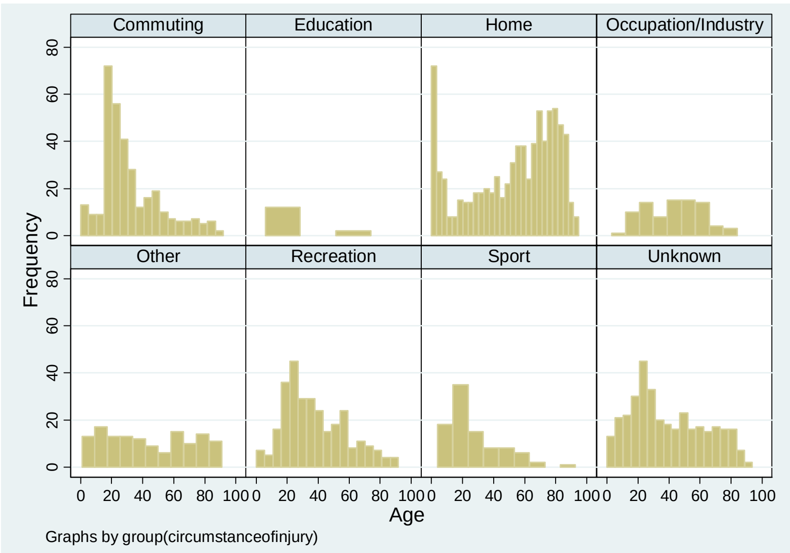
Half the injuries affecting women and a third of injuries affecting men occurred at home (Table 5.1). Ten times as many men were injured in an occupational setting when compared with women.

Table 5.1 Gender variation in circumstance of Traumatic Brain Injury[vi]

Circumstance of injury	Female (%)	Male (%)	Total (%)
Home	268 (50%)	530 (34%)	798 (38%)
Commuting	69 (13%)	252 (16%)	321 (15%)
Recreation	49 (9%)	244 (16%)	293 (14%)
Sport	24 (5%)	69 (4%)	93 (4%)
Occupation/Industry	8 (2%)	76 (5%)	84 (4%)
Education	5 (1%)	9 (<1%)	14 (<1%)
Other	41 (8%)	91 (6%)	132 (6%)
Unknown	67 (13%)	282 (18%)	349 (17%)
Total	**531**	**1,553**	**2,084 (100%)**

Pre-school children and elderly patients were most often injured at home, while young men aged 16 to 24 years are more likely to be injured during recreation, commuting and sport (Figure 5.5).

Figure 5.4: Age variation in Circumstance of Injury



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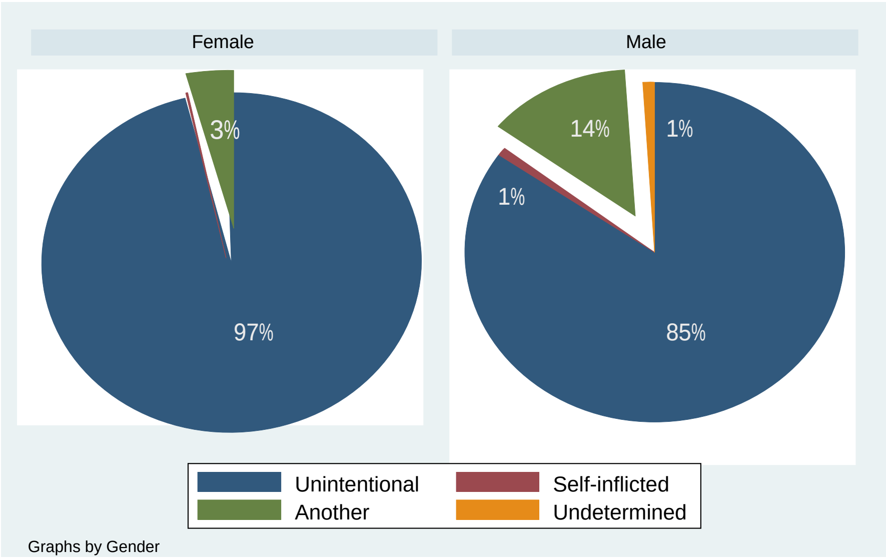
[v] Recreation, an umbrella term, includes leisure activities, entertainment and socialising.
[vi] Information on circumstance was obtained from medical notes or the 'on call' logbook and is often poorly recorded; it was classified as unknown for 17% of patients and when this is analysed further, the data is unknown for 84 out of 794 NSU patients (11%) and 266 out of 1301 NAS patients (20%).

Intent

Intent examined purpose. Injuries could be unintentional where there was no desire to cause harm or intentional where harm was deliberate to either themselves (self-inflicted) or another. Undetermined implies that intent was unclear, for example, whether someone was pushed or fell down the stairs. Injuries were mainly unintentional (88%). Intentional injury, either assault (11%) or self inflicted (<1%) was more frequent amongst men (14% men; 3% women).This is shown in Figure 5.6. [n=2,047]

Figure 5.5: Intent in Traumatic Brain Injury



5.3 Details of Injury

The severity of the brain injury, as measured by the Glasgow Coma Score (GCS), the actual type of injury sustained and the co-existence of other injuries is examined in this section.

Neurosurgical Advice Service (NAS) and Admission to the Neurosurgical Unit (NSU)

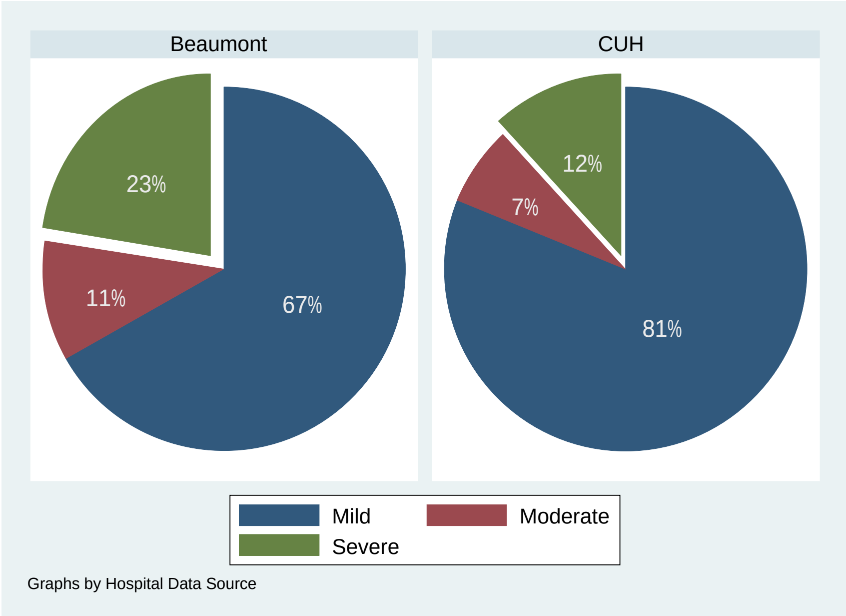
Not all patients with a traumatic brain injury referred to the neurosurgical registrar "on-call" are admitted to the Neurosurgical Unit (NSU). In many instances, advice on management of the TBI is given by telephone (NAS). There were 794 patients admitted to the NSU and 1301 patients managed by the NAS. This section will profile the characteristics of each cohort of patients; the patients admitted to a Neurosurgical Unit (NSU) and those treated in the referring hospital (NAS). NSU patient data is more comprehensive than NAS data as information on the latter was taken from the neurosurgical registrar's on-call log book (4.2.2).

5.3.1 Injury Severity

GCS scores range from 3 to15; 13-15 is considered a mild TBI, 9-12 corresponds with moderate injury and a GCS less than 9 is a severe injury. Generally speaking, a severe TBI (GCS 3-8) correlates with a patient unresponsive to verbal stimuli and, at best, will groan and move abnormally to painful stimuli. An additional category of "Irreversible Injury" was devised for a GCS of 3 and bilateral fixed and dilated pupils where survival was thought unlikely.

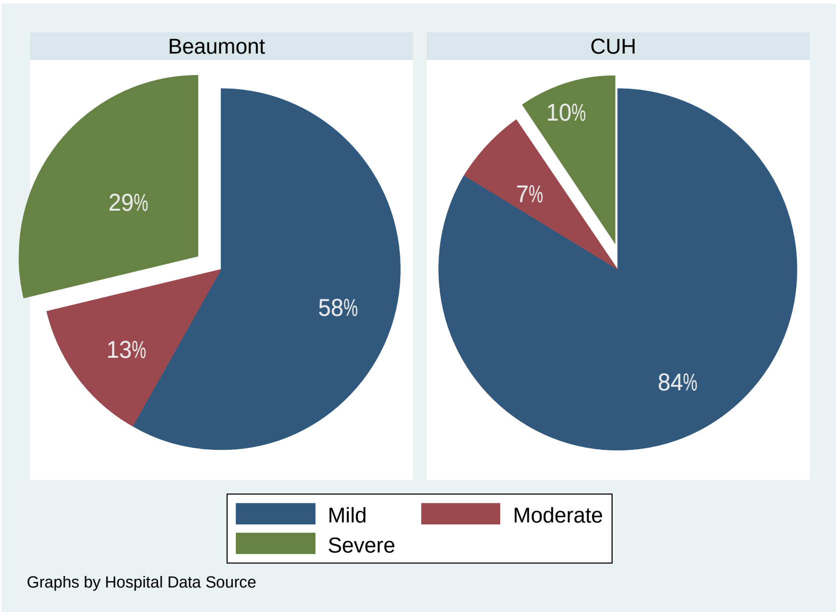
Overall, 1442 out of 2,095 patients (69%) had a mild injury, 205 had a moderate injury (10%) and 420 (20%) had a severe TBI. All of these cases were discussed with the neurosurgical team and are termed "referrals to the neurosurgical service". Severe injuries form 23% of referrals to BH and 12% of referrals to CUH (Figure 5.7). [n=2,067]

Figure 5.6: Injury severity of patients referred to the neurosurgical service



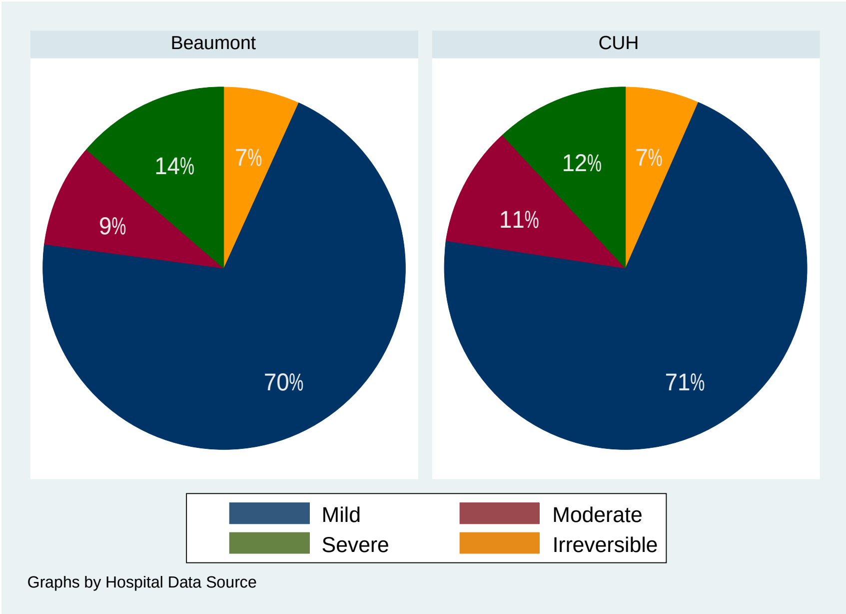
Once the referral to the neurosurgical service has been made, a decision to either admit the patient to the neurosurgical unit (NSU) or to keep them in the referring hospital with specialist advice (NAS) is made. Overall, 174 out of 420 patients (41%) with a severe TBI were treated in a NSU in Ireland. The remaining 246 (59%) patients with a severe brain injury were treated in the initial referring hospital. The NSU in BH has more patients with a severe TBI than the NSU in CUH (Figure 5.8).

Figure 5.7: Injury severity of patients admitted to the NSU (n=794)



The case-mix of patients given advice by telephone (NAS patients) is similar for both institutions (Figure 5.9).

Figure 5.8: Injury severity of patients given advice from NAS (n=1,301)



5.3.2 Injury Type

Different mechanisms of injury result in different injury patterns. Intentional injuries (alleged assaults) often occur due to a single or repeated blow to the head and have a higher incidence of an extra-dural haematoma, cerebral contusion, intra-cerebral haemorrhage and skull fracture (Table 2). Direct trauma over the temporal area can result in extra-dural haematomas (arterial bleeds). They are a neurosurgical emergency and frequently necessitate urgent neurosurgical evacuation. Shearing forces, seen with falls, can tear veins crossing the sub-dural space and cause sub-dural haematomas. A more frequent injury in older patients as brain shrinkage or atrophy is more common. Diffuse axonal injury, a frequent cause of coma, refers to severe, global damage to the axons of the brain's neurons due to rapid acceleration, deceleration or rotational injury (as witnessed in high velocity injuries). It is a microscopic injury, seen poorly on CT or missed on early MRI and is often under-detected.

Table 5.2 describes the different types of brain injury sustained by patients either admitted to the NSU or given advice via the NAS populations. The total count of each injury type is also included.

Patients may have more than one brain injury, for example, any blunt injury may cause a skull fracture, cerebral contusions and bleed. More than 50% of patients had more than one brain injury identified on CT imaging. Cerebral contusions, skull fractures, subdural haematomas and diffuse axonal injuries were the most frequent injuries. Injuries amenable to surgical evacuation or correction (particularly extradural and subdural haematomas) are more frequently to be admitted to the NSU. Table 2 demonstrate this, having a higher incidence of extradural bleeds, subdural bleeds and skull fractures in the NSU cohort.

Table 5.2: Pattern of Brain Injury in NSU and NAS patients

Brain Injury – Type*	NSU patients n=794	NAS patients n=1301	Total n=2,095
Extradural Haematoma	104 (15%)	51 (4%)	155 (8%)
Subdural Haematoma	293 (43%)	268 (22%)	561 (29%)
Subarachnoid Haemorrhage	106 (16%)	142 (12%)	248 (13%)
Intracerebral Haemorrhage	54 (8%)	65 (5%)	119 (6%)
Cerebral Contusion	393 (57%)	756 (62%)	1149 (60%)
Skull Fracture	256 (37%)	297 (24%)	553 (29%)
Diffuse Axonal Injury	98 (14%)	241 (20%)	339 (18%)

*Note patients may have more than one type of injury

Midline shift was present on 546/1892 (29%) of CT scans; 361 patients admitted to the NSU (45%) and 185 NAS patients (14%). Sixty NAS patients (32%) with midline shift had an irreversible injury.

5.3.3 Other injuries

Over three-quarters of all patients (1,630 or 78%) had an isolated head injury and 321 (15%) patients definitely had other injuries. Information on concomitant injuries on the remaining 144 (7%) patients was not available. Once again, a patient may have more than one other injury.
Details of the specific injuries sustained were available on patients admitted to the NSU (Table 5.3). Long bone and pelvic fractures were most frequent, followed by thoracic injury, maxillo-facial injury, spinal injury and intra-abdominal injury in decreasing order.

Table 5.3: Types of other (non-neurosurgical) injury (NSU only)

Other Injury Type*	Number NSU patients (%)
Long bone & pelvic fracture	68 (9%)
Major Chest Injury	54 (7%)
Major Abdominal Injury	19 (2%)
Spinal Injury (n=722)	33 (4%)
Maxillofacial Injury (n=717)	37 (5%)

* Note patients may have more than one injury

5.4 Contributing Factors

Many factors contribute to the occurrence and outcome of a TBI. The loss of self control associated with alcohol and drug ingestion results in high risk behaviour with an associated reduction in co-ordination thus lowering the threshold for injury; prescription medication, particularly cardiac medication, can contribute to falls. Aspirin and warfarin medication increase the bleeding tendency after injury, may aggravate bleeding and worsen the outcome. The incidence of these contributing factors is discussed in this section.

5.4.1 Alcohol ingestion

Alcohol was involved in one in four TBI in Ireland (Table 5.4). There was inadequate recording of alcohol ingestion in 60% of medical notes. When alcohol use was “suspected” but not confirmed then it was included with the unknowns. Alcohol use is highest amongst patients who were struck by or against an object (both intentionally and unintentionally); a third of all struck patients had ingested alcohol and this rose to 80% in the cohort of assaulted patients admitted to the NSU (Section 6.4.4).

Table 5.4: Relationship between alcohol consumption and manner of injury

	NSU patients			NAS patients			Total		
	Yes	No	Unknown	Yes	No	Unknown	Yes	No	Unknown
Falls	31%	31%	38%	20%	10%	70%	24%	18%	58%
Struck	50%	31%	19%	25%	7%	68%	34%	16%	50%
Road User	23%	22%	55%	12%	9%	79%	17%	14%	39%
Other	18%	18%	64%	15%	3%	82%	16%	8%	76%
Total	32%	28%	40%	20%	9%	71%	24%	16%	60%

5.4.2 Drug ingestion

Drug ingestion was poorly recorded. Fifteen percent of case report forms (314/2095) had data available. Twenty-seven out of 2,095 patients (1.3%) had drug use documented; 13 were admitted to the NSU and 14 were given advice by telephone (NAS). The manner of injury included falls (11 patients), being struck (10), road users (4), firearm injury and 2 causes were unknown.

5.4.3 Medication

Aspirin and warfarin exacerbate bleeding. Warfarin therapy reduces a patient’s ability to clot blood and can cause devastating bleeds. Aspirin is an anti-platelet agent that also increases bleeding. Data on these drugs was collected because of their known effect on bleeding and the need for re-operation to achieve haemostasis[21]. The use of these medications is poorly recorded for NAS patients. Almost 10% of NSU patients were on aspirin therapy and 5% were on warfarin (Table 5.5). The INR (International normalised ratio) is one blood test that measures the ability of blood to clot[vii].

Table 5.5: Risk factors for bleeding (NSU patients only, n=794)

	Aspirin Therapy	Warfarin Therapy	INR > 1.5
Yes	71 (9%)	39 (5%)	36 (5%)
No	677 (85%)	707 (89%)	531 (67%)
Unknown	9 (1%)	10 (1%)	186 (23%)
Not documented	37 (5%)	38 (5%)	41 (5%)

Less than 1% of the NAS patients had either anti-coagulation or anti-platelet therapy noted by the ‘on call’ service and of those that did approximately half were on aspirin and half were on warfarin.

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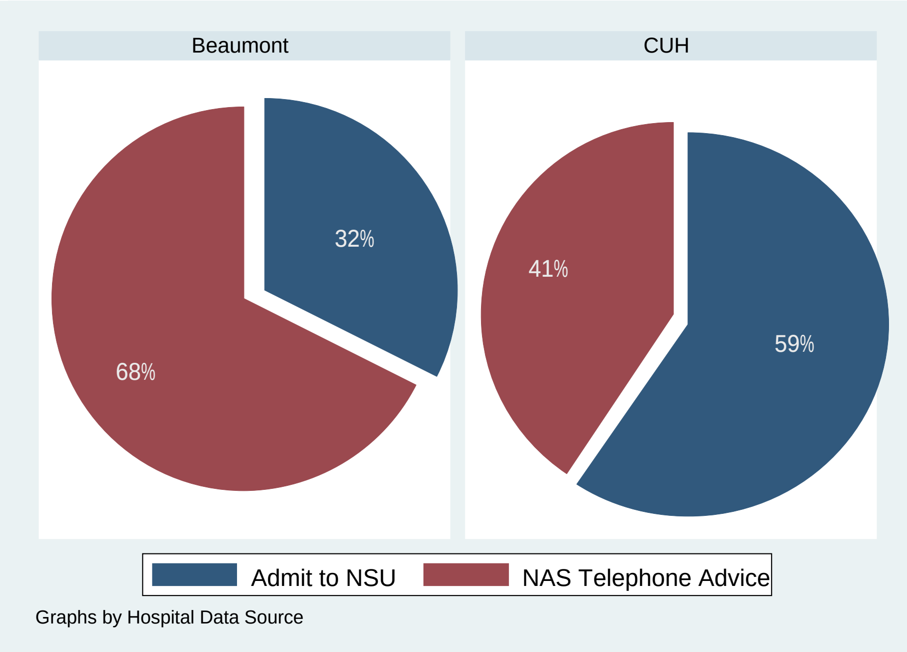
vii The INR compares the patient’s clotting ability to a healthy persons clotting time. Therefore, one is considered normal. An INR of 2 means clotting takes twice as long as a healthy person. Warfarin, liver disease and other medical conditions increase the INR.

5.5 Management

Both neurosurgical services receive numerous calls per day from other hospitals requesting advice or admission for patients with TBI and other urgent neurosurgical conditions (Chapter 3). BH received an average 2.3 TBI referrals per day and admitted 0.75, while CUH received 1.2 referrals per day and admitted 0.7 of these. The patients referred to and admitted to BH had more severe injuries than those admitted to CUH (Section5.3.1). The overall national admission rate of a patient with a TBI to a NSU in Ireland was 38% (794 out of 2,095 referrals). The referral to admission rate was 32% and 59% for BH and CUH respectively (Figure 5.10). The injury severity of NSU and NAS patients is shown in Figures 5.8 and 5.9 (Chapter 5.3).

Figure 5.9: Proportion of TBI referrals admitted to a neurosurgical unit (n=2,095)



5.5.1 Transfer information

Inter-hospital transfer is usually required when a patient is admitted to a NSU (unless the referral originated in the Emergency Department of BH or CUH). There are 35 acute Emergency Departments in the public sector in Ireland and two neurosurgical units (NSU). The overall transfer rate from a referring hospital into a NSU is one journey every two days.

Almost one third of patients (31%), were admitted from the Emergency Departments of the two hospitals with NSU's (BH 56 patients and CUH 193 patients) and did not require an inter-hospital transfer. The remaining 545 patients required an inter-hospital transfer; 485 patients to BH and 60 transfers to CUH.

Distance

Over 40% of patients needed to travel more than 100km to a NSU (Table 5.6). Road transfers are most frequently employed (523/545 patients or 96%), 6 patients (<1%) were transferred by air and mode of transport was unrecorded on the remaining 16 patients (3%).

Table 5.6: Inter-hospital transfers and Distance travelled (Km)*

Distance travelled	Number of Patients (%)
<20 Km	138 (27%)
20-50 Km	118 (24%)
50-100 Km	41 (8%)
100-200 Km	122 (24%)
>200 KM	84 (16%)

* Transfer distance unrecorded for 42 patients (8%)

Transfer details

Two thirds of all patients transferred (355 out of 545) had both a medical and nursing escort. Ninety-five patients (17%) were escorted by a non-consultant hospital doctor alone and 77 (14%) were transferred with a nurse escort. Eighteen patients (3%) were transferred without either doctor or nurse escort recorded (Table 5.7).

Table 5.7: Transfer details for patients admitted to the NSU from another hospital (n=545)

Transfer Details	**Yes**
Escorted by Doctor*	432 (79%)
Escorted by Nurse	413 (76%)
Escorted by Doctor and Nurse	355 (65%)
Unescorted	18 (3%)[viii]
Intubated before transfer	246 (45%)

* Doctor information; 431 were NCHD's and 1 was a consultant

Intubation for transfer

Patients with severe TBI frequently require intubation as a) they are unable to protect their own airway and are at risk of aspirating secretions or vomit, b) to regulate oxygen and carbon dioxide levels, c) to facilitate treatment of raised intracranial pressure and d) to manage the severe agitation that can accompany a TBI. Almost half (43%) of patients transferred to the NSU from another hospital were intubated and a further 6 patients (1%) were intubated after admission to the NSU.

Half (101/206 or 49%) the patients transferred more than 100km were intubated. Generally an experienced anaesthestist will accompany the patient often resulting in an essential staff deficit in the referring hospital. The majority of adult intra-hospital transfers in Ireland for TBI patients are performed without a formal retrieval team. The mobile intensive care ambulance service (MICAS)[22] will transfer TBI patients on a semi-elective basis from one intensive care unit to another from 9am to 5pm on weekdays. It does not provide a service from the ED to ICU.

[viii] Ten of the 18 patients had a GCS 15

NATIONAL

Referring Hospitals

Beaumont Hospital received referrals from 22 counties and CUH received referrals from the other four. Some overlap occurred, for example Waterford Regional Hospital, the Mid-Western Regional Hospital and South Tipperary hospital often referred to both units. The source of the patients admitted to the NSU in BH is shown in Table 5.8. The identity of the hospitals contacting the neurosurgical service in BH was recorded in the 'on call' log book, but a limitation of this study, is that they were not recorded in the TBI database. This additional data was recorded in the CUH database. Results in Table 5.9 refer to the both source of patients admitted to the NSU and given advice via the NAS.

BH accepts much fewer patients with TBI from its own ED (52% of CUH admissions were via their ED compared with 10% from the ED in BH). The majority of referrals to the NSU in CUH come from its own Emergency Department, which is the largest ED in the South West of Ireland

Table 5.8: Beaumont Hospital - Source of patients admitted to NSU*

Hospital	Number of patients	Hospital	Number of patients
Beaumont Hospital	56	Our Lady's Hospital for Sick Children	5
Cavan General Hospital	19	Our Lady's Hospital, Navan	10
Children's University Hospital	11	Portiuncula Hospital, Ballinasloe	10
Connolly Hospital, Blanchardstown	24	Roscommon County Hospital	14
Galway University Hospitals	27	Sligo General Hospital	21
Kilkenny General Hospital	26	South Tipperary General Hospital	1
Letterkenny General Hospital	15	St Colmcille's, Loughlinstown	12
Louth County Hospital	6	St James Hospital	31
Mater Misericordiae University Hospital	29	St Michael's Hospital, Dun Laoighre	1
Mayo General Hospital	18	St Vincent's University Hospital	38
Mid-Western Regional Hospital-Limerick	1	Tallaght – AMNCH	45
Mid-Western Regional Hospital Nenagh	1	Waterford Regional Hospital	2
Midland Regional Hospital – Mullingar	9	Wexford General Hospital	16
Midland Regional Hospital – Portlaoise	14	Private Hospital - various	2
Midland Regional Hospital – Tullamore	16	Abroad (including Northern Ireland)	4
Naas General Hospital	23	Unknown	1
Our Lady of Lourdes Hospital, Drogheda	34	**Total**	**541**

*The source of hospital receiving advice from the neurosurgical service in BH was recorded in the 'on call' log but not into the study database.

Table 5.9: CUH - Source of patients admitted to NSU and given advice via NAS

Hospital	Admitted to NSU	Managed via NAS	Total
Bantry General Hospital	3	10	14
Cork University Hospital	193	29	222
Kerry General Hospital	8	28	36
Mallow General Hospital	8	13	21
Mercy University Hospital	6	10	16
Mid-Western Regional Hospital –Dooradoyle	11	22	33
Mid-Western Regional Hospital Ennis	6	8	14
Mid-Western Regional Hospital Croom	1	0	1
Mid-Western Regional Hospital Nenagh	2	4	6
South Infirmary Victoria Hospital	1	13	14
South Tipperary General Hospital	8	21	29
Waterford Regional Hospital	6	14	20
Other		5	5
Total	253	173	426

5.5.2 Imaging

Computed tomography or CT imaging is the modality of choice for the initial assessment of TBI. It is increasingly more available, even in smaller hospitals, throughout the country. Images are usually "linked" or electronically transferred to the NSU which facilitates review from a distant location. CT imaging was performed on 521 out of 541 patients (96%) admitted to BH NSU and 177 out of 253 patients (70%) admitted to CUH NSU[ix]. A fifth of patients (165/794) admitted to the NSU had a repeat CT scan and 3 (<1%) had an MRI scan. The majority of patients (83%) had neuro-imaging only and 17% had additional scans.

5.5.3 Management in the NSU - Surgical and Non-operative

Forty-four percent (347) of patients admitted to the NSU had a neurosurgical operation. In total, 473 procedures were performed on 347 patients. The procedures performed were craniotomy (196), burr hole evacuation (127), ICP monitor insertion (80), elevation of depressed fracture (36) and extra-ventricular drain insertion (8). An additional 106 (13%) patients had an ICP monitor alone inserted bringing the overall surgical intervention rate to 57%. The surgical operative rate (excluding isolated ICP monitor insertion) was significantly higher in BH than CUH (53% of patients compared with 23%). Some patients with potentially operable conditions not admitted to the NSU. Often, this is because the bleed is small and the patient is clinically stable. A repeat CT is usually performed within 48 hours. Four percent of NAS patients had an extradural haematoma and 22% had a subdural haematoma.

[ix] Seventy-eight patients did not have a CT brain; 70 (90%) had a GCS 15, 52 (67%) had a skull x-ray and 73 (94%) were admitted for less than 48 hours.

It is worth noting that, the rate of surgery (excluding isolated ICP monitoring) is approximately 40-45% irrespective of injury severity. Severely injured patients are admitted to Intensive Care (ICU) and have ICP monitoring more often (Table 5.10). Overall, one third of all NSU patients were intubated; 48% were intubated in BH (257 out of 541) and 13% were intubated in CUH (33 out of 253 patients). Intubation is more frequent with increasing injury severity; Seventeen percent of patients with a GCS 13-15 (mild) were intubated, 52% with a GCS 9-12 (moderate) and 86% with a GCS 3-8 (severe).

Table 5.10: Injury management according to injury severity (NSU only)*

Management	Mild n=514	Moderate n=85	Severe n=174	Total n= 794
Surgical operation (excluding ICP only)	222 (43%)	39 (46%)	72 (41%)	347 (44%)
Admission to ICU – without surgery	33 (6%)	21 (25%)	86 (49%)	142 (18%)
ICP monitor and Surgery	25 (5%)	14 (16%)	39 (22%)	80 (10%)
ICP monitor insertion only	18 (4%)	16 (19%)	69 (40%)	106 (13%)
Intubated	86 (17%)	44 (52%)	150 (86%)	290 (37%)

* missing 21/794 patient's injury severity category.

5.6 Outcome

Mortality rates

The estimates of mortality in this study are limited, and are likely to be significantly lower than the true mortality rate because the mortality rates quoted refer to patients who died within the NSU as the data does not include 1) patients who died in other hospitals that had been referred to the NAS nor to 2) patients that died after discharge from the NSU (for example, after transfer to another hospital or institution). The mortality rates for the NSU and NAS patients are reported separately.

NSU

The overall mortality rate was 12% (97/794) nationally. The mortality rate increased with increasing severity of injury with a rate of 5% (28/514) for mild TBI, 19% (16/85) for moderate TBI and 29% (50/174) for severe injuries. The initial GCS for 3 fatalities was unknown. The mortality rate was significantly higher in BH (16% verses 3% in CUH); this reflects the greater proportion of severely injured patients admitted to BH (Section 5.3.1).

NAS

The mortality rate for this category is not known. However, there is information on the proportion of patients with an "Irreversible Injury". This refers to patients referred to the NAS who had a GCS of 3 with bilaterally fixed and dilated pupils, where death is impending. The national "Irreversible injury" rate was 7% (86 out of 1293 patients) with no variation between the two NSU's (BH 75 out of 1121 and CUH 11 out of 168). The initial injury severity of patients with an "Irreversible Injury" was severe for 70 out of 86 (82%) patients, moderate for 5 patients (6%) and mild for 10 (12%) of patients.

Results

Specific groups

6. Results – Specific groups

Certain populations merit special consideration and are reviewed in this chapter. A comparative overview is presented initially and then specific sub-groups are considered individually. The main areas of interest include falls, injuries at home, road users, sports injuries and assaults. There is some overlap between groups, for example, a person who fell at home would be included in both "falls" and "injuries at home". For this reason sometimes direct comparison between sub-groups is not possible (for example, twenty-two alleged assaults occurred in the home, two patients were intentionally injured during sport and 747 patients fell in the home).

Information regarding the NAS patients came from the neurosurgical registrar's 'on call' logbook. Medical records containing in-patient management were available on the patients admitted to the NSU. In general, both NAS and NSU data will be presented together but when data exist for the NSU patients these additional NSU data will be presented separately. In this "At a glance" section, a summary of combined NAS and NSU data is presented in Table 6.1, 6.3 and 6.4 and additional NSU data is given in Table 6.2. The remainder of this chapter will discuss the sub-groups eg falls and road users in more detail.

The majority of TBI in Ireland is due to falls (59% of all injury) and more than a third of injuries occur in the home. Overall, men are more frequently injured (3:1 ratio) and this ratio increases to 12:1 if the injury was due to an assault. Older patients tend to fall or be injured at home while young patients are injured on the roads, during sports and as a result of assault. More than 10% of all TBI injury is due to intentional injury. There is a higher incidence of severe injury amongst road users.

Table 6.1: Major characteristics of specific sub-groups (NAS and NSU)

Sub-group	Falls	Home	Road users	Alleged Assault	Sports	Total
Number (% total)	1,243 (59%)	803 (38%)	466 (22%)	222 (11%)	93 (4%)	2,095
Male	69%	66%	77%	92%	74%	75%
Mean Age (years)	50	52	31	32	27	43
Admit to NSU	38%	41%	40%	34%	51%	38%
Unintentional	97%	96%	97%	0	97%	88%
GCS 3-8 (severe)	15%	13%	38%	17%	5%	20%
Alcohol involved	24%	27%	21%	59%	7%	24%
Drugs involved*	1%	1%	1%	5%	0	1%
Irreversible Injury**	6%**	5%**	9%**	3%**	0**	7%**

*Significant amounts of unrecorded data **NAS only

Alcohol involvement is higher in the NSU patients, probably due to better data capture. Four of every five assaults had alcohol involved (80%). Documentation of drug use was low. High velocity injuries, as seen amongst road users, result in a greater incidence of other injuries and in non-operable TBI. Patients with these injuries require higher levels of intubation and ICU admission. Mortality rates, within the NSU, are highest for patients who fell and were injured at home. These patients are older than the overall study population (50-52 years respectively compared with 43 years).

Table 6.2: Major characteristics of specific sub-groups (NSU only)

Sub-group	Falls	Home	Road users	Alleged Assault	Sports	Total
Number (% total)	471 (59%)	325 (41%)	186 (23%)	75 (9%)	47 6%)	794
Alcohol involved	31%	30%	23%	80%	2%	32%
Drugs involved*	1%	1%	1%	8%	0	2%
Other injuries	8%	7%	42%	13%	15%	17%
Intubated	31%	26%	55%	32%	36%	36%
Surgery	49%	54%	28%	51%	34%	43%
ICU without surgery±	13%	21%	37%	12%	19%	18%
NSU Mortality rate	13%	13%	12%	7%	6%	12%

*Significant amounts of unrecorded data

"**Surgery**" refers to a neurosurgical operation (for example, the evacuation of a haematoma or elevation of a depressed fracture) with or without the insertion of an intra-cranial pressure (ICP) monitor. "**ICU without surgery**" refers to patients admitted to ICU for non-operative neuro-critical care (excluding ICP monitor insertion).

"**Irreversible Injury**" refers to NAS patients with a GCS of 3 with bilateral fixed, dilated pupils. The "mortality rate" refers to patients that died within the NSU. It does not include NAS patients who died in other hospitals nor patients who died after discharge from the NSU. The true mortality rate of TBI in Ireland is likely to be significantly higher than the combined "NSU Mortality rate" and "Irreversible Injury rate".

As discussed in Chapter 5.3.2, different mechanisms of injury result in different injury patterns. Table 6.3 shows that the highest frequency of extradural haemorrhage and skull fracture is due to assaults (typically a repeated blow to the head). Subdural haematomas are most common in the older population who fall or are injured at home. Road users, are a collective of motor vehicle collisions, motorbike accidents, pedal cyclists and pedestrians who demonstrate a great variety of injury which is discussed in section 6.3.

Table 6.3: Brain injuries sustained according to sub-group (NAS and NSU)

Sub-group	Falls n=1243	Home n=803	Road users n=466	Assaults n=222	Sports n=93
Extradural Haematoma	86 (7%)	43 (5%)	31 (7%)	30 (14%)	8 (9%)
Subdural Haematoma	437 (35%)	309 (38%)	65 (14%)	32 (14%)	11 (12%)
Subarachnoid Haemorrhage	154 (12%)	86 (11%)	65 (14%)	14 (6%)	5 (5%)
Intracerebral Haemorrhage	48 (4%)	29 (4%)	31 (7%)	24 (11%)	4 (4%)
Cerebral Contusion	661 (53%)	390 (49%)	281 (60%)	141 (64%)	43 (46%)
Skull Fracture	280 (23%)	146 (18%)	132 (28%)	94 (42%)	27 (29%)
Diffuse Axonal Injury	296 (24%)	217 (27%)	26 (6%)	5 (2%)	1 (1%)
More than 1 brain injury on CT	631 (58%)	410 (58%)	187 (65%)	104 (54%)	27 (35%)

Injuries arise due to a transfer of energy. The actual injuries depend on the amount of energy transferred and the specific mechanism of injury. The injuries include brain injury, fractures of any bone (pelvic, long bones, facial and spine), thoracic and intra-abdominal injury. Most “other injuries” are due to motor and motor bike collisions. These are often high energy events due to the speed involved, are and cause a wide spectrum of injury affecting the entire body (Table 6.4).

Sometimes a patient was not accepted to a neurosurgical unit (NSU) because their other injuries took precedence over the brain injury, for example, massive bleeding from a solid organ injury requires immediate surgical correction in the referring hospital to restore haemodynamic stability and reduce secondary brain injury.

Table 6.4: Other injuries sustained according to sub-group (NAS and NSU)

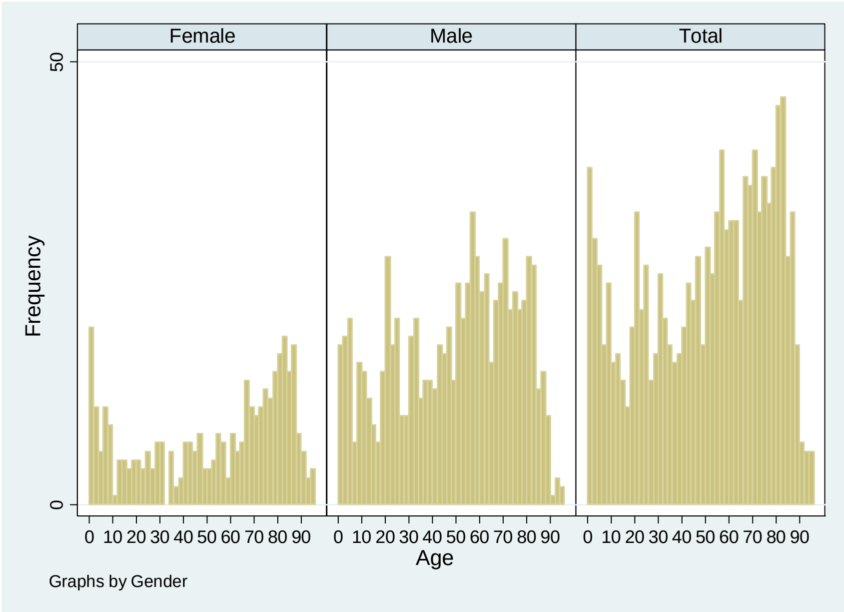
Sub-group	Falls n=1243	Home n=803	Road users n=466	Assaults n=222	Sports n=93
Longbone & pelvic fracture	22 (2%)	14 (1.7%)	40 (9%)	3 (1%)	4 (4%)
Major Chest Injury	18 (1.5%)	7 (0.9%)	34 (7%)	2 (1%)	1 (1%)
Major Abdominal Injury	3 (0.2%)	2 (0.2%)	14 (3%)	2 (1%)	0
Spinal Injury	14 (1%)	1 (0.1%)	15 (3%)	4 (2%)	1 (1%)
Maxillofacial Injury	6 (0.5%)	9 (1%)	24 (5%)	6 (3%)	2 (2%)

6.1 Falls

6.1.1 Demographics

Falls accounted for 59% of injuries referred to the neurosurgical service. Incidence increases with age with peaks at the extremes of age. The median age for falls was 55 years (95% CI 52-57); 8% of patients were less than 5 years old and 37% were over 65 years. The male to female ratio was 2:1 (Figure 6.1).

Figure 6.1: Falls - Age and gender distribution (NAS and NSU)



6.1.2 Cause of TBI

Circumstance

The home is the most frequent location of falls and 749 patients (60%) fell there. Less commonly, patients fell during recreation (159 patients or 13%), work (53 patients or 4%), sports (49 or 4%) and other (60 or 5%). Less than 1% of falls occurred while commuting or in places of education.

Intent

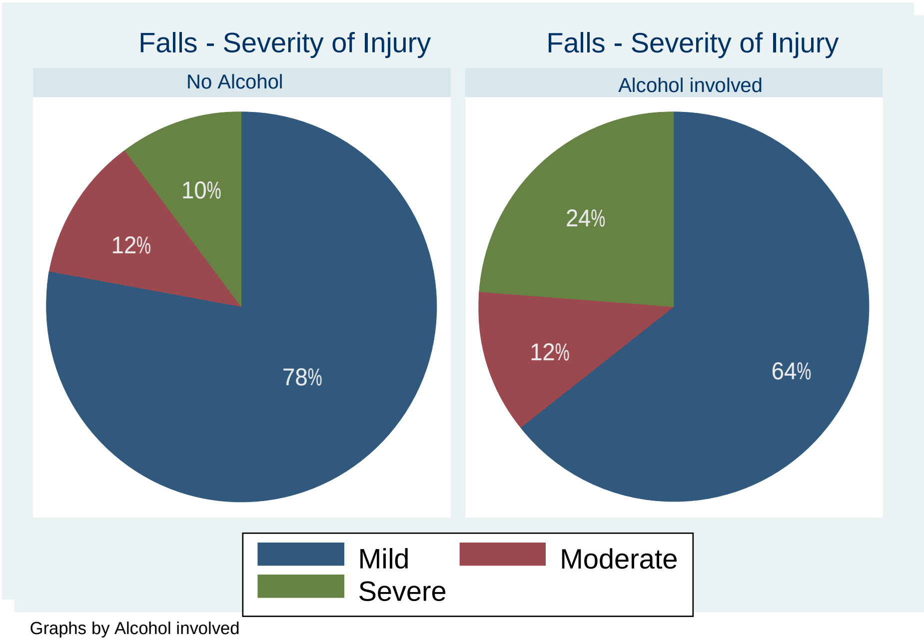
Falls were largely unintentional with only 2% due to another reason; 9 patients fell due to self harm, 2 patients who were intentionally injured, 5 cases were undetermined and 13 were unknown.

6.1.3 Injury details

Injury Severity

Three-quarters of patients who had fallen (913 out of 1,243) sustained a mild injury, 125 (10%) a moderate injury and the remaining 186 (15%) sustained a severe TBI. Injury severity did not vary significantly with gender (p=0.79). Injuries were more likely to be severe if alcohol had been consumed (p<0.001)[x] or if the height of the fall was greater than 2 metres or 10 steps (p=0.016). Figure 6.2 shows the effect of alcohol on injury severity.

Figure 6.2: Falls - Severity of Injury and Alcohol (NAS and NSU)



The incidence of severe brain injury in those who fell (GCS 3-8) doubled when the distance fallen was greater than 2 metres or 10 steps. Falls onto a hard surface resulted in more severe injuries.

Table 6.5: Falls - Factors associated with a severe TBI (NAS and NSU)

Nature of Fall		Frequency of Severe TBI (GCS <9)
Height of fall	<2 metres (582)	70 (12%)
	>2metres (91)	44 (23%)
	Unknown (302)	27 (9%)
Ground Type	Soft eg bed	4/87 (5%)
	Hard eg tiles	100/478 (21%)
	Unknown	39/323 (12%)

Injury type

The injury types are shown in Table 6.3. The most frequent injuries were cerebral contusions (53% patients) and subdural haematomas (35%). Fifty-eight percent of patients had more than one injury noted on CT (for example a subdural haematoma and cerebral contusions).

[x] It is unclear whether alcohol actually causes a more severe injury or if its presence skews the assessment of the injury severity.

6.1.4 Contributing Factors

Alcohol and Drugs

A quarter of all injuries due to falls were associated with alcohol (Table 6.1). Alcohol use was unrecorded in 58% of charts. Some missing data may be explained by age, as 186 out of 1243 patients (15%) were under 15 years and alcohol use is less likely. When patients under 15 were excluded then proportion of falls associated with alcohol increased to 35%. Drug ingestion was poorly recorded and absent in 1042 out of 1243 (84%) notes. Six patients (<1%) were recorded to have used drugs.

Prescription Medication

In the NSU falls patients, aspirin was used by 65 patients (14%) and warfarin by 37 patients (8%).

6.1.5 Management

Over a third of patients (471 out 1243) injured by falling were admitted to the NSU. Almost half (226 patients or 48%) the NSU patients had surgery and one third were intubated (145 patients). Fifty-eight patients (12%) were admitted to ICU without having surgery and 39 of these had ICP monitoring. The high operative rate and lower non-operative ICU admission rate reflects the amenable nature of subdural haemorrhage to surgical correction.

6.1.6 Outcome

The mortality rate for falls patients admitted to the NSU was 13% (61 out of 471 patients died) and the incidence of irreversible injury in the NAS cohort of patients was 6% (46 out of 768 patients).

6.2 Injury in the Home

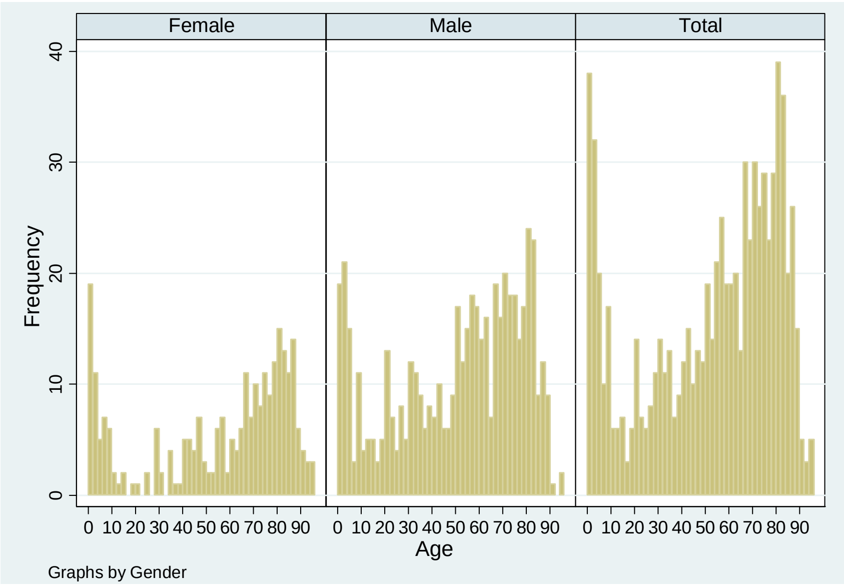
HOME

One in three patients were injured in the home (803 patients or 38%), and when gender is considered, 50% of all women and 34% of men are injured at home. This is twice the number of patients injured while commuting or during recreation (Table 5.1).

6.2.1 Demographics

Two-thirds of the patients injured at home are men (530 men or 66%). The age distribution is bimodal with peaks for pre-school children (less than 5 years) and patients over 65 years (Figure 6.3). The age profile is higher; the mean age is 52 and median age is 59 (95% CI 56-62). Eleven percent of patients were under 5 and in total the under 5's or over 50's accounted for 72% of patients injured at home.

Figure 6.3: Home - Age and gender distribution (NAS and NSU)



6.2.2 Cause of TBI

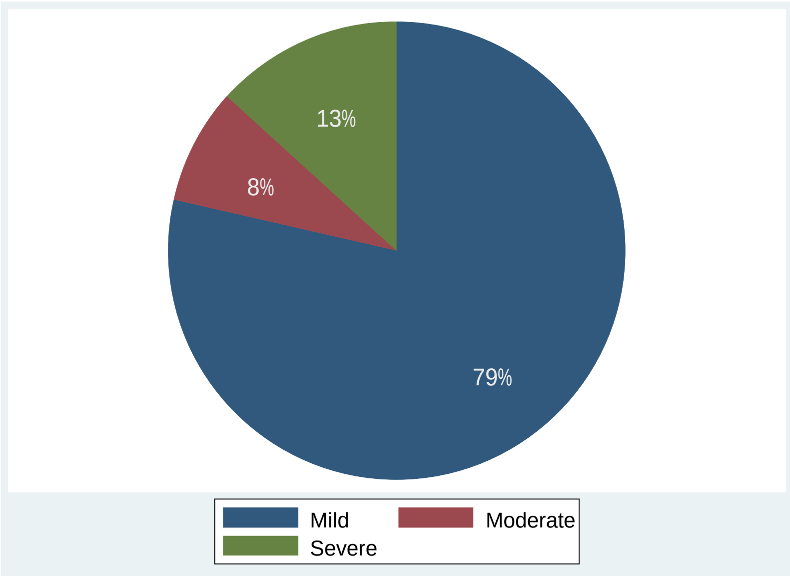
The vast majority of injuries at home were due to accidental falls (747 out of 803 patients or 93%). Another 43 patients (5%) were struck by or against an object, almost half of which were recorded as intentional and in two cases the assault was self-directed. The remaining 11 patients were injured in a variety of ways, including two intentional firearm injuries.

6.2.3 Injury Details

Severity

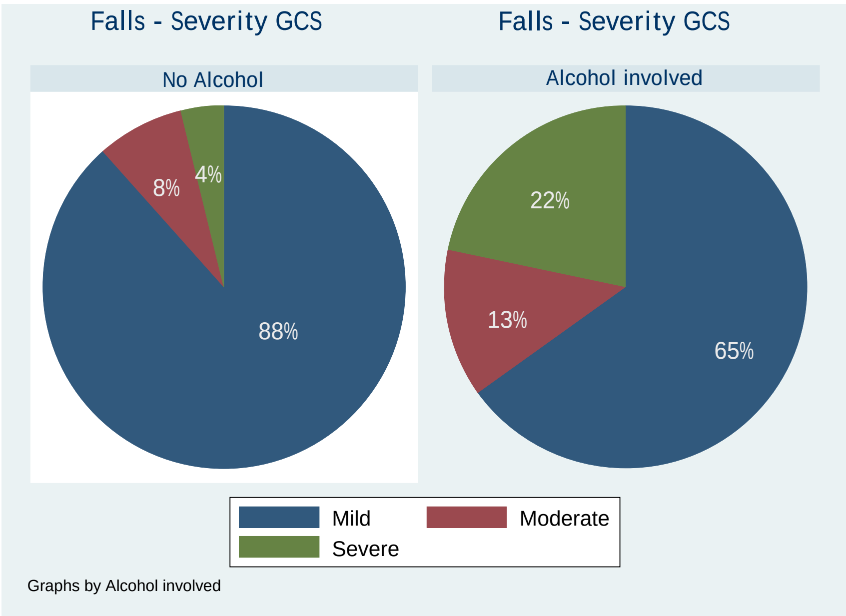
Those injured in the home typically had less severe TBI compared to the general population (13% and 20% respectively with a GCS 3-8). The most severely injured patients were aged 45-54 years; 31% of this age group (21 out of 69) had a GCS < 9, compared with 13% of the group total. Less than 5% of children under 10 years had a severe injury. There was no gender difference in this group in terms of injury severity. The overall distribution of injury severity is shown in Figure 6.4

Figure 6.4: Home - Severity of injury (NAS and NSU)



Alcohol use was associated with a higher rate of severe injury (p<0.001). Six out of 155 patients (22%) who were injured at home and used alcohol had a severe TBI compared with 22 out of 175(4%) who had not used alcohol (Figure 6.5).

Figure 6.5: Home - Severity of injury and alcohol (NAS and NSU)



Injury type

The most common injuries sustained at home (Table 6.3) were cerebral contusions (49%), subdural haemorrhage (38%) and diffuse axonal injury (27%); 58% of patients had more than one injury. Subdural haematomas are more common in older patients, consistent the age distribution for this patient sub-group.

HOME

6.2.4 Contributing Factors

Alcohol and drug use at the time of the injury for those injured at home is shown in Table 6.6. Alcohol use was frequent; 27% of all patients and 32% of patients if patients under the age of 15 are excluded. Alcohol use was associated with greater injury severity ($p<0.001$); 22% of the patients who had consumed alcohol had a severe TBI compared with 4% of patients who had no alcohol[xi].

Table 6.6: Home - Alcohol and Drug (NAS and NSU, n=803)

	Yes	No	Unknown
Alcohol Ingestion	180 (27%)	158 (23%)	335 (50%)
Drug Ingestion	7 (1%)	125 (19%)	540 (80%)

Prescription medication for patients injured in the home and admitted to the NSU is shown in Table 6.7. Aspirin and warfarin were higher than other sub-groups reflecting the older demographic; 1 in 7 patients were on aspirin and 1 in 10 were on warfarin therapy.

Table 6.7: Home - Medication use (NSU only, n=325)

	Yes	No	Unknown
Aspirin	46 (14%)	264 (81%)	15 (5%)
Warfarin	32 (10%)	277 (85%)	16 (5%)

6.2.5 Management

Of the 325 patients admitted to the NSU (40% admission rate), 171 had surgery (53%), 85 were intubated (26%), 41 had ICP monitoring (13%) and 26 were admitted to ICU bed within the NSU without surgery (8%). (78% of sub-dural haematomas were surgically evacuated).

6.2.6 Outcome

Forty-three patients admitted to the NSU died while in the neurosurgical unit, giving a mortality rate of 13%. Another 26 patients (5%) in the NAS group had an irreversible injury.

[xi] It is unclear whether alcohol actually causes a more severe injury or if its presence skews the assessment of the injury severity.

6.3 Road Users

Road users are people in motor vehicle collisions (MVC), motorbike collisions (MBC), pedal cyclists and pedestrians and collectively they account for almost a quarter of TBI in Ireland.

6.3.1 Demographics of Road Users

While age and gender vary within each category, road users were generally young and men were injured more often than women (Figure 6.6). The age profile is young (Table 6.8); the mode refers to the most frequent age injured and it ranges from 12 for pedal cyclists to maximum of 18 for motorcyclists. The mode for patients involved in MVC is the legal age for driving, 17 years.

Figure 6.6: Road users - age and gender distribution (NAS and NSU)

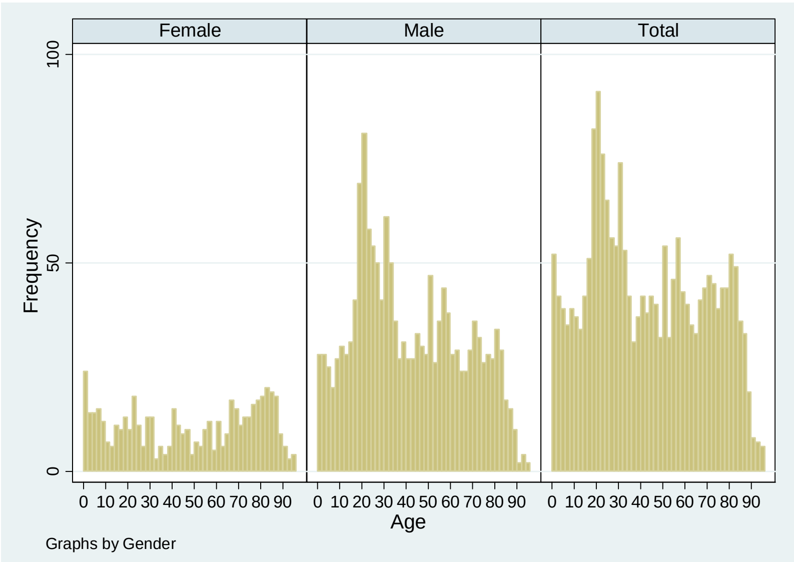


Table 6.8: Demographic profile of road users (NAS and NSU).

Sub-group	MVC n=263	MBC n=46	Pedal Cyclists n=69	Pedestrians n=85
Number (% total)	265	47	69	84
Male	76%	89%	81%	72%
Median Age (95% CI)	26 (23-29)	21 (18-28)	17 (12-29)	30 (21-39)
Mean Age (years)	33	25	27	35
Mode (years)	17	18	12	14

6.3.2 Cause of TBI

Motor vehicle and motorbike collisions usually occurred while commuting (95% and 87% respectively). The circumstance surrounding pedal cyclist and pedestrian injuries was frequently described as other, unknown and recreation. Unintentional injury was the norm. Less than 3% of injuries were due to other causes; a motorcyclist was injured by self harm, 2 pedestrians were intentionally injured and intent was undetermined for 5 pedestrians.

6.3.3 Injury Details

Injury Severity

Road accidents are high energy events resulting in severe injury. A severe TBI was sustained by a third of road users (38%) and 68% of motorcyclists. Severe TBI in pedal cyclists is low (13%) despite having less protection than people in vehicles as they are slower and energy transfer is less (Figure 6.9).

Table 6.9: Road Users - severity of injury (NAS and NSU)

Sub-group	MVC	MBC	Pedal Cyclist	Pedestrian	Total
Mild GCS 13-15	135 (51%)	10 (21%)	52 (76%)	39 (46%)	236 (51%)
Moderate GCS 9-12	28 (11%)	5 (11%)	7 (10%)	10 (12%)	50 (11%)
Severe GCS 3-8	100 (38%)	32 (68%)	9 (13%)	35 (42%)	176 (38%)

Injury type

Pedestrians are vulnerable; they are often hit at speed without any protective equipment. In this study, they were at most risk of extra-axial injury (extradural, subdural and subarachnoid bleeds). Pedal cyclists had the highest incidence of extradural haematomas. Contusions and fractures were similar amongst all road users (Table 6.10).

Table 6.10: Road Users - Type of brain injury* (NAS and NSU)

Sub-group	MVC	MBC	Pedal Cyclist	Pedestrian
Extradural Haematoma	11 (4%)	2 (4%)	9 (13%)	9 (11%)
Subdural Haematoma	35 (13%)	7 (15%)	8 (12%)	15 (18%)
Subarachnoid Haemorrhage	31 (12%)	8 (17%)	7 (10%)	19 (22%)
Intracerebral Haemorrhage	15 (6%)	6 (13%)	4 (6%)	6 (7%)
Cerebral Contusion	145 (55%)	35 (76%)	37 (54%)	64 (75%)
Skull Fracture	65 (25%)	14 (30%)	22 (32%)	31 (36%)
Diffuse Axonal Injury	12 (5%)	4 (9%)	2 (3%)	8 (9%)

*a patient may have more than one injury

Other injury

High energy trauma produces a significant amount of other injury. Overall, 43% of road users admitted to the NSU had other injuries (Table 6.11); 10 out of 18 motorcyclists (56%), 17 out of 32 pedestrians (53%) and 48 out of 104 people in MVC (46%) had other injuries. Pedal cyclists were the most likely road user to have an isolated head injury (81%).

Table 6.11: Road Users - Other injuries* (NSU only)

Sub-group	MVC	MBC	Pedal Cyclist	Pedestrian
Long bone & pelvic fractures	25 (10%)	3 (7%)	2 (3%)	10 (12%)
Major Chest Injury	19 (7%)	6 (13%)	2 (3%)	7 (8%)
Major Abdominal Injury	8 (3%)	2 (4%)	1 (1%)	3 (4%)
Spinal Injury	12 (5%)	1 (2%)	0	2 (2%)
Maxillofacial Injury	15 (6%)	4 (9%)	1 (1%)	4 (5%)

*a patient may have more than one injury

6.3.4 Contributory Factors

Alcohol and Drugs

At least a quarter of all patients involved in motor vehicle collisions were reported to have consumed alcohol before the collision and its involvement was poorly recorded for another 63% of patients and therefore termed unknown (Table 6.12). When the patient's position in the car was considered, then 35 of the 150 drivers injured had used alcohol. Pedal cyclists were the least likely road user to have consumed alcohol. The recording of drug ingestion was poor.

Table 6.12: Road Users - Alcohol and drug use (NAS and NSU)

Road User	Alcohol			Drugs		
	Yes	No	Unknown	Yes	No	Unknown
MVC	54 (25%)	26 (12%)	134 (63%)	3 (1%)	19 (9%)	192 (90%)
MBC	8 (22%)	6 (16%)	23 (62%)	0	2 (5%)	35 (95%)
Pedal Cyclist	5 (11%)	15 (32%)	27 (58%)	1 (2%)	12 (26%)	34 (72%)
Pedestrian	10 (16%)	17 (28%)	34 (56%)	0	14 (23%)	47 (77%)

Position in vehicle

The patient's position in the vehicle was known for 238 out of 265 (89%) collisions. There were 150 drivers (56%), 53 front seat passengers (20%), 34 back seat passengers (13%) and the position was unknown for 27 patients (11%).

Protective equipment employed

Improvements in engineering and legislation have resulted in many safety devices being employed to protect road users. Their use is discussed in this section.

Seat belts

Seat belts were not worn by 50% of patients involved in MVC's (Table 6.13). Severe injury was more frequent in those not wearing a seat belt (p=0.03); 57 out of 130 patients (44%) not wearing a seat belt had a GCS<9 (severe injury) compared with 24 out of 78 patients (30%) of wearing a seat belt.

Table 6.13: Position in vehicle and seat belt use (NAS and NSU)

	Seat Belt	No Seat Belt	Unknown	Total
Driver	52 (35%)	73 (49%)	25 (16%)	150
Front seat passenger	20 (38%)	28 (53%)	5 (9%)	53
Back seat passenger	5 (15%)	24 (71%)	5 (15%)	34

Driver airbags

These are designed to deploy in only in head-on collisions above a certain force. They protect the driver's head from hitting the windscreen. Only 11 out of 265 notes (4%) referred to airbags; 5 were deployed and 6 were not.

Helmets

The non-wearing of helmets was frequent and noted for one in five NAS and NSU cyclists and motorcyclists (Table 6.14). In the NSU, 15 out of 29 (52%) pedal cyclists and 6 out of 18 motor-cyclists (33%) were reported to be without a helmet. Nine of the 10 motorcyclists without a helmet had a GCS <9 (a severe injury) but no statistical difference is injury severity was proven for either pedal or motorcyclists. Reference to protective devices was often lacking in the medical notes.

Table 6.14: Road Users - Use of protective devises (NAS and NSU)

	Number	Yes	No	Unknown
Seat Belt (MVC)	265	76 (29%)	131 (49%)	58 (22%)
Airbag (MVC)	265	5 (2%)	6 (2%)	254 (96%)
Helmet (MBC)	47	15 (32%)	10 (21%)	22 (47%)
Helmet (Pedal Cyclist)	69	2 (3%)	15 (22%)	52 (75%)

6.3.5 Management

Forty percent (186 out of 466) of road users were admitted to the NSU (Table 6.15). Non-operative, critical care management was common; more than half the patients were intubated and over one third were admitted to an ICU bed (without surgery) or had ICP monitoring. Motorcyclists required the most neuro-critical care; 83% were intubated, 61% were admitted to ICU and 67% had ICP monitoring. Pedal cyclists needed the least critical care facilities of all road users.

Table 65: Road Users - Management (NSU)

Sub-group	MVC	MBC	Pedal Cyclist	Pedestrian	Total
Admit to NSU	104 (39%)	18 (38%)	29 (42%)	35 (41%)	186 (40%)
Intubated	57 (54%)	15 (83%)	8 (29%)	24 (71%)	103 (55%)
Surgery	27 (26%)	4 (22%)	11 (38%)	12 (34%)	53 (28%)
ICU without surgery	37 (36%)	11 (61%)	5 (17%)	17 (49%)	69 (37%)
ICP Monitor	42 (40%)	12 (67%)	4 (14%)	19 (54%)	76 (41%)

6.3.6 Outcome

The road users overall mortality rate was similar to the audit average (12%) with higher levels seen amongst motorcyclists (17%) and lower levels amongst the pedal cyclists (7%). Nine percent of NAS patients were recorded to have had an irreversible injury, rising to 21% of all NAS patients involved in a motorbike collision (Table 6.16).

Table 6.16: Road Users - Mortality and irreversible injury rates

Sub-group	MVC	MBC	Pedal Cyclist	Pedestrian	Total
NAS Irreversible Injury	11 (7%)	6 (21%)	1 (3%)	8 (16%)	26 (9%)
NSU Mortality rate	11 (11%)	3 (17%)	2 (7%)	6 (17%)	22 (12%)

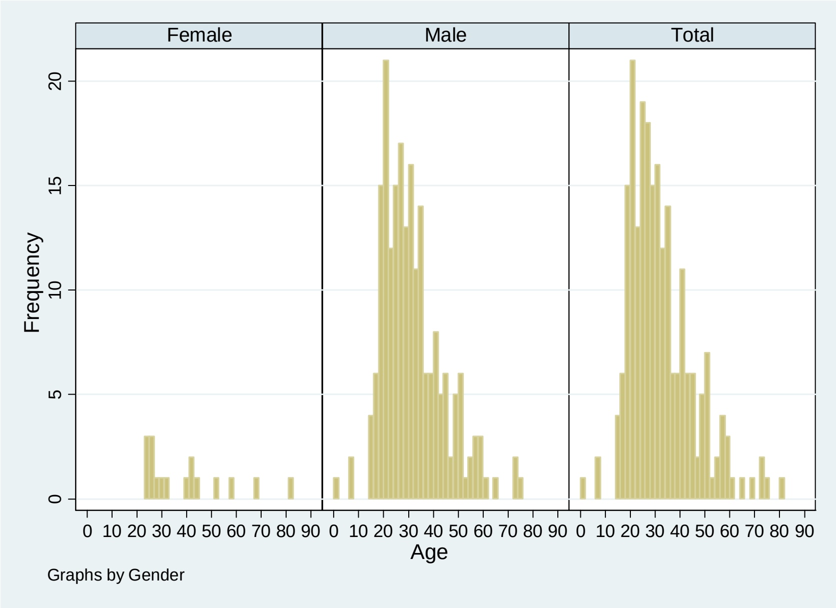
6.4 Alleged Assaults

This section considers all patients that were intentionally injured by another person. In total, 222 patients (11%) of the NSU/NAS total database were alleged assaults.

6.4.1 Demographics

Over 90% of assaulted patients were men (Figure 6.7). The population involved were younger than the NSU and NAS average. Two thirds of patients (145) were aged 16-24 years and within this category 26% (57) were aged 18-20 years. The mean age was 31 and median age was 29 (95% CI 27-31 years).

Figure 6.7: Alleged assaults - Age and gender distribution (NAS and NSU)



6.4.2 Cause of TBI

Nearly all the intentional injuries (215 patients or 96%) involved being struck, either by or against an object, while the remaining manner was either falls (1%) or firearm (1%) related. Injury most frequently occurred during recreation (100 patients or 44%) and the home was second (24 patients or 10%). There was a high proportion of unknown circumstances (87 patients or 39%) particularly in the NAS cohort (70 out of 87 patients). Occupation, education and sport formed 3% of total injury (6 patients).

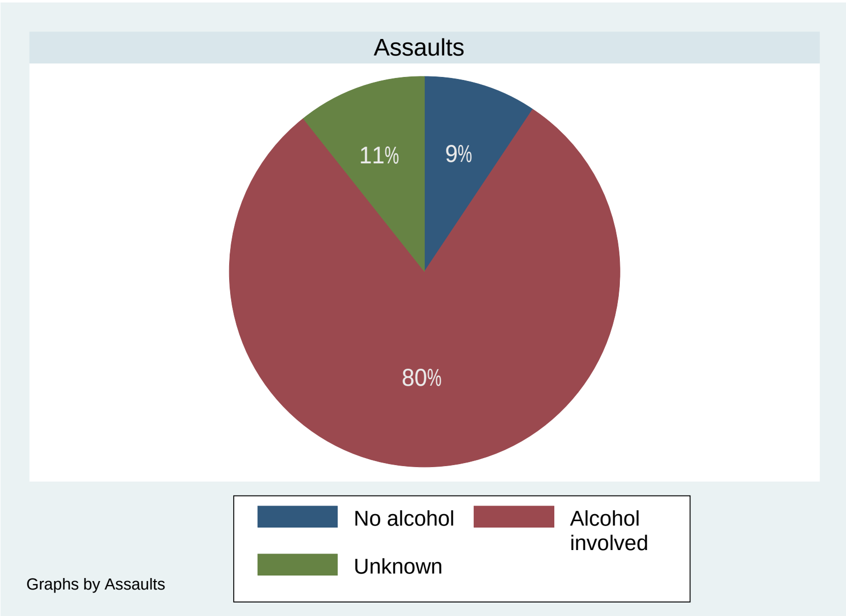
6.4.3 Injury Details

Three-quarters of patients assaulted sustained a mild injury (GCS 3-8), while 37 patients (17%) had a severe injury. The remaining patients were moderately injured. Assaults are frequently due to a single or repeated blow to the head and this pattern of energy transmission results in a higher incidence of extradural haemorrhage, skull fracture and cerebral contusion (Table 6.3). Over 90% of the injuries were isolated head injuries, suggesting that the head was the target of the attack.

6.4.4 Contributory factors - Alcohol/Drugs

Documentation of alcohol ingestion occurs more for assaults than for other sub-groups. Half the NAS and NSU patients (111 out of 222) were recorded as having had alcohol before the injury and this rises to 80% (60 out 75 patients) for patients admitted to the NSU (Figure 6.8). Information on drug use was not available for 92% of patients; 9 patients (4%) were noted to have used drugs prior to admission.

Figure 6.8: Alleged assaults - alcohol use (NSU only)



Medication

Three patients (4%) were on aspirin therapy and two (3%) were on warfarin therapy.

6.4.5 Management

The majority of the 222 patients assaulted were referred to the neurosurgical service from Dublin hospitals; Sixty-one (27%) were referred from the Emergency Department in Beaumont Hospital, 20 (9%) were referred from the Mater Misericordiae Hospital, 18 (8%) were referred from St James hospital and 16 (7%) were referred by the AMNCH hospital in Tallaght. Nineteen (8%) assaults were referred to the neurosurgical service in CUH from their own Emergency Department.

One third of patients (76 out of 222) referred to the neurosurgical service were admitted to the NSU. Half the patients (38 patients) admitted to the NSU had surgery, a third (25 patients) required intubation and 13% (10 patients) were admitted to ICU without having surgery.

6.4.6 Outcome

Five patients admitted to the NSU following an assault died giving a mortality rate of 7%. There were 6 patients not admitted to the NSU with an irreversible injury (4% of the NAS cohort).

SPORTS

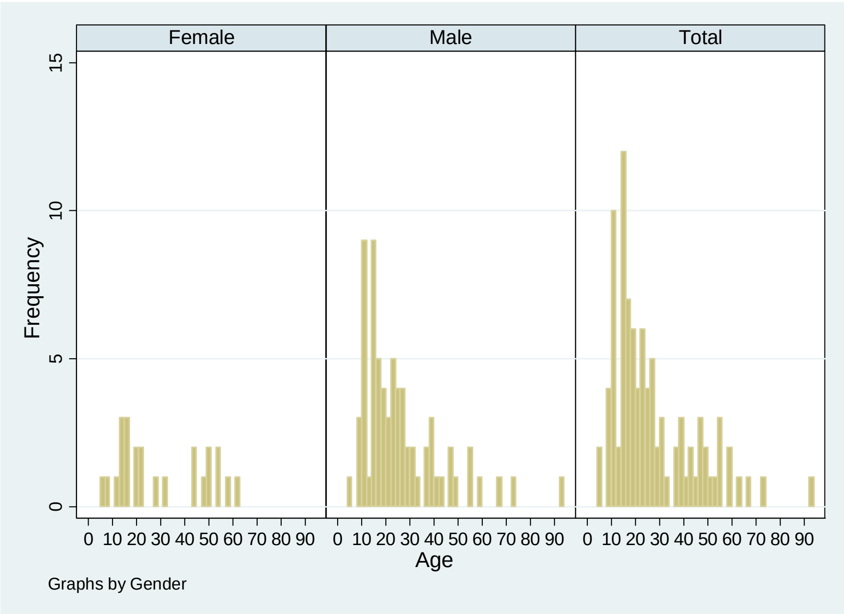
6.5 Sports

Sports injuries, as identified from the circumstance of injury, are discussed in this section. They formed only a small proportion (4%) of all TBI in this study.

6.5.1 Demographics

Again, the gender trend continues with men three times more likely to be injured than women (Figure 6.9). However, the mean and median ages are lower than other sub-groups (mean 27 and median 27, CI 18-25 years). Young adolescents, particularly 10-16 year old boys, are most affected and formed 35% of all sports injuries.

Figure 6.9: Sports - Age and gender distribution



6.5.2 Cause of TBI

Falls and being struck are responsible for almost all the sports related injuries (Table 6.17). Almost all injuries are unintentional. Two patients (2%) were intentionally injured. The study did not record the type of sport involved.

Table 6.17: Sports - Manner of injury

Manner	Number (%)
Fall	49 (53%)
Struck by or against	39 (42%)
Pedal Cyclist	2 (2%)
Unknown	2 (2%)
Other	1 (1%)

6.5.3 Injury Details

Severity

Eighty-one patients (87%) injured while participating in sport sustained a mild injury, 7 patients (8%) a moderate injury and 5 patients (5%) were severely injured.

Injury type

Cerebral contusion and skull fractures were the most common injuries sustained (43 patients or 46% and 27 patients or 29% respectively), reflective of the manner of injury. Falls results in contusions and contre-coup injuries while the force involved in a blow (being struck) can causing a skull fracture. The incidence of diffuse axonal injury and intra-cerebral haemorrhage are relatively low (1% and 4% respectively).

Other Injury

In general, other injuries are infrequent with long-bone and pelvic fractures the most common other injury sustained (4%).

6.5.4 Contributing Factors

Less alcohol and drug use is reported in patients with sports related injuries. Alcohol involvement was noted for 7% of patients and no drug use was recorded. Prescription medication was infrequent with no patients on warfarin and only one patient on aspirin.

6.5.5 Management

More than half the patients injured during sports were admitted to the NSU despite only 5% of them sustaining a severe injury. The incidence of intubation was similar to that of the total NSU population (38%) despite having less severely injured patients. The rate of surgical intervention was significantly lower than the NSU average (16 patients or 17% with sports related injury had surgery compared with 44% of the total). Nine non-operative patients (10%) were admitted to ICU compared with 18% of NSU patients overall.

6.5.6 Outcome

The 3% mortality rate for sports related injury is lower than the 12% study average, probably reflecting a younger population with less severe injury. There were no NAS patients with an irreversible injury.

Discussion

7 Discussion

"Detailed injury data makes it possible to develop prevention measures, monitor injury trends, prioritise issues, guide policies and evaluate the success of interventions designed to reduce injury[23]".

This report provides the Irish public, health care workers and policy makers with some of that data. It is valuable to many stakeholders. It captures quantitative measures of activity; the occurrence, the nature and treatment of TBI from the two neurosurgical units in the Republic of Ireland so the results obtained reflect national data. To date, there are only a limited number of national TBI studies available within Europe. A systematic review in 2005, cites 6 national studies (two from Germany and one from Denmark, Sweden, Finland and Portugal). Differences in patient identification, variations in injury severity definitions and data reporting methods have created difficulties in comparing studies.

7.1 Demographics

The epidemiology of TBI in Ireland parallels the international experience of high-income countries. This report shows that men in Ireland are three times more likely to be injured than women. There is a sharp peak in injury amongst 16-24 year old men; overall, one in 6 patients are aged 16-24 and in the assault sub-group 2 out of 3 patients are aged 16-24. Generally though the mean age of injury is rising and is now 42.5 years. Data from a multi-centre ICU study in Australia and New Zealand[24] show similar results; 74.2% of patients were male and the median age was 42.6 years. A review of 23 studies of brain injury in Europe showed that men are consistently injured more often than women.

A regional study of TBI in Ireland[25], published in 1996, showed the same male to female distribution but the patients were significantly younger (mean age 28 years and 57% were less than 25 years old). This increasing age profile has been demonstrated in many studies. A review article by Maas et al[26] demonstrates that the median age has risen from the mid-20's to the mid-40's over the last 20 years.

Despite the overall rising age profile of TBI patients generally, young men are the most vulnerable patients to TBI in this study and to all forms of trauma in general. The UK's National Confidential Enquiry into Patient Outcome and Death (NCEPOD) on all forms of trauma in 2007 entitled "Trauma: Who cares?[27]" showed that 75% of patients were male and one in 6 patients were aged 16-20 years.

The vulnerability of young people to injury has been recognised in the EU and a task force has been established to examine and minimise the effect of risk taking behaviour amongst 15 to 25 year olds[28].

Summary: Men were three times more likely to be injured than women. One in six patients was aged between 16-24 years in this study. The median age has been increasing over the past two decades in Ireland and in other high income countries.
Recommendation: Further study into why men, and most particularly young adult men, are so vulnerable to trauma and traumatic brain injury. These men need to be targeted specifically when developing risk awareness and injury prevention strategies.

7.2 Causal Factors

7.2.1 Manner

There has been a significant change in the manner of TBI in Europe over the past two decades. Traffic safety laws and preventative measures have reduced the incidence of TBI amongst road users[29]. A 12 month study of patients with TBI admitted to the NSU in Beaumont Hospital in the 1990's found that 48% of injuries were amongst road users, 36% were due to falls and 8% were due to assaults. The report findings show a major change over a decade and now 59% of all TBI are due to falls, 22% occur amongst road users and 11% are due to assaults. The incidence of TBI due to motor vehicle collisions, however, is growing in the developing world and the WHO has projected that this will increase.

The reduction of TBI amongst road users in Ireland has been multi-factorial and includes road improvements, enhanced safety features in cars (seat belts and airbags) and helmets. The Road Safety Authority[30] launched its first road safety strategy in 1998 and the monthly fatality rate has decreased from an average of 39 per month in 1997 to 28 per month in 2007[31]. The cornerstone of its accident prevention strategy is education, enforcement, engineering and evaluation. Goodbody Economic Consultants in a Department of Transport commissioned study estimated that the cost to the state of traffic collisions from 2000-2005 was €10.6 billion, the estimated cost of implementing the first road safety strategy was €169 million and further estimates suggest that the benefit to cost ratio will be 4.5-8.3:1 once further stages of the strategy are implemented[32].

Falls, however, are the silent killers. Tagliaferri et al, estimate that falls are responsible for 21% of head injuries in the USA, 49% in Australia and 59% in India. An economic study of falls in the UK[33] from 2000-2005 showed that 50% of all injuries were due to falls and 33% were due to MVC. The Health Service Executive published a report on falls in 2008[34]. It is estimated that one in three people over the age of 65 will fall once per year and that two-thirds will fall again within 6 months. Currently 11% of the Irish population is greater than 65 years. The Irish Centre for Social Gerontology undertook an economic burden of illness study and state that falls currently cost the economy €402 million per year and that this will escalate unless a "National fall and fracture prevention strategy" is implemented.

Accidents are not unpreventable random occurrences. There is wide scope for prevention. The report "Injuries in the European Union – 2003-2005" estimated that 1400 people die in Ireland each year from injury and 300 of these deaths are preventable. The burden of injury on our health service is larger than many other health problems but is somewhat neglected as a focus for policy development.

Summary: Accidents are preventable. Total fatalities and TBI amongst road users are decreasing, partly due to the effectiveness of the Road Safety Strategy.
Falls are responsible for 3 of every 5 TBI in Ireland, and a major cause of all injury. They are costly to society and cause significant morbidity and mortality.
Recommendation: Implementation of a national "fall and fracture prevention strategy" is needed to reduce the burden of injury caused by falls.

7.2.2 Circumstance

The family home is a common place of injury (38% of all injuries). This finding is echoed in the "Injuries in the European Union –2003-2005" report which state that 43% of all fatalities and 78% of all injuries occur at home, leisure, sports or school and the bathroom, stairs and kitchen are the most dangerous places. This report shows that people who spend the most time in the home, that is pre-school children and the elderly, are most often injured at home.

Sports are high risk (either high energy or confrontational) by nature but form only a small proportion of injury. Regulations, for example, head protection for horse riding, boxing and hurling, are in place to protect sports participants.

Occupational injury forms only 4% of the total TBI load. The Health and Safety Authority[35] , established under the Safety, Health and Welfare at Work Act 2005, is a state body with statutory powers for securing health and safety at work. Eurostat (the Statistical Agency of the European Commission) data for 2005 showed that the non-fatal injury rate in Ireland was a third of the EU average and Ireland has the second lowest non-fatal injury rate in the EU[36]. These statistics tend to support the effectiveness of the HSA in reducing injury.

Summary: Two in 5 traumatic brain injuries occur in the home in Ireland. Occupational TBI and occupational injury are low, possibly due to the effectiveness of the HSA.
Recommendation: Create a political mandate to target injury prevention by participation in the EU Injury Database[37], establishment of a national injury surveillance system and formation of an Injury Prevention Authority, similar to the RSA and HAS.

7.2.3 Intent

The majority of TBI was unintentional (88%) and a small minority was self inflicted (<1%). The level of assault was high and increased gradually from 8% of all TBI in the 1990's to 11% in this report. The estimated incidence in Europe, the USA and Asia is approximately 6-7% but rises to 9% in Australia and 14% in India. One Scottish study estimates that 28% of TBI in Glasgow is due to assault[38].

Assaults involve young men, 2 out of 3 people assaulted were aged 16-24. They cause both death and devastating injury. Alcohol use was reported in 80% of patients admitted to the NSU in this study. Recreational drug use was very poorly documented in this report (noted in 1.3% of patients) but is very prevalent in our society[39]. Cocaine use is an independent risk factor for violent behaviour[40,41] and the victim of the assault may not be the drug user[42]. It is worth noting that the locality with the highest cocaine use in the National Advisory Committee on Drugs report 2008[43] was the area that referred the highest number of assault patients to the NSU (Section 6.4.5). Further study is needed to investigate if there is a link between these statistics.

These injuries are not accidents per se. Preventing intentional injury is a societal issue and not within the remit of any single agency. It reflects society's attitude to conflict-resolution, how strong emotions are managed and how the perpetrator and victim are treated. However, the principles of education, enforcement, engineering and evaluation still apply in assault prevention. Awareness, policing, removing potential weapons (eg glass bottles at concerts) and legal redress are important factors. Simple measures, for example, night-time community transport schemes may reduce late night assaults as young people frequently opt to walk home for economic reasons.

Summary: The incidence of assaults is increasing and higher than international levels. There was a strong association between assault and alcohol consumption. No definite association with drug use can be made, partly due to poor documentation of drug use.
Recommendation: Make the reduction of assaults a priority by a) the establishment of a working party to assess the cause, prevalence, impact and prevention of assaults and b) adoption of the European Council 2007 report[44] on "Recommendation on Injury Prevention and Safety Promotion" (the prevention of inter-personal violence and the safety of children and adolescents being two priority areas).

7.3 Injury Details

7.3.1 Injury Severity

The patients' injury severity in this study was classified according to the initial GCS score in the Emergency Department (ED). A single recording of the GCS is not ideal; it may be falsely low prior to resuscitation or falsely high as the clinical condition deteriorates. This issue was acknowledged by the European Brain Injury Consortium in its survey of head injury management[45]. It was decided in that the GCS score in the ED was the most useful GCS score in stratifying the patient's risk, as subsequent intubation and pharmacological agents will potentially alter GCS assessment further.

Enormous international variation in injury severity occurs depending on the study methods employed; comparison is therefore difficult. The study by O'Brien and Phillips categorised patients admitted to the NSU in Beaumont Hospital using the GCS score. They reported a higher proportion of patients with severe injury (26% mild, 23% moderate and 51% severe). Some comparative papers look at admissions to ICU only (Stochetti's45 and Myburgh's studies had 61% and 57% of patients respectively with a GCS 3-8). Other studies include patients seen and discharged from the Emergency Department and therefore estimate that less than 10% of all patients have a moderate or severe injury.

The Royal College of Surgeons in England[46] and the 2007 NICE guidelines48 on the management of head injury recommend that all patients presenting with a severe brain injury be treated in a neurosurgical centre. This report shows that 41% of patients in Ireland with a severe TBI are treated in a specialised unit. An observational study on behalf of TARN showed that in the UK, 33% of patients with a severe TBI were treated in non-neurosurgical centres and that their odds of death were 2.15 times higher than matched patients treated in a neurosurgical centre.

The lack of specialised facilities in Ireland has been reported by the Neurological Alliance of Ireland[47]and their suggestions include increasing the number of consultants (with the appropriate resources) from 7 to 10 in BH and from 3 to 6 in CUH, improved access to neurosurgical units and improved transportation facilities.

Summary: International recommendations state that all patients with a severe TBI should be treated in a NSU. Two in 5 Irish patients with a severe TBI are treated there. Observational studies report increased odds of death for patients treated outside a NSU.
Recommendation: All patients with a severe TBI (GCS 3-8) are treated in a neurosurgical unit in line with international best practice.

7.3.2 Injury Type

Certain injuries, such as extradural or subdural haematomas are amenable to surgery and 43% of patients admitted to the NSU had neurosurgery (excluding ICP monitor insertion). Other injuries, such as contusions and diffuse axonal injuries are non-operable. All injury, however, can cause raised intracranial pressure (ICP) and optimal treatment for these patients often requires neuro-critical care facilities with or without invasive intra-cranial pressure monitoring. At present, ICP monitor insertion is only available in BH and CUH in the Republic of Ireland. Two large studies[24,455] demonstrate that one third of patients admitted to ICU with a severe brain injury required an operative intervention prior to ICU admission. This report shows that 59% of patients (246 out 420) with a severe non-operable TBI in Ireland are being treated outside a NSU. Stoccheti et al[5], state that the likelihood of a rise in ICP could not be predicted from the motor response on arrival in the ED and a failure to measure ICP may result in inadequate diagnosis and treatment. The NICE guidelines[48] recommend that patients with a GCS less than 9, be managed in a NSU irrespective of the need for neurosurgery.

Summary: Three out of 5 patients in Ireland with a severe TBI do not gain access to a NSU. Predicting the occurrence of raised ICP is often inaccurate without ICP monitoring. Best practice recommends treatment of severe injuries in a NSU, irrespective of the need for surgery.
Recommendation: Provision of sufficient neuro-critical care facilities in Ireland to meet international standards of care.

7.3.3 Other Injuries

Patients may have other injuries which take precedence over the TBI. In this study, 15% of patients had other injuries. An important goal in managing severe brain injury is the prevention of secondary brain injury by maintaining cerebral oxygenation and perfusion and by preventing increases in ICP. This requires early resuscitation and often surgical intervention. International recommendations suggest that a poly-trauma patient should not be transferred to a NSU until they are haemo-dynamically stable and safe for transfer[49].

Summary: Injuries, other than the brain injury, often take precedence in the initial management of a poly-trauma patient.
Recommendations: a poly-trauma patient should not be transferred to a NSU until time critical injuries have been addressed and the patient is haemodynamically stable.

7.4 Contributing factors

7.4.1 Alcohol and Recreational Drugs

Alcohol and recreational drug use were frequently unrecorded in this report. Overall, alcohol is involved in 24% of injuries but this rises to 80% for assaulted patients admitted to the NSU. Drug use is rarely mentioned. Any agent that impairs a patient's consciousness may 1) contribute to the injury 2) mask the injury 3) lead to bias in the assessment of the injury 4) render a patient combative and uncooperative and 5) increase the severity of the injury. Tagliaferri's review of TBI in Europe found reference to alcohol use in 4 out of 23 studies. Alcohol use ranged from 24% to 51% in these studies. This study also reported that alcohol use was associated with an increased risk of severe injury for patients that fell or were injured in the home.

Summary: Alcohol was associated with a) 1 in 4 TBI in Ireland and b) more severe injury in certain sub-groups.
Recommendation: Alcohol awareness strategies must highlight to the public the increased risk of serious injury associated with alcohol use.

7.4.2 Prescription medication

Aspirin & warfarin were included in this dataset. Clopidogrel is another potent anti-platelet agent frequently used in patients with coronary artery disease but was not included in this study. For patients injured in the home, one in seven patients in this report was taking aspirin and one in ten were on warfarin. Studies have shown that anti-platelet agents increase mortality in elderly patients with intra-cerebral haemorrhage due to trauma[50] and increase the likelihood of re-operation to achieve haemostasis. Warfarin, unlike the anti-platelet agents, can be reversed and studies have shown that early normalisation of INR can decrease haemorrhage progression and reduce mortality[51].

Summary: Aspirin and warfarin use is common and their use can increase the risk of bleeding and increase morbidity and mortality.
Recommendation: Patients prescribed these medications should be aware of increased complication if they sustain a TBI and take extra precautions to avoid injury.

7.4.3 Road users and protective devices

Protective devices exist to protect people from injury. However, this study demonstrates that more than 50% of patients in motor vehicle collisions were not wearing a seat belt and they were more severely injured than those wearing seat belts ($p=0.03$). Half the pedal cyclists and a third of the motor cyclists were not wearing helmets. Helmets are proven to save lives. The National Highway Traffic Safety Administration in the USA[52] has shown that helmets reduce the severity of injury and the likelihood of death by 35-50%. When helmet laws are enacted, usage increases and cycling related injuries decrease. There was an 81% increase in fatalities amongst motorcyclists in Florida when the mandatory motor cycle helmet law was repealed.

There is a perception that some patients were the "victim of a tragic accident". However, many neglected to use precautionary behaviour when choosing to use protective devices; their perception of risk and their attitudes towards protective equipment influences the decision making process or changes in circumstance impairs their judgement. Understanding the decision making process is a key factor to developing effective intervention programmes and subsequent behaviour modification.

Summary: Half the motorists and pedal cyclists and one third of motorcyclists injured were not using protective devices at the time of the accident.
Recommendations: Study risk behaviour (risk perception, influences on judgement and populations who under-estimate potential risk) to increase precautionary behaviour.

7.5 Management

The initial reception of the trauma patient was outside the scope of this study. However, intuition dictates that if a patient is not appropriately resuscitated in the pre-hospital and emergency department setting then there is little a neurosurgeon can do to retrieve the situation.

7.5.1 Imaging

One third of patients admitted to the NSU in CUH did not have CT scan at admission. This study did not report the time taken for a CT to be performed. International guidelines recommend the 24-hour CT imaging be available; NCEPOD recommends CT within one hour of arrival to hospital, the American Brain Injury Consortium[53] recommend CT promptly in a stable patient and emergently in a comatose patient and the 2007 NICE guidelines recommend that a CT is performed and reported within one hour. The NCEPOD report Trauma: Who Cares? found that one in five TBI patients did not have a timely CT and delays were primarily due to organisational factors.
The Irish Association of Emergency Medicine (IAEM) Standards Document 2001[54] states that radiology services need to be immediately available on a 24 hour basis. Not all emergency departments (ED) receiving trauma can currently meet these requirements and therefore not all patients are offered the same quality of care. There needs to be acceptance that a rationalisation of ED services in Ireland is needed as "the available evidence emphasises the need to provide timely emergency care to patients in an appropriate setting"[55].

Summary: Prompt CT imaging is the gold standard investigation for acute TBI and access to 24 hour CT imaging is an IAEM standard for Irish ED's.
Recommendation: All Emergency Departments receiving trauma patients should have 24 hour access to CT. Scans should be performed and reported within 60 minutes.

7.5.2 Transfers

An inter-hospital transfer of a brain injured patient occurs every second day in Ireland. This study and the earlier Irish study showed that 45% of patients were intubated and 40% travelled more than 100km. Transfers were usually performed by a non consultant hospital doctor and nurse from the referring hospital. The NICE guidelines and the Association of Anaesthetists of Great Britain and Ireland guidelines recommend that transfers be performed by doctors with adequate training and experience. Since these specialised inter-hospital transfers usually involve staff from the referring hospital, a serious deficit in front line service providers occurs at that site.

The Mobile Intensive Care Ambulance Service (MICAS) currently in commission can facilitate the inter-hospital transfer of a patient from one ICU to another, weekdays from 9am to 5pm. It is not resourced to provide a 24 hour, 7 day service, nor can it accommodate the transfer of an acutely injured patient from an Emergency Department to a NSU. O'Brien and Phillips highlighted that 54% of transfers occurred at weekends and on bank holidays. A 24-hour inter-hospital transfer service is needed which can transfer one or more one critically ill patients to a specialised centre during high demand out-of-office hours periods.

Summary: Inter-hospital transfers were common; 45% of patients were intubated and 40% travelled long distances. The escort is usually provided by the referring hospital, leaving a staff deficit at that site.
Recommendation: Development of a 24-hour retrieval service for critically ill patients.

7.5.3 Operative and non-operative management

Surgical intervention was required for approximately 40% of patients admitted to the NSU. Surgery was performed with similar frequency for patients with mild, moderate and severe injury. Severely injured patients had a greater need for intensive care facilities and ICP monitoring. There is debate regarding ICP monitoring; the level of injury before it is justified and its potential complications. However, many treatment algorithms for severely injured patients depend on ICP measurement. Stocchetti's et al's[45] survey of European ICU practice demonstrated that ICP monitoring led to a greater recognition of intracranial hypertension; infective and haemorrhagic complications were low. The NCEPOD report Trauma: Who cares? states that all severe TBI patients should be transferred to a neurosurgical or neuro-critical care centre irrespective of the need for surgical intervention. The American Brain Injury Consortium guidelines recommend ICP monitoring either peri-operatively for a comatosed patient or in patients with an abnormal CT scan and two of the following: age greater than 40 years, motor posturing and a systolic blood pressure less than 90mmHg.
Surgical management of progressively raised ICP is under review at present and there is an on-going multi-centre study investigating the role of decompressive craniectomy for refractory raised ICP in the trauma patient[56].

Summary: Two in five patients admitted to the NSU have surgery, irrespective of the severity of their injury. Severe injury requires a combination of both operative and non-operative care. ICP monitoring facilitates early recognition and treatment of intracranial hypertension. ICP monitoring is only available in the NSU in BH and CUH.
Recommendation: All patients with a severe TBI are managed in a facility with ICP monitoring, neurosurgery and neuro-critical care.

7.6 Outcome

7.6.1 Mortality rates

International data on mortality varies widely, depending on the characteristics of the study population and type of facility involved. The mortality from the large ICU studies ranges from 27% to 31%. A large regional study in France[57] conducted in 3 NSU serving a population of 2.8 million patients had a very severely injured cohort of patients; 69% had a GCS < 9 and the mortality rate was 52%. Tagliaferri et al's international comparative data estimate mortality for each geographical area as follows: Europe 15.4%, USA 18.1%, India 20% and Asia 38%. Studies also report a reduced life expectancy in patients that survive both mild and moderate to severe TBI[58].
The mortality rate of 12% from this report only includes patients that died within the NSU. Follow up of patients discharged from the NSU or treated in the NAS was not performed. Previous Irish data examined mortality rates and the Glasgow Outcome Score (GOS) for patients admitted to the NSU; overall mortality was 16%, full recovery 54%, moderate disability 17%, severe disability 8% and vegetative state 5%.

Summary: The NSU mortality rate was 12%. Mortality after discharge from the NSU and mortality rates for NAS patients that did not gain access to the NSU was not studied.
Recommendation: A national trauma audit registry would capture the national mortality rate from TBI in Ireland.

Limitations of the report

This report examined the care of the TBI in the acute hospital setting and the events leading up to injury. It did not however encompass the entire patient journey; that is, the care they received in the pre-hospital setting, their initial reception and resuscitation in the Emergency Department, their ongoing progress if they stayed in the initial hospital. Nor did it objectively assess functional outcome and subsequent rehabilitation. This information would be immensely valuable.

The limitations encountered in this report are the building blocks of further study. TBI management in the Republic of Ireland would be enhanced if this data was captured, for example, a system of auditing the progress of the NAS patients would be invaluable. Other areas potential areas include an audit of the early management of TBI patients and follow up of the patients once they leave the NSU with regard to their mortality and long-term functional performance.

Closing Summary

Front-line health care providers generated this report, as an addition to their full time clinical commitment. On-going data collection is warranted but it needs to be part of a cohesive system of trauma audit. There is an over-whelming need for the development of a national trauma registry for all trauma patients[59].TARN, is the largest trauma database in Europe, and at present only one Irish hospital is submitting trauma data there for analysis. An organised system of trauma audit not only provides data on the injury and the patient but it also facilitates comparison of institutional characteristics, highlighting the strengths and weaknesses of a service. The Royal College of Surgeons in Ireland Trauma Audit Committee[60] have calculated that the establishment of a trauma audit system for 13 regionally spread hospitals in Ireland over three years would cost approximately €1.5 million. The proposed system has been welcomed in principle by various state bodies but funding has not yet been allocated to the project.

"Emergency neurosurgical care, like emergency care in general, has benefited from sustained efforts at system planning, integration and cooperation"[61] and a robust audit system is required to inform this process. The European Council's "Recommendation on injury prevention and safety promotion" requests that member states make better use of injury data and develop national injury surveillance and reporting systems. It also advocates that national plans for injury prevention be established that can be guided by national injury data.

Summary: A system for the introduction of a national trauma registry has been developed but not implemented.
Recommendation: Establishment of a national trauma registry.

Recommendations

Recommendations

Injury prevention

- **Implementation of a national "fall and fracture prevention strategy".**
- **Participation in the EU Injury Database and establishment of an injury surveillance register.**
- **Creation of a national injury prevention authority.**
- **Education: Highlight the strong associations between alcohol and drugs with injury.**
- **Establish a working party to explore the risk factors and impact of assaults in our community.**
- **Study of risk behaviour (risk perception, influences on judgement and populations who under-estimate potential risk) to improve use of protective devices.**

Provisions of appropriate services

- **Emergency Department: 24 hour CT access; scans performed and reported within 60 minutes.**
- **Inter-hospital Transfers: A poly-trauma patient should only be transferred when haemodynamically stable.**
- **Provision of a 24 hour National Retrieval Service for critically ill patients.**
- **Neurosurgical management: Provision of sufficient neuro-critical care facilities in Ireland so that all patients with a severe TBI (GCS 3-8) can be treated in a neurosurgical unit in line with international best practice, irrespective of their need for operative intervention.**
- **Performance assessment: Development of a national trauma registry.**

Glossary

ABI	Acquired Brain Injury
BH	Beaumont Hospital
CUH	Cork University Hospital
CRF	Case Report Form
ED	Emergency Department
GCS	Glasgow Coma Score
HDU	High Dependency Unit
HIPE	Hospital In-patient Enquiry System
HSE	Health Service Executive
ICU	Intensive Care Unit
NSU	Neurosurgical Unit
NAS	Neurosurgical Advise Service (telephone)
TBI	Traumatic Brain Injury

Appendix 1

Glasgow Coma Score

The GCS score comprises the values from three component tests (eye, motor and verbal scales). Injuries are classified as severe (GCS 3-8), moderate (GCS 9-12) or mild (GCS 13-15).

Eye opening

1= no response; 2= opens in response to pain; 3=opens in response to speech; 4 = opens spontaneously.

Motor response

1= no response; 2= extension to painful stimuli; 3 = abnormal flexion to painful stimuli; 4 = withdrawal to painful stimuli; 5 = localises to painful stimuli; 6 = obeys commands.

Verbal response

1 = no response; 2 = incomprehensible sounds; 3 = inappropriate words; 4 = confused; 5 = orientated

Minimum score = 3. Maximum score = 15.

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