# Issues of loss to follow up in a longitudinal study of traumatic brain injury.

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## INTRODUCTION

*Longitudinal studies*

Longitudinal studies in neurological trauma and disease have faced many challenges not experienced by other areas of medical research. The inclusion of people who experience cognitive dysfunction due to their neurological disorder makes them unique. Studies of other areas of medicine usually exclude people displaying cognitive disorders as they are difficult to recruit, retain and gain useful information from. Retaining participants within longitudinal studies is important so that the study's validity is maintained, leading to the production of generalizable results. This is the key objective of cohort studies, to ensure the benefit of the research can be made to the broader population (Booker, Harding, & Benzeval, 2011; McGonagle, Couper, & Schoeni, 2011; Newberry, Sherwood, Hricic, Bradley, Kuo and Crago, 2011; Ribislk, Walton, Mowbray, Luke, Davidson, Bootsmiller 1991).

Traumatic brain injury (TBI) is among the most common causes of serious neurological disorder in adults and research is the key to understanding the needs of those who sustain TBI and the needs of those who are the carers of people with TBI (Helps, Henley, & Harrison, 2004-05; Zasler, Katz, & Zafonte, 2007, p.3). The most effective way to carry out this research is through longitudinal studies, although these are difficult to establish and maintain. This is because recruitment often involves consent by proxy due to levels of disorientation, confusion or coma experienced by the potential participant. In addition retention within the study relies on the memory of the participant or caregiver and regular reminders by research staff. Furthermore lengthy interviews are often needed for the information to meet the needs of the research. These three factors make TBI studies time

consuming and expensive. Increasing competition and accountability for financial and human resources, in an environment where people are less inclined to participate in research, means it is important to understand the cohort thoroughly to maximise the information gained and ensure part of the study population is not excluded. (Booker et al., 2011; Newberry et al., 2011; Ribislk et al., 1991).

Once time is allowed for recruitment and initial interview/assessment the priority becomes the maintenance of the cohort between review points. Without the adequate retention of participants a study loses information, loses power and also faces the possibility that it is no longer relevant to the total TBI population which the study was established to help.

Loss to follow up in TBI studies is an issue that requires consideration. TBI research has been identified as a difficult area of research which experiences a loss to follow up rate of 30-50% over a one to two year follow up (Corrigan, Bogner, Mysiw, Clinchot, & Fugate, 1997; Corrigan, Harrison-Felix, Bogner, Dijkers, Terrill & Whiteneck 2003). Such high losses leave a gap in our knowledge as there is no way of knowing how these individuals recover and what effect their injury has on their lives and those around them. It may further indicate an area of unmet need in the community that is yet to be identified, leaving the people affected exposed to medical and psychological impediments.

In addition to exposing an area of unmet need it may be possible to predict who is at risk of dropping out of studies. If people at risk of non-participation in studies and in therapy can be recognised at the time of trauma strategies can be established to assist people to return for follow up interview or treatment. This information is needed by researchers and clinicians to underpin the methodology of future research and the direction of clinical practice ( Zasler et al., 2007, p.38)

The influential work of Corrigan et al., (2003) stated participants were lost to follow up if they could not be located, refused to be interviewed, died, made not response to contact or were unable to be identified.

**Definition of TBI**

The Australian Institute of Health and Welfare defines TBI as "a non-degenerative , non-congenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairments of cognitive, physical and psychosocial functions with and associated diminished or altered state of consciousness" (Helps et al., 2004-05). This definition of TBI does not reflect the different levels of severity that can be experienced ranging from very mild TBI (mTBI) to very severe TBI. Differentiation is required for both research and clinical needs as the care required by patients varies with the level of severity (Tate, McDonald, & Lulham J, 1998). Lack of standardisation of the definition of TBI and classification of severity contributes to the challenges of identifying people with TBI. It also creates lack of consistency between studies (Carroll, Cassidy, Holm, Kraus, & Coronado V, 2004).

The disparities in definition relate to the length of post traumatic amnesia (PTA), the depth of coma and nomenclature for TBI and difficulty of reporting. The work of W.R. Russell (Russell, 1932; Russell & Smith, 1961)is frequently quoted in the literature in discussions on PTA. He characterised PTA as the sum of the comatosed and confusional periods post head injury. This has been more recently adapted to include people who experience mild traumatic brain injury and do not experience any loss of consciousness. This is best demonstrated by the Report to Congress on

mTBI (Gerberding & Binder, 2003) which outlined their concern over inconsistencies of definition between studies. The recommended definition follows-

"The conceptual definition of MTBI is an injury to the head as a result of blunt trauma or acceleration or deceleration forces that result in one or more of the following conditions: Any period of observed or self-reported:

- Transient confusion, disorientation or impaired consciousness
- Dysfunction of memory around the time of the incidence
- Loss of consciousness lasting less than thirty minutes
- Observed signs of neurological or neuropsychological dysfunction, such as:

  Seizures acutely following injury to the head" (Gerberding & Binder, 2003)

The observation of PTA is central to the classification of severity of TBI. Knowing the severity of the injury is vital to planning care and services. It is understood that levels of severity influence the care required for people with TBI (Tate et al., 1998). Russell (1961) defined levels of severity by the length of PTA. PTA of less than one hours is indicative of a very mild injury; less than one day a mild injury; one day to a week a moderate injury; one week to four weeks a severe injury; more than four seeks an extremely severe injury. This categorisation is still prevalent in the literature.

Other attempts to define severity have been made by assessing the depth of coma. The word coma has its origins in Greek. It means deep sleep or a state of extreme unresponsiveness in which an individual exhibits no voluntary movement or behaviour. As with PTA the depth of coma needs to be examined to understand the severity of brain injury sustained. This involves using a tool known as the Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974). This scale is used universally by

clinicians to measure the level of arousal by reviewing the patient's wakefulness, level of orientation and compliance to commands. These three components of the score are given individual scores out of five. The maximum score is fifteen. The minimum, worst score is three. To grade severity of injury mild injuries are reflected in a GCS of 13-15. A score of 9-12 indicates a moderate injury and 3-8 denotes a severe injury. This scale has great utility in the clinical arena when used to share information on a patient's condition and observation of their progress. The use of it in research for the measurement of severity has been questioned however, particularly in relation to the classification of mTBI. Many people who would be classified as mild, by determination of their GCS, may have a PTA that lands them in the moderate to severe category using Russell's methodology (Petchpapai & Winkelman, 2007).

In addition it is difficult to determine the GCS of someone who is so ill following trauma they have been placed in a drug induced coma in the intensive care unit. In this situation it is easier for clinical staff to stabilize a critically ill person by sedation them heavily and using paralysing drugs to prevent any voluntary or involuntary movement from occurring. Recording GCS in this situation is very limited. The patient would not be able to speak due to an endotracheal tube in place breathing for them. They would be unable to move any limbs therefore unable to respond to any commands. The most anyone could score would be a three due to the medication involved. The only response that can be recorded it the pupil's response to light. When the medical team need to assess the patients neurological function they wean the medication, while constantly supervising the patient, to allow the patient to respond to the stimuli around them.

Recreational drugs and alcohol may also affect the ability of the GCS to give an accurate account of someone's neurological state. Excess of either will affect the reticular activating system and reduce the responsive state of the effected person. As a result people presenting to the emergency department are following trauma are often screened for drug and alcohol status so an accurate neurological state can be established.

One other classification system used occasionally is the Abbreviated Injury Severity Score (AIS). This is a score of overall body injury not exclusively TBI related. Injuries are ranked on a scale of 1 to 6, with 1 being minor, 5 severe and 6 an unsurvivable injury. The designers of this scale state it represents 'threat to life' and it is not meant to be used as a measure of severity (Copes, Sacco, Champion, & Bain).

TBI has been described as a global and silent epidemic(Feinstein & Rapport, 2000; Langlois, Marr, Mitchko, & Johnson, 2005; Stuart, 2004). This is due to the lack of accurate reporting of the occurrence in the health care system (Carroll et al., 2004; Cassidy, Carroll, Peloso, Borg, Holst , Holm et al., 2004). In Australia injuries and diseases are recorded and catalogued by means of the International Classification of Disease Codes – Series 10 (Australian Modification), implemented by the World Health Organisation (WHO) in 1994 by member countries (2012). The WHO were concerned that up to 50% of TBI cases may be missed with this system as TBI was not adequately described by the codes. There was no acknowledgement of injury to the brain but a set of injuries of physical structures housing the brain. This resulted in sketchy information for epidemiological work. (Carroll et al., 2004; Helps et al., 2004-05; Tate et al., 1998). Now, in 2012, coding is available for diffuse brain injury and it is categorised by length of coma. This bodes well for future reporting but continues to impair retrospective review of people with brain injury.

In addition to this potential loss of information some people who experience milder injuries do not present to hospitals who use this reporting system. They may be managed by individual general practitioners or they may not even seek assistance as the injury appears mild initially and resulting symptoms may not be thought to be associated with the TBI (Gerberding & Binder, 2003). When these concerns are associated with studies that experience a high rate of loss to follow up our knowledge base of TBI is further jeopardised as it becomes more difficult to identify people in the community with TBI.

**Incidence**

A global view of the incidence of TBI has been challenging to quantify. Rates are extremely variable which may come back to lack of consistency in reporting and documentation. In the US information taken from 1974-1997 find the highest incidence was recorded in Chicago inner city at 403/100 000 in 1980. The lowest rate in the US was 93/100 000 in Iowa in 1993. Both studies included live hospital admissions, hospital inpatient fatalities and non-hospitalised fatalities (Thurman, Coronado, & Selassie, 2007) In Britain 250-300/100 000 hospital admissions each year involve a head injury (Wade, King, Wenden, Crawford, & Caldwell, 1998).

According to the Australian Institute of Health and Welfare South Australia recorded 322/100 000 in 1998. They give the lowest global incidence in Cantabria in Spain having 91/100 000. These numbers are also related to hospital based admissions and fatalities. The authors urged caution in the interpretation of these figures due to the lack of consistency with definitions of TBI and the coding processes in the

reporting of TBI as previously discussed here. Due to these issues it is recognised that previous studies may have been underestimates (Helps et al., 2004-05).

In Australia between 2004-2005 Helps et al. reported 14 190 hospital discharges (separations) with TBI as their primary diagnostic code. They categorised the incidence rates into age groups. The 0-14 age group was 93/100 000. The 15-19 age group had the highest incidence at 284/100 000. Those aged 45-64 rated 66/100 000. The incidence for those aged over 65 rose to 153/100 000. The mid-range age group was not commented on but they state their overall hospitalisation rate was 107/100 000.

The rise and fall of incidence with people's ages is slightly different for findings by Thurman et al. When looking a seven states of the US in 1994 the age related incidence at 75 years and over was 191/100 000; a 65-74 age group was included at 82/100 000. Overall for those over 65 years a higher incidence was recorded in the US. Other age groups are close to the Australian figures.

Thurman et al. (2007) calculated the cause of injuries from these same figures. Transportation injuries were the highest at 48.9%; falls 25.8%; firearms 9.7%; other assaults 7.5%; other injuries 7.4% and unknown cause 0.6%.

Australian figures on cause of injury between 2004-2005 indicate falls having the highest occurrence at 42.1%. Transport injuries make up 29.4%; intentional injury inflicted by another 14.4%; other unintentional injuries 13% and a small level of injuries cause by intentional self-harm, undetermined intention, near drowning, surgical and medical complications(Helps et al., 2004-05). Of these injuries 70% were male.

At a local level in Tasmania the incidence of people discharged from hospitals with a diagnosis of TBI was 278/100 000 in the 2002-2003 period. The biggest age group at

risk was 20-24 year olds followed by 0-4 year olds then the elderly, 80-84 years of age. Men outnumbered women two to one (Slatyer, Skilbeck, Erasmus, Bell, Marsden, 2004).

These figures do not account for people who experience MTBI and are not admitted to hospital or are treated in community health clinics or general practitioners surgeries.

**Loss to follow up in TBI**

The only publication focused on loss to follow up in TBI studies is the work published by Corrigan et al., (1997, 2003). Their 1997 article identified the difficulty of conducting TBI research because of the loss of participants when follow up after hospital discharge is attempted. Having listed a number of longitudinal studies with attrition rates of 39% (TBI Model Systems database) to 51% (Head Injury Program Bethesda Hospital Melbourne) at one year follow up, the team established their own study to examine the possibility those who could not be found after discharge created a systematic bias to their study.

This study involved 88 participants. Transport injuries accounted for 65% of the population, 11% falls, 8% gunshot wounds and 16% by other mechanical means. The mean GCS was four and the level of injury severity was divided into GCS 3-4, GCS 5-7, GCS 8-15. This is an unusual breakdown as most studies using this tool to measure severity of TBI for analytical purposes would use GCS 3-8, GCS 9-12, GCS 13-15 (Teasdale & Jennett, 1974).

They experienced a loss to follow up of 39% at one year. Demographic and premorbid variables were tested and those with a history of alcohol abuse were more likely to be lost to follow up. The finding for people without a high school

diploma and of African-American origins did not reach significance but they reported it showing trends towards significance. Cause of injury, age, severity of injury did not differ between the group that was lost to follow up and the group that attended the review.

They found it was not possible to draw a conclusion to the presence of systematic bias or not but in their study findings were not representative of the total TBI population as they only studied inpatients and participants who experienced alcohol abuse were lost at a high rate from the study .

In 2003 Corrigan et.al. revisited this issue with a broader study involving three large data bases in the US. They looked at one and two year follow up time points for the Suboptimal Outcome Study (Ohio State University), the Colorado Brain Injury Registry and Follow-up System and the Traumatic Brain Injury Model System (national data base). None of the participants overlapped data bases.

At the one year time point the Suboptimal Outcome Study (SOS) lost 42% of participants, the Colorado team lost 42% and the Model Systems lost 41%. In the second year the loss to follow up increased to 48% for SOS and 45% for the Model Systems. In Colorado they excluded the first year loss from the second year total which meant their total numbers available for interview dropped. J This in turn dropped their attrition rate to 15%.

in their study of loss to follow up they focussed on a number of variables, including demographic characteristics; pre injury history including drug and alcohol use, psychological and neurological disorders; injury related characteristics and type of hospitalisation. Their findings were that those who were socioeconomically disadvantaged; had a history of substance abuse; and had injuries of violent aetiologies were more likely to be lost to follow up. This may display in a systematic

bias within the study that they acknowledged. Corrigan et al., (2003) stated these are issues that should concern all researchers and illustrate the difficulty in conducting longitudinal research in TBI.

The main reason for longitudinal studies in TBI is to observe outcome following injury (Corrigan et. al., 1997; Corrigan et al., 2003). Most of these studies have looked at only part of the total population of TBI. Those focusing on people with moderate to severe TBI have drawn their sample from inpatient rehabilitation units (Hammond, Hart, Bushnik, Corrigan, & Sasser, 2004; Olver. J, Ponsford. J, & Curran, 1996; Ponsford. J, Olver. J, M., & Nelms, 2003; Sander, Kreutzer, Rosenthal, Delmoico, & Young, 1996; Tomberg, Toomela, Ennok, & Tikki, 2007). These authors acknowledged that the loss to follow up they experienced was large, whilst noting that the characteristics of those lost to follow up and those continuing in the studies were the same. Thus eliminating systematic bias. The attrition rates ranged from 52% at two years (Olver. J et al., 1996) to 64% at three years (Tomberg et al., 2007) Despite this, the valuable information gained from these studies was of assistance to clinicians. Each study adds value to the overall picture.

Not all of the above studies included all groups of the community. Two only included people who were injured in a transport accident or were workers compensation clients. All of these participants would have been compensable (Olver, et al., 1996; Ponsford, et al., 2003) and it is not clear if this is a factor in loss to follow up.

The studies who followed milder injuries have used varying definition of MTBI, inclusion criteria, methodologies and reporting of loss to follow up has been inconsistent (Bazarian et al., 1999; Boake et al., 2005; Jakola et al., 2007; Kraus et al., 2005; Reynolds, Paniak, Toller-Lobe, & Nagy, 2003; Stalanacke, Bjornsig, Karlsson, &

Sojka, 2005; Stulemeijer et al., 2006; van der Naalt, van Zomersen, Sluiter, & Minderhoud J, 1999; Wade et al., 1998).

The lack of population- based studies was commented on by Pickelsmimer, Lelassie, Gu and Langlosis (2006) in their description of the establishment of a TBI registry in South Carolina. To try and overcome this they included mild to severe injuries in the registry. The classification of severity used was the Abbreviated Injury Scale ((Copes, Sacco, Champion, & Bain).

As pointed out above this scale was not intended to represent severity of TBI injury and the participants' scores ranged from AIS two to five, indicating a large degree of variation between them. The participants were taken from hospital admissions and excluded those with milder injuries that were seen within the emergency department but not admitted to hospital.

In addition to Pickelsmimer, et al.,(2006) an Edinburgh study included all levels of severity when studying outcome (Whitnall, McMillan, Murray, & Teasdale, 2006). Both studies acknowledged the work by Corrigan et al., (2003) and stated their loss to follow up rates at one year were 43% and 29% respectively; both denied any systematic bias.

Whitnall, et al., (2006) measured level of injury using GCS and again participants were drawn from hospital admissions only. Within these studies the first follow up point was at one year post injury. There was no monitoring of the milder injuries before this time. Pickelsmimer and colleagues mailed letters of introduction, consent, and an addressed return envelope out to potential recruits, with a dollar bill to encourage return postage. Interviews were conducted over the telephone. Whitnall encouraged face to face interviews but allowed for interviewers to visit people at home if they were unable to travel, take part in a telephone interview or

complete a postal questionnaire. The rates of attrition in these studies illustrate the variation of loss to follow up between studies fit closely with the range of one third to one half of participants falling out of studies at one year. The categorisation of severity of injury and the interview approach are the most obvious differences between the studies and this may account for the difference in compliance.

Information on loss to follow up can be found by looking at who is retained within the study and could be examined further to ask the question - 'who is retained within clinical practice?' The presentation to clinical practice is relevant to loss to follow up as many studies rely on collecting data when a participant attends medical or therapeutic appointments (Olver et al., 1996, Ponsford et al. 2003).

The World Health Organisation acknowledged the importance of adherence to long term therapies in their report published in 2003. It is document designed for policy makers, health managers and clinical practitioners that examines the consequences of poor attendances to ongoing health care with the overall health of the community and economy. The underlying message from this report is that adherence to long term therapy in developed countries is only 50%, and lower in developing countries. The eventual outcome of this is an overburdened health system and a drain on national economies. The report took a systems approach to disease but it did not include TBI or Stroke care both of which are known to be major causes of acquired disability in adults in developed countries (Bruns, Hauser, 2003, Carroll, et al. 2004, Whitnall et al., 2006, Stroke Foundation 2008). This gap in information from WHO illustrates the need for more information in relation to TBI to understand the impact and the consequences of poor follow up after injury, and failure of participants to attend appointments.

**CURRENT STUDY**

The objective purpose of this study was to examine the rate of loss to follow up in a population based study of TBI that had run for three years and consisted of follow up testing at one month, three months, six months, one, two and three years. The influence of demographic and premorbid factors was analysed and the risk of those being lost to follow up calculated.

A brief introduction to the study is provided in Langley, Johnson, Slatyer, Skilbeck and Thomas (2010), a copy of which is included in appendix *1.*

*Background*

In Southern Tasmania the incidence of TBI has been discussed but not reported to agencies responsible for allocating resources for health care. Pathways for clinical care need to be established, providing an ideal opportunity to develop a local data base and research program to follow the natural history of brain injury in this region. The total population of Southern Tasmania is 250 000 which is supported by the Royal Hobart Hospital (RHH), a tertiary referral centre for the whole island (population 500 000). All cases of head injury in the region and patients requiring neurosurgery across the island are treated in the RHH, although their rehabilitation needs are provided on a regional basis across the state. The provision of rehabilitation services varies in complexity. The needs of people who experience brain injury are not managed within a specialised unit and there is no provision for outpatient services across the state.

The Tasmanian Neurotrauma Register (TNTR) was funded by the Motor Accident Insurance Board from 2003 – 2007 (Langley et al, 2010). Permission to undertake a prospective population based study was obtained from the Southern Tasmania Health and Human Medical Research Ethics Committee, and collaborative links were

established within the RHH, involving the Department of Emergency Medicine, Intensive Care, Neurosurgery, Rehabilitation and the Community Rehabilitation Unit (CRU). CRU was also established in 2003. Before this time any outpatient rehabilitation was tendered out by the government to the private sector. The clinical pathway for brain injury services in the Hobart was in its infancy, so support from all these departments was crucial to assist in the identification of people with TBI. Initially, additional attempts were made to recruit people from private practice but this yielded very few referrals and required more resources that the study had available.

The study aimed to be population- based and longitudinal, and as such it was important to identify people with TBI who were admitted to hospital but for whom their primary diagnosis was not TBI. Equally, TNTR needed to recognise people who were not admitted to hospital but discharged from the Emergency Department following their injury. This group had much milder TBIs and its presence allowed for all levels of severity of injury to be examined.

Inclusion in the study was based upon criteria and definition taken from the American Report to Congress by the National Centre for Injury and Prevention and Control (2003). In addition people who answered positively to three or more items on the Post-Concussion Rivermead Scale ( King N, Crawford S, Wendon F, Moss N. 1995) were also included. Associations have been made between psychological conditions, drug and alcohol usage and previous head injury and recovery rates (Silver McAllister and Youofsky, 2006, p. 290-293; O'Jile, Ryan, Parks-Levy, Betz and Gouvier, 2004). As these conditions are thought to amplify the symptoms of mTBI it was of interest to look at them in terms of their rate of loss to follow up. People with these pre-existing problems are often excluded from studies on TBI and mTBI as impediments they may have before the injury can often be seen as clouding data.

It was an adult study, excluding those under the age of 16 years and those with global progressive neurological conditions. Children were excluded as the measurement and evaluation tools used were not relevant to children. The latter group was excluded due to the difficulty in differentiation between the dual pathology and assessing the effects and recovery of TBI.

Using these criteria, the Emergency Department isolated a set of International Classification of Disease and Health Related Problems, Revision 10, Australian Modification Codes (ICD-10-AM) that identified potential recruits. The details for each person and their injury were systematically emailed to research staff on a daily basis. Information on road trauma cases was also sent to the TNTR on a daily basis and once consented these people were screened for possible TBI by interview and review of medical notes. This was an attempt to capture people who may have experienced a TBI but it had not been significant enough for it to be seen in the initial trauma screening and diagnosis.

*Methods*

The objective of this study was to examine the rate of loss to follow up in a population based study of TBI that had run for three years and consisted of follow up testing at one month, three months, six months, one, two and three years. The influence of demographic and premorbid factors was analysed and the risk of those being lost to follow up calculated.

During the three year period (2003-2006) 1760 people were identified as having sustained a TBI in Southern Tasmania. Of this total 14% refused to be involved in the study, 12% could not be contacted following the initial medical contact in the emergency department, 2% travelled overseas before they could be contacted and 1% of people were in prison at the time of injury.

Participants who consented to the study were assessed as close to the time of injury as possible. Determinants of this include the end of any period of PTA and a Mini-Mental Examination greater than 23 (Folstein M, F,. Folstein S, E., McHugh P, R. 1975). They were then followed up at one, three, six and twelve months, and two and three years post injury. Assessments were conducted face to face with research assistants from postgraduate psychology background, and involved a battery of tests and questionnaires covering physical, social and cognitive domains. Each assessment took 60-90 minutes. No reimbursement or incentive as offered to participants, but home visits were offered if people were unable to travel.

Phone calls were routinely used to remind participants of their follow-up appointments. If they could not be contacted after several attempts by telephone, letters were sent to their last known address with an appointment time. If participants missed an appointment staff would attempt to call them up at the next follow-up unless they had withdrawn from the study. Therefore, it was possible a participant may have attended one time point, missed one, and then appeared at the next time point. Up-to-date address and phone numbers were checked with each contact. The majority of people who could not be contacted moved without leaving a forwarding address or their mobile phones had become disconnected. Some actively withdrew from the study and asked not to be contacted again due to other commitments, and some would confirm their appointment then fail to attend.

If participant failed to attend three consecutive time points and they could not be contacted, they were considered lost to follow up. People were considered lost to follow up if they could not be located, refused to be interviewed, died made no response to contact or were unable to be interviewed.

*Participants*

Participants included 947 individuals (334 female, 613 male) who attended the Department of Emergency Medicine RHH after sustaining a TBI between 1st November 2003 and 1st November 2006. The majority of participants were from the southern region of Tasmania, with a small number of people from interstate (who sustained their injuries in Tasmania), or from other regions of the state who were referred to southern Tasmania for treatment. Participants from other areas of the state were often admitted directly to the Intensive Care Unit or Department of Neurosurgery. Close liaison with these areas and the TNTR provided researchers with their admission notification. Individuals from southern Tasmania who sustained their injuries elsewhere were not included.

Consent was obtained from all participants, except for cases where people were unable to give informed consent due to heavy medication or cognitive impairment, or where individuals were under 18 years of age. In these circumstances next of kin were approached as the person responsible to give consent.

Male participants accounted for 65% of the population and the mean age of participants was 36.08 years (*SD* 17.69; Median 31.00). The majority of injuries were caused by transport accidents at 39%. These included pedestrian and bicycle accidents. Assaults made up 27%, falls 19% sport 7% and other unclassified injuries 8%. Of the total population 52% were employed at the time of their injury. Students accounted for 13%, unemployed people 12%, retired 10%, disability pensioner 8% and home duties 5%.

The categorisation of severity of injury is shown in table 1, based on length of PTA as described by Russell and Smith (1961).

Table 1. *Severity of traumatic brain injury*

Breakdown of level of severity within studied population on TNTR N=947

| Severity of TBI | Duration of PTA | n | % |
|---|---|---|---|
| Very mild | <=5 minutes | 258 | 27% |
| Mild | 5-60 minutes | 211 | 23% |
| Moderate | 1-24 hours | 258 | 27% |
| Severe | 1-7 days | 147 | 16% |
| Very Severe | 1-4 weeks | 51 | 5% |
| Extremely Severe | >4 weeks | 22 | 2% |

Calculations of the loss to follow up were made after the study had been running for three years. Recruitment took place over this period and the calculation of loss to follow up started after the last recruited participant in the three year period had been in the study for 6 months. As such each time point was observed as a new base line population as some participants would have already dropped out, some would not have reached this follow-up time point in the study, and there would have been new participants entering the study

*Design*

Hypotheses

On the basis of limited previous research, it is hypothesised that higher rates of loss to follow up will be associated with those participants who:

1 Had a mild traumatic brain injury

2 Had a history of assault

3 Had no orthopaedic injuries that occurred at the same time as the TBI

4 Were not hospitalised at the time of injury

5 Were under 25

6 Were male

7 Had a lower IQ

8 Had fewer years of education

9 Had no fixed employment

10 Had no long term significant relationship

11 Had a history of psychological or psychiatric illness

12 Had a history of drug and alcohol abuse

13 Had a history of previous brain injury

The risk of drop out can be broken down into three categories each containing a number of variables, which are listed in the table below.

| **Category** | **Independent Variable** |
|---|---|
| Clinical factors | TBI severity (PTA/LOC), hospitalisation, cause of TBI, comorbid orthopaedic injury |
| Premorbid demographics | Age, Gender, estimated premorbid IQ, employment, gender, partnered |
| Premorbid risk factors | Prior psychiatric history, previous TBI, drug and alcohol use |

The current research is influenced by Corrigan et al., (2003) but differs as severity of TBI is measured using PTA and this study uses TBI as an independent variable. It is a population based study that does not rely on the convenience based sampling that was available to the US program, and is, therefore, more rigorous. Difference also lies in the time point of follow up. The current study has three separate time points for follow up prior to the twelve month point information that was not available to Corrigan et al., (2003).

**RESULTS**

Calculations of the loss to follow-up were made after the study had been running for three years. Recruitment took place over this period and the calculation of loss to follow-up started after the last recruited participant in the three year period had been in the study for six months. Up to and including 12 months post-injury the loss to follow-up can be seen as a gradual increase to 38% at this time point. At the two year and three year time points this increased to 61% and 81% respectively as seen in Table 2. Although data are missing for some variables good sample sizes are maintained.

The calculations for mTBI were done at the six and twelve month time points. The six month time point represents the third presentation a participant would have made to the register and there has been potential for natural recovery over this period of time. The twelve month time point was chosen as clinicians use this as the marker for those who continue to be symptomatic as having post-concussion syndrome (Ruff 2005).

Table *2. Loss to follow up of total study population (n = 947)*

| One month | Three months | Six months | One year | Two years | Three years |
|---|---|---|---|---|---|
| 22% | 35% | 37% | 38% | 61% | 81% |

**TBI Variables**

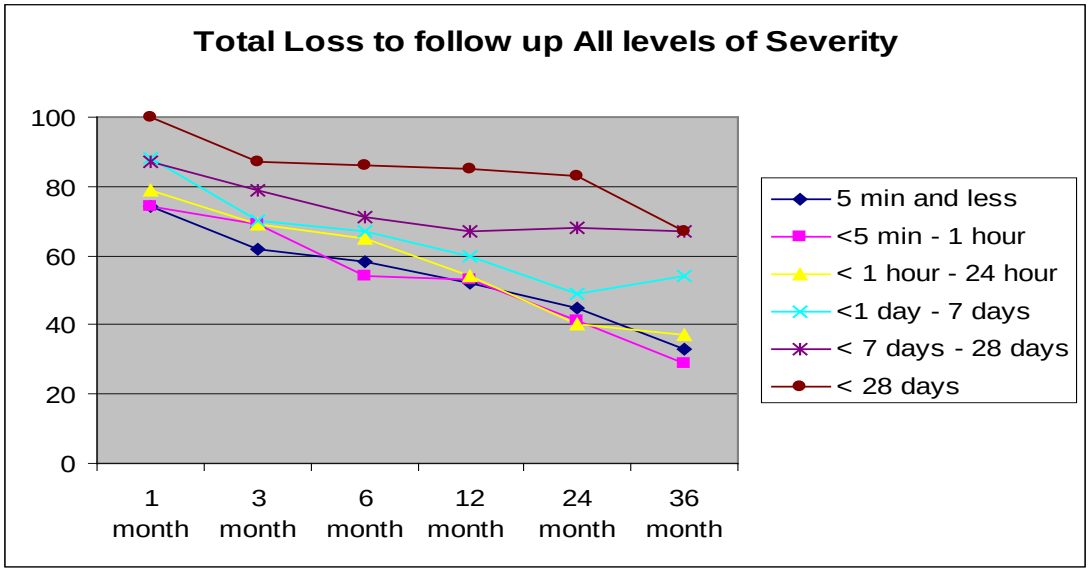
In investigating the increase in loss to follow-up at the two-year and three-year points post-injury, it was hypothesised that mTBI participants would be at greater risk of being lost to follow up. To test this hypothesis loss to follow-up at each time point was then calculated across the levels of severity shown in table 5 with each level forming a separate group.

Table 3. Attendance rates at each time point against severity

| PTA | Day 28 | Day 90 | 6 Months | 12 Months | 2 years | 3 years |
|---|---|---|---|---|---|---|
| 0-5min | 74% | 62% | 58% | 52% | 45% | 32% |
| 6-60min | 74 | 68 | 56 | 53 | 41 | 49 |
| 61min-24hr | 79 | 69 | 64 | 54 | 40 | 37 |
| 25hr-7days | 88 | 70 | 67 | 60 | 50 | 54 |
| 8days-4wks | 87 | 79 | 71 | 67 | 68 | 66 |
| 29+days | 100 | 87 | 86 | 86 | 83 | 66 |

Table 5 shows the attendance rates at each follow-up point for the separate severity groups. As TBI becomes more severe, participants are more likely to remain in the study and to attend at the later follow-up points, as shown visually in figure 1.

Figure 1. Percentage Attendance, time post-TBI, & Length of PTA (n=947)




Survival in the study and severity of TBI was examined statistically by collapsing the attendance data for those participants whose PTA was <= 1 day into one group (labelled 'mild'), the 'severe' group comprising the data for those with a PTA > 1 day Participants with PTA <= was 726 and those with PTA > one day 221.

$Chi^2$ analyses were conducted using the attendance numbers underlying the percentage rates shown in table 3,. These analyses at early follow-up points were not statistically significant, but by 12 months post-injury there was a tendency for the severe TBI group to show a higher rate of survival in the study ($Chi^2(1) = 3.4357$; $p<.10$). At both the 2year follow-up ($Chi^2(1) = 4.7213$; $p<.01$) and the 3-year follow-up ($Chi^2(1) = 6.1963$; $p<.01$) the severe group showed significantly higher attendance rates.

*Mild TBI variables*

Mild TBI comprised a very large proportion of the study' sample. This is consistent with the literature on TBI. The WHO task force on TBI estimated 70 – 90% of TBI to be mild. It was not possible for them to be more accurate than this due to the inconsistency in methodology and definition of mTBI used throughout the studies they examined (Cassidy, J.D., Carroll, L.J., Peloso. P.M., Borg. J. 2004). Because of the size of the population of mTBI and the evidence they drop out of TNTR earlier than participants with more severe TBI it was decided to concentrate this study on examining the characteristics of mTBI.

**Table 4. Cause of injury**

| | | **6 months Chi$^2$** | **12 months** | **Chi$^2$** |
|---|---|---|---|---|
| **Cause of injury** | **726** | | | |
| Transport | **246** | 144 (149) 10.8495 | 124 (126) | 8.902 |
| Assault | **223** | 115 (135) p=<0.05 | 95 (114) | p=<0.1 |
| Fall | **139** | 109 (84) | 88 (71) | |
| Sport | **60** | 39 (36) | 37 (30) | |
| Other | **58** | 34 (35) | 29 (29) | |
| | | | | |
| **Cause of injury Modified** | | | | |
| Transport | **246** | 144 (149) 10.571 | 124 (126) | 7.2687 |
| Assault | **223** | 115 (135) p=<0.01 | 95 (114) | p=<0.05 |
| Falls | **139** | 109 (84) | 88 (71) | |

| | | | | | |
|---|---|---|---|---|---|
| **Hospitalisation** | | | | | |
| Admitted | **59** | 42 (42) 0.053 | | 32 (35) | 0.4269 |
| Not admitted | **91** | 66 (65) | NS | 56 (53) | NS |
| **Orthopaedic comorbidities** | | | | | |
| With | **277** | 166 (172) 0.5278 | | 141 (145) | 0.2787 |
| Without | **119** | 119 (113) | NS | 99 (95) | NS |

At six months the Chi $^2$ analysis was significant and at twelve months it just failed to reach statistical significance ($p<0.05 = 9.488$). To look at this variable in more detail the sport and "other "category were excluded as the numbers in these subsets were considered comparatively small. With this modification of the variable Chi $^2$ (2) = 10.571, p=<0.01 at six months and Chi $^2$ (2) = 7.268, p=<0.05, at twelve months post injury.

Hospitalisation contained two groups, those who were admitted for more than twenty four hours and those that were not. The data at six months had Chi$^2$ (1)at 0.053 p= <0.75. At twelve months Chi$^2$ (1) was 0.4269 p= <0.75.

Orthopaedic co morbidities were separated into those who did sustain orthopaedic injuries with their mTBI and those who did not. It failed to reach significance at both time points.

*Demographic Variables*

The demographic variables investigated in terms of loss to follow up were age, gender, estimated premorbid IQ, education and employment as seen in Table 5. Gender was tested at six and twelve months but failed to reach significance at six and twelve months.

Exploration of age was divided into four groups. This achieved significance at six months with $Chi^2$ (3) 10.9379 p=<0.01. Significance was also achieved at twelve months with $Chi^2$ (3) 8.67 p=<0.05.

Relationship status was divided into partnered and single. This variable failed to reach significance at both six and twelve months.

Analysis of the premorbid IQ data was carried out using 2 groups: estimated premorbid IQ below the mid-point of average, and estimated premorbid IQ at, or above, the mid-point of average (table 7). At six months post-injury, $Chi^2$ (1) = 3.762, which verged on statistical significant (3.841 = p<.05 value), and the analysis conducted at 12 months was significant, $Chi^2$ (1) = 4,156, p<.05.

Education was divided into two groups: education up to year 12, versus >year 12. At six months post injury $Chi^2$ (1) =3.2006 which failed to reach significant (3.841 = p<.05 value). The analysis at twelve months also failed to reach significance – $Chi^2$ (1) = 2.7566, p<0.1.

Analysis of the occupation data was conducted by splitting the variable into retired, disability support pension, home duties, employed, unemployed and students. At six months $Chi^2$ (5) was 9.9235 p=<0.1 (11.070, p<0.05). At twelve months significance was reached with $Chi^2$ (5) 14.057 p=<0.02. This variable was then collapsed placing employed and students in the same category as they both have the intention of

being employed. People on disability support pension and home duties were included in the unemployed group as they did not have the intention to have paid employment. Using this combination significance was achieved at six months with $Chi^2$ (2) =6.0832, p=<0.05. At twelve months $Chi^2$ (2) = 12.0247, p=0.01.

**Table 5. Demographic Variables**

| Baseline | | 6 months Observed (expected) | $Chi^2$ | 12 months observed (expected) | $Chi^2$ |
|---|---|---|---|---|---|
| **Gender** | | | | | |
| Male | **463** | 283 (281) | 0.0097 | 231 (238) | 0.5687 |
| Female | **263** | 159 (160) | | 142 (135) | |
| **Age** | | | | | |
| Under 25 | **274** | 144 (166) | 10.9379 | 127 (140) | 8.67 |
| 26-35 | **145** | 76 (88) | p=<0.01 | 64 (74) | p=<0.025 |
| 36-50 | **149** | 101 (90) | | 101 (90) | |
| 50+ | **157** | 118 (96) | | 102 (80) | |
| **Relationship status** | | | | | |
| Partnered | **280** | 172 (172) | 0.0062 | 142 (144) | 0.0573 |
| Single | **262** | 162 (161) | | 137 (135) | |
| **Education** | | | | | |
| <=year 12 | | 363 (375) | 3.2006 | 304 (315) | 2.7566 |
| > year 12 | 99 | 73 (60) | p=<0.1 | 62 (51) | p=>0.1 |
| **Premorbid IQ** | | | | | |
| IQ<99 | 206 | 112 (128) | 3.762 NS | 94 (110) | 4.156 |
| IQ>=100 | 262 | 181 (164) | 3.841=p<0.05 | 156 (140) | p=<0.05 |

| **Table 5 continued** | | | | |
|---|---|---|---|---|
| **Baseline Occupation** | 6 months Observed (expected) | $Chi^2$ | 12 months observed (expected) | $Chi^2$ |
| Retired **82** | 63 (51) | 9.9235 | 59 (42) | 14.057 |
| *DSP **34** | 23 (21) | p=<0.1 | 17 (18) | p=<0.01 |
| **HD **25** | 13 (16) | | 12 (13) | |
| Employed **380** | 236 (236) | | 201 (197) | |
| Unemployed **90** | 39 (59) | | 29 (47) | |
| Students **112** | 74 (70) | | 56 (58) | |

*Disability Support Pension

** Home Duties

**Table 5 continued.**

| | | | | |
|---|---|---|---|---|
| **Modified Occupation** | | | | |
| Employed + Students **+** Retired **=574** | 373 (355) | 4.0539 | 316 (297) | 12.0247 p=<0.01 |
| Unemployed **+** Disability+ Home duties **149=** | 75 (92) | p=<0.05 | 58 (78) | p=<0.01 |

**Table 6. Pre injury risk factors**

| | | 6 months | Chi$^2$ | 12 months | Chi$^2$ |
|---|---|---|---|---|---|
| **Previous TBI** | | | | | |
| With | 48 | 28 (29) | 0.0371 | 24 (24) | 0.0031 |
| Without | 613 | 371 (370) | NS | 313 (314) | NS |
| **Psychological impairment** | | | | | |
| Psych history | **86** | 52 (54) | 0.0858 | 47 (45) | 0.1028 |
| None | **561** | 340 (338) | NS | 283 (285) | NS |
| **Substance Abuse** | | | | | |
| With | | 22 (20) | 0.2174 | 20 (17) | 0.5495 |
| Without | | 227 (229) | NS | 197 (199) | NS |

*NS denotes not significant

All the pre injury risk factors failed to reach statistical significance at six and twelve months.

## Discussion

As stated in the introduction, the aim of this study was to test a number of hypotheses relating to loss to follow-up, including the hypothesis that people who experienced mTBI would be lost from a longitudinal study at a higher rate than those who experienced a more severe TBI. Using the total TNTR sample, the results obtained confirmed this hypothesis: the longer the follow-up period, the greater was the drop- out rate from those sustaining milder TBIs. Retention of severe TBI participants in the study was significantly higher at two and three years' post-injury (both $p<.01$) (Langley et al 2010). The only other study identified on loss to follow up in TBI was by Corrigan et al., and this study differs in the cohort, the follow up point and the design. Included in TNTR sample are people who were seen within the emergency department of the Royal Hobart Hospital and then discharged home. TNTR was also a prospective study following participants at six time points post injury: one month, three months, six months, one year, two years and three years. Corrigan et al (2003) looked retrospectively at data collected from three data bases that only included hospital admissions at one year and two years.

*MTBI variables*

These hypotheses in the study were cause of injury, the presence of orthopaedic injury and hospitalisation at the time of injury would influence the loss to follow up of participants.

Cause of injury was seen to influence loss to follow up. People who were assaulted dropped out of the study at a faster rate than those in any other causal category both six ($p<.05$) and twelve ($p<.1$) months post-injury. When the 'sport' and 'other' causes were excluded (due to their small numbers), those who were assaulted were

lost from the study at a higher rate than those who sustained their TBI in a transport accident, or fall, at both the six-month ($p<.01$) and twelve-month ($p<.05$) follow-up points.

An explanation for the high loss to follow up rate of assaults from the data may be the victims of assault recovered from their injuries quicker and therefore moved on with their lives as they became less symptomatic or alternatively the felt such psychological trauma following the event that attending any kind of follow up caused them to be reminded of the assault and their vulnerability.

It is possible to hypothesis assaults are generally less severe physical injuries than transport accidents as people who experience MTBI as a result of transport accidents are travelling at a greater velocity when injured than those who are assaulted. Thus it could be argued the greater the velocity the person is travelling at when impacted, the more severe the symptoms and the more diffuse the injury (even within the mTBI category). A future study might investigate the length of PTA experienced by those who suffered assault and those involved in transport accidents, but this was beyond the scope of this thesis.

One of the most distinguishing factors between people with assault and those in transport accidents is that of medical insurance. Those who were injured in a transport accident were covered medically by the no fault accident scheme provided by the Motor Accident Insurance Board of Tasmania. They were able to access the services of rehabilitation medical physicians in the private sector and were not subject to public hospital waiting lists to receive medical, nursing or allied health care. This inequity may have been an incentive to participate in the study but the examination of this point is beyond the scope of this thesis. Two of the data bases examined by Corrigan et al., (2003) showed that those with medical insurance attended at a higher rate.

As in the current study, Corrigan et al., (2003) also found those who had suffered assault or injuries arising from violence, were statistically more likely to be lost to follow up that those with any other cause of injury. He stated the characteristics of people who had been assaulted and those with drug and alcohol issues were often interrelated. This was supported by O'Jile et al., (2004), describing people with drug and alcohol problems as being at a higher risk of experiencing TBI . Yet this was not the case in the current study: the previous discussion of alcohol and drug analysis showed different findings to those of Corrigan et al., (2003).

The participants studied by TNTR differ from earlier research in that 27% of the overall study and 33% of the people with mTBI sustained assaults. Other studies report 9-12% assault rate (Stulemeijer et, al 2006; Gerhart, Mellick & Weintraub, 2003; Tate et. al. 1998; Hillier et. al. 1997). With the exception of Stulemeijer et al., (2006) these studies excluded people who presented to emergency departments. They were undertaken retrospectively using hospital separation ICD – 9 codes. The current research was prospective, and many patients with mTBI were recruited from self-report and medical notes before codes were allocated to diagnosis. Although ICD – 10 AM codes were used in the present research, this should not account for the difference in assault percentages.

A potential reason for the high level of participants with a TBI caused by assault is an increase in the community's presentation to emergency departments in recent years, instead of seeing a general practitioner (GP). It has become difficult to see a GP on the same day as the request for an appointment, and there has been a decline in those who bulk bill, resulting in people seeing emergency departments as a more realistic and affordable avenue for care. In addition to this the inclusion of very 'minor' injuries in the current study, including those with a PTA of less than five minutes, may have meant TNTR had a higher rate of assault. There is also the

possibility that there has been an increase in violent activity that was picked up by TNTR but not by studies before the 2003-2006 period.

The variable of hospitalisation was included for study, as people who had been admitted to hospital may feel a relationship had been established with the health care services, encouraging them to come back into the hospital environment to participate in the research. When examined the data did not show hospitalisation influenced the loss to follow up significantly. Those who were admitted to hospital attended for follow-up at a similar rate to those who were not admitted. It is important to note that people were not necessary admitted for their MTBI, but often for other injuries such as orthopaedic trauma, so their MTBI was not recorded as their primary injury. In some circumstances there had been no recognition of the patient suffering a MTBI.

Orthopaedic trauma was a common comorbidity with MTBI and it was of interest to determine if injuries that required follow up in the clinical situation, had any bearing on the loss to follow up. It could not be demonstrated that people who needed to be reviewed in the hospital setting with coexisting orthopaedic injuries attended at a significantly different rate to those without clinical orthopaedic follow up.

*Demographic Variables*

The study also examined the influences of demographic factors on loss to follow-up. It was hypothesised that age, gender, education, IQ, employment status and relationship status would affect loss to follow-up from the current research for mTBI. It was found that age did influence attendance. Those under 25 years were lost to follow up at a significantly high rate than other age groups at the six-months ($p<.01$) and 12 months ($p<.025$) follow-up. Older individuals were retained within the study at a higher than expected rate. The higher attrition rate of young people is of

concern, as the epidemiological studies of Tate et al., (1998) and Hillier et al., (1997), and the Australian Institute of Health and Welfare (Helps et al., 2004) indicate the highest incidence of TBI is in the 16 – 25 year age group. While Zasler et al., (2007) also identified this age group as high drop-out, they also reported those aged 75 years and above to have a higher incidence of TBI.

The young participants may be difficult to retain in studies as they have many commitments such as study, sport and socialising and it would be easy to forget appointments that have little personal gain to them. Older people, on the other hand, may lead a more organised lifestyle and understand the importance of research and the beneficial effect it can have.

Gender in TBI and mTBI studies show males represented at a ratio of two to one (Cassidy, et al., 2004). TNTR also reflects this. It was not seen to have any influence over loss to follow up as males and females did not differ in their attendance rates.

At the time of this study Tasmania had the lowest retention rates in education in the country. Only 68.6% of students completed year 12 (Australian Bureau of Statistics, 2006. Evans, N. 2006-2007). With a mean education level of 11.24 years it can be seen TNTR has captured a sample of people with TBI which is consistent with the education standards of the broader state population. In this study it was hypothesised that those with a lower level of education would show a higher level of drop out. At six and twelve months $p< 0.1$. This is the same significance level used by Corrigan et al in their bivariate analysis so it was accepted as significant in this study. Loss of people with lower levels of education may suggest these people may be unemployed, they may not be able to afford transport to appointments or they may fail to appreciate the usefulness of their contribution to the study.

The Australian national IQ average is 98 (iqtest-austrailia.com) which sits just below the mean IQ of the TNTR of 99. The hypothesis in this case was those had a lower IQ

(estimated using the National Adult Reading Test; NART, Nelson & Willison, 1991), would drop out of the study sooner than those with a higher IQ . The results showed those with an IQ of 99 or less (below the mid-point of the average range) were more likely to have dropped out of the study by 12 months post-injury ($p<05$). This variable was used in addition to education as high IQ does not always reflect a person's academic attainment. However, the result was expected as those with a lower IQ are more likely to have a lower education standard and this group had been seen to attrite from studies at a higher rate (Corrigan et al., 2003). No other studies were found in the literature that included IQ in their data set. This may be as many of them were retrospective and could only use the information collected on admission of participants into the health care system. In addition there is controversy over IQs efficacy as a measure in people with TBI as it does not reflect their level of functional capacity or potential recovery (Kay & Lezak).

When looking at relationship status people in the current study were either classified partnered or single at the time of injury. It was hypothesised that those who were single would manifest a higher level of loss to follow-up. Family members and a person's social network play a large part in ongoing care of people with TBI and often assist with reminders of the person's clinical appointments (Khan, Bagulay and Cameron, 2003). As we were unable to identify the larger social network of participants we focused on whether or not they were partnered to see if that affected loss to follow-up.

In TNTR each category had similar numbers and there was no demonstrable influence on loss to follow up. Corrigan et al., (2003) had mixed results when looking at this variable. At the Ohio State University (OSU) data base those in relationships were found to attend more consistently than those who were single, at both time points. In the CTBIFS, relationship status was not seen to influence loss to follow up

but in the TBIMS it was significant at one year but not at two years. It is unclear why there were a mixture of findings but the OSU data base included people as young as fourteen and the minimum age for the other two was sixteen years. This may have meant there were more people in OSU who were not eligible for marriage due to age.

It was suggested that unemployed participants would drop-out of the TNTR at a higher rate. The level of paid employment in the TNTR sample of mTBI was 53%.This is close to the finding of the Australian epidemiological work by Hillier et al., (1997) who found those employed in the overall TBI population to be 52%. At the time of recruitment into the current study, the unemployment rate in Tasmania was 5% (Australian Bureau of Statistics, 2006). The employment rate for the mTBI component in the TNTR sample was 11% for the same time frame. This would suggest a link between being unemployed and being at risk of mTBI.

International studies have not always provided the employment status of participants. Of those who did they ranged between 61 – 86% employment (Stalnacke et al., 2005; Van der Naalt et al., 1999; Kraus et al., 2005; Sander et al., 1996). The first of two of these studies focused only on mTBI.

In TNTR at six months after injury the results for employment and loss to follow-up trended towards significance but did not reach the 0.05 value, ($Chi^2$ =9.9235. 0.05 $Chi^2$ = 11.070). As with education Corrigan et al., (2003) used significance level of 0.1 in bivariate analysis and TNTR finding is consistent with this. In addition this study missed the data at the six month point. At twelve months it was clear those who were unemployed dropped out of the study at a significantly higher rate ($p<0.01$). The data was then collapsed into two groups. The first group being those who were employed; those who had intention seek employment (students) or had worked for a large part of their lives (retirees). The second group were those who were either

unemployed, lived on disability support pension and those who listed their occupation as home duties. This showed higher levels of retention in the study by the first group at six and twelve months with $p<0.05$ and $p<0.01$ respectively.

In all three of the data sets examined by Corrigan et al., (2003) he found unemployed people were less likely to be found at one and two years post injury with the exception of year one of the Traumatic Brain Injury Model System (TBIMS) and year two of the Colorado Traumatic Brain Injury Registry and Follow-up System (CTBIFS). He raised the concern that loss to follow up amongst the unemployed may reflect a better outcome for TBI than is justified (Corrigan et al., 2003). As mentioned previously his study only included mTBI if they were admitted to hospital and rehabilitation units, but it would appear the cohorts show similar behavioural patterns.

*Pre injury risk factors*

It was hypothesised the pre injury or pre morbid factors of psychological disorders (depression and anxiety), drug and alcohol usage and previous TBI would be associated with a higher rate of loss to follow up.

These variables have been documented as being associated with people who experience TBI. It is also suggested the presence of these factors increase the risk of an individual sustaining a TBI (O'Jile, et al., 2004).

The diagnosis of depression is frequently made using the Diagnostic and Statistical Manual of Mental Health Disorders, 4$^{th}$ edition (DSM-IV). It is estimated that between twenty and thirty precent of people can experience depression following mTBI (Silver et al, 2006 p. 292). In the general TBI population the presence of anxiety, depression and low self-esteem is associated with poor outcome (Whitnall et. al., 2006). Within the TBIMS data base it has been found that of those people

without depression at the time of injury, 26% had developed mild depression by the one year follow up point. Of these one third went on to develop major depression at the two year time point (Hart, Hoffman, Pretz, Kennedy, Clark and Brenner, 2012). Within the TNTR population 16% of mTBI participants admitted to some prior anxiety, depression, or both at the initial interview. Inclusion of people in this category was made on self-report and responses using the Hospital and Anxiety Depression and Anxiety Scale (HADS) and not the DSM-IV as aforementioned studies had. This is lower than the rates for the general population provided by the Mental Health Council of Australia who estimated 20% of the total Australian population will have a mental health issue at some stage in their life.

Corrigan et al., (2003) could only partially include psychological disorders as a variable as this information was only collected by CTBIRFS and not by OSU and TBIMS. At the first year follow-up CTBIRFS found psychological illness was associated with loss to follow up but this was not the case at the two year time point.

The current TNTR research found no significant association between psychological illness and loss to follow-up. This was an unexpected finding although there was no available published literature to draw comparisons from. One possible explanation could be the fact that there is little support for people with these disorders in the broader health care environment in Hobart. The invitation to participated in a study, where they were able to discuss their progress with a researcher who has a psychology background, may have provided an unintentional therapeutic effect for participants resulting in their retention in the study.

Substance abuse was also based on self-report. The numbers for people admitting to using illegal drugs and alcohol were placed together as singularly they were small. This is a difficult variable to verify and it is accepted in clinical practice that people

usually underestimate their usage of drugs and alcohol (Rosengren, Beadnall, Nason, Stafford and Daugherty, 2012).

As with the psychological factors there was no association between drug and alcohol abuse and loss to follow up in the mTBI population. This result was very surprising as Corrigan et al., (2003) found a strong association with high blood alcohol level at the time of injury and loss to follow up in two of the data sets, although it did not reach statistical significance in the TBIMS. Premorbid alcohol and drug use data were not collected in the TBIMS, but were found to be linked with loss to follow up in both the other data bases at the twelve month follow-up.

It is difficult to explain the difference in the results between the data bases. It may that, again, people with alcohol/drug histories possibly gained an unintended therapeutic effect from the follow-up interviews, in an overall health environment where little support existed. There is also the possible overlap between substance abuse and psychological disorders.

Previous TBI was a variable that had not been tested by Corrigan et al., (2003). It was hypothesised people who had experienced a TBI in the past would not comply with the study. This was not based on prior research but the knowledge that people with mTBI may experience a range of symptoms that lead them to forget appointments. However they did not behave any differently to those who did not report past TBI. At an anecdotal level some participants stated they were pleased the study was undertaken because when they had been injured in the past there had not been any support. Again the study provided an unintended therapeutic effect.

When recruiting participants for longitudinal studies people who have experienced a TBI in the past are often excluded, as previous TBI or neurological disorder may confound results of an outcome study if a baseline of function has not been established. It is interesting and valuable to be able to include these participants in a

data set, to observe the natural history of TBI. If necessary those participants can be excluded from research if the requirement is a cohort without the possibility of prior neurological diagnosis. If a study is conducting research retrospectively it may be difficult to determine the pre morbid health status of participants.

Variability in methodology and definition in previous studies has been noted. Tate et al., (1998) and Carroll et al., (2004) described the inadequacy of diagnostic codes to accurately quantify the incidence of TBI and mTBI. Reviewing the coding against diagnosis in TNTR did reveal that as many as one third of the participants had not been allocated ICD – 10 AM codes. The majority of these cases were people who were discharged from the Emergency Department or did not wait to be treated. This suggests more of a problem with the recognition, subsequent diagnosis and documentation of mTBI, or the input of data from an organisational perspective, rather than with the codes themselves.

The geographical location of TNTR is helpful to this type of research, in that Hobart has only one public hospital with one Emergency Department, which assists with identification and recruitment. Although Hobart does not have a specialised brain injury unit, it is linked to a tertiary referral centre that manages neurosurgery on a state-wide basis. The rehabilitation of moderate to severe TBI occurs within mainstream rehabilitation, but there is little coordination of follow- up care for all severities of TBI. This may have an effect on the ability of TNTR to follow participants. As previously mentioned some participants may view it as providing them with an unintended therapeutic consultation that was otherwise unavailable. Alternatively, it may have been difficult to identify the TBI population due to the lack of coordinated services.

As TNTR is an intensive research program for participants, the time commitment asked of them, and the frequency of their attendance in the first year, may have

caused participant fatigue and contributed to loss to follow up. However, the loss to follow-up of the mild and moderate TBI participants rose from approximately 40% to approximately 55% between the one and two year follow-up assessments, and not at earlier follow-up points, which argues against this explanation. It could also be reasoned that maintenance of the sample between one- and two-year follow-up assessments may have improved if an eighteen-month follow-up had been included.

**LIMITATIONS**

At the start of this thesis the difficulties of conducting longitudinal studies on TBI were outlined. Assisting the cohort to remain in the study can be limited by financial resources, as each attempted contact with participants has a monetary component. There are also cognitive and physical components as we were dealing with people who had the potential to be suffering with symptoms including, but not limited to, memory loss, confusion and reduced organisation skills, as well as headache, anger, irritability and fatigue. Due to these factors participants often needed to be contacted more frequently. Appointments were often cancelled on the day of scheduled interview due to the health, mood or fatigue level of the injured person. They would then be rebooked or a home visit offered. This impacted on the cost of the study as wages consumed most of the budget.

While the current study was able to quantify the loss to follow up and identify some important predictive variables, it was unable to determine the underlying reason for non-attendance. Those who withdrew could not be contacted retrospectively due to the ethical constraints of the study. The recording of some of the variables lacked robust enquiry. The presence of drug and alcohol abuse or use relied on self-report. It may have been possible to examine this variable via past medical notes relating to

previous presentations to emergency, or admissions where drug and alcohol use was recorded. However this would have required further resources.

The presence of premorbid depression, anxiety or psychiatric illness was also identified by self-report. Again clearer information may have been gained by reviewing previous hospital notes or having participants screened at baseline to determine if they met the DSM IV criteria for any mental health issues. Higher numbers may have been identified, which may have affected loss to follow up. Although the Hospital Depression and Anxiety Scale was administered as part of the battery of tests throughout the program, only the self-report of the participant at baseline was used for the present study.

The number of people in research who reported a previous TBI may have been an under estimate due to the manner in which the question was worded and the participants understanding of MTBI. The question was, "Have you had a previous traumatic brain injury?" As researchers and clinicians became more experienced this question was clarified so the term TBI may be understood by the participant to include, head injury, loss of consciousness and concussion. This difficulty with terminology was identified in the clinical setting. If people were struggling to recover from their injury they would be referred to the Community Rehabilitation Unit in Hobart. On admission to this service they would be asked if they had ever experienced similar injuries to the one that had bought them in contact with TNTR, for example loss of consciousness or concussion. It was found some people who had denied previous TBI responded positively when the question was couched in these terms. This information was fed back to the study group and research assistants were able to update their data as appropriate. It is likely, however, other individuals with previous TBI were missed as only 12% of the MTBI population was referred for clinical follow up through this avenue.

**SUMMARY**

This study was concerned with the participants in a longitudinal study on TBI who were lost to follow up. The concern was raised because if this loss to follow up isolated to defined groups selective bias can occur and the results cannot be generalised to the broader TBI population.

Mild TBI was of primary interest to the study as this population had not been studied before in relation to loss to follow up. Within the mTBI group those who were vulnerable to falling out of the study were those whose injury was caused by assault: those who were under twenty five; who did not reach year twelve in education; whose IQ was under ninety nine and those who were unemployed.

The identification of these people is of great importance. Clinical programs are underpinned by evidence that is provided by longitudinal studies. Selective bias will undermine the evidence and inhibit effective treatment. Secondly, the loss of these individuals to research may be masking an unmet need in the community. While this study has identified those at risk of loss to follow up further work would be useful to model and predict attrition at time of injury or recruitment. This would assist clinicians to provide timely and effective interventions for all people who sustain mTBI.

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Appendix One

# Appendix Two

## Assessment tools used in The Neurotrauma Register

**Assessment of all Cranial Nerves**

**Community Integration Scale**

Millis, S.R., Rosenthal, M., Lourie, I.F. Predicting community integration after traumatic brain injury with neuropsychological measures. International Journal of Neuroscience 1994; 79:165-7.

**Disability Rating Scale**

Rappaport, M., Hall, K.M., Hopkins, H.K., et al.: Disability rating scale for severe head trauma: coma to community. Archives of Physical Medicine and Rehabilitation 1982;63:118-123.

**Functional Independence Measure**

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**Galveston Orientation and Amnesia Test**

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**Hospital Anxiety and Depression Score**

Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. Acta Psychiatry Scandinavia 1983; 67:361–70.

**H-Brixton**

Burgess, P.W., Shallice, T. The Hayling and Brixton Tests. Thames Valley Test Company, Thurston, Suffolk (1997).

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Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-Mental State": A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research, 12,189-198.

**Phonemic Verbal Fluency Task – FAS**

Vilkki J, Holst P. Speed and flexibility on word fluency tasks after focal brain lesions. Neuropsychological 1994; 32:1257-1262.

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**Sharpened Romberg's Assessment**

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**Trails B**

Army Individual Test Battery (1944). Manual of Directions and Scoring. Washington, DC: War Department, Adjutant General's Office.

**Visual Analogue Scale for Headache**

Donald D. Price, D.D., McGrath, M.A., Rafi-, A., Buckingham, B., The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. Volume 17, Issue 1, September 1983, Pages 45–56.

**Validity and reliability of a scale to assess fatigue**

Lee, K.A., Hicks, G. Psychiatry Research Vol 36 (3) 1991, 291-298