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**Comparison of early and late depression after TBI; (the SHEFBIT study)**

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**Abstract**

Objective: evaluate the prevalence and risk factors for depression at 1 year after traumatic brain injury(TBI) and contrast against those at 10 weeks.

Methods: prospective TBI admissions over 2years to an emergency department were recruited to form a representative TBI population. Depression was recorded at 10weeks and 1year by HADS(Hospital Anxiety and Depression Scale) with score>8. Demographic and injury features were analysed for association with depression.

Results: 774 individuals were recruited of whom 690 attended one year follow-up; 38 had died. Only 6% of the cohort was lost to follow-up. The prevalence of depression at ten weeks was 56.3% [95%CI 52.8-59.8] and at one year 41.2% [95%CI 37.6-44.9]

A multivariable analysis identified the independent predictors of 1yr depression as abnormal CT scan, past psychiatric history, alcohol intoxication and female gender. TBI severity, age, aetiology and medical comorbidity were not significant. By contrast at 10weeks, increasing severity and CT findings were highly significant.

Conclusions: depression at 1year post-TBI remains high but injury features are less predictive than early after injury. It is likely that pre-injury personality and coping mechanisms are more important in determining long term outcome. The predictors identified may allow targeting of vulnerable sub-populations.

Keywords: TBI, depression, outcome, follow-up, cohort, rehabilitation

## Introduction

Depression is the most common psychological sequela after Traumatic Brain Injury (TBI). Individuals who manifest depression, suffer greater disability and worse outcome, not only for individuals themselves, but also their families[1-5.] They also exhibit higher levels of physical symptoms, poorer life quality and diminished psychosocial functioning[6,7].

It is long established that there is a wide range in the incidence of post-TBI depression (12-77%)[8-10] Such variation reflects the considerable disparities between studies. Examples of such variation includes the time since injury, the specific population of TBI studied and the different diagnostic tools used to identify depression[9,10]. Many studies use cross sectional assessments and few follow prospective change in prevalence over time. Difficulty in long-term follow-up means that there are relatively few, large well-designed studies.[2,3,4,11-14] These have shown that a number of demographic or injury features are associated with higher depression risk such as age, gender, ethnicity, TBI severity, past psychiatric or medical comorbidity but these findings differ considerably such that literature reviews have concluded that there is no *consistent* risk factor that can be implicated from these studies.[8-10] Indeed, different studies have found that that the prevalence of post-TBI depression itself, can remain the same, increase or decrease over time[11]. It is therefore apparent that there is a requirement for organised prospective studies to examine the risk of post-TBI depression and how this evolves over time. At the same time, examination of the risk factors associated with depression, would help to identify those individuals at high risk and target treatments.

We aimed to design such a prospective cohort to include the complete range of TBI severities and causes, with minimal exclusion criteria; we therefore believe that it is truly representative of TBI as seen by clinicians without selection bias. The hope is to yield results that are applicable to everyday clinical practice rather than just a select group and hence overcome some of the deficits in much of the literature. This is particularly relevant for elderly patients, a group often omitted from studies.

We have previously reported on the results of early depression at 10 weeks[15] and now compare and contrast with the follow-up data from one year. The primary aim of the study was to record the prevalence of depression at one year with secondary aims of showing the associations with key injury and demographic features. The factors of interest were identified as “likely or potential risk factors” in previous literature reviews. [8,10]

A further aim was to report on other common TBI outcomes that were collected on long-term symptoms, participation restriction and overall global function as well as describe the effect of depression on these.

## Methods

The SHEFBIT (Sheffield Brain Injury after Trauma) study, is a large, systematically recruited, observational cohort of patients admitted with a diagnosis of TBI. They are all admitted by an Emergency Department and followed up by a Physical and Rehabilitation Medicine (PRM) department both in the short and long-term. Participants are comprised of individuals who were admitted to a large University Hospital with a confirmed TBI diagnosis. Recruitment was from 08/13- 08/15. All subjects had at least one night's stay in hospital and they all had a CT brain scan performed. Admission criteria for TBI were decided with the NICE (National Institute for Health and Care Excellence) Guidelines (January 2014))[16] which is standard UK practice. Exclusion criteria were children under 17, previous TBI treated in hospital, dementia or non-local residence. There was no exclusion based on age which was designed to result in a "real-life" cohort and obtain a truly representative population encompassing all severity categories, causes of TBI and ages. TBI diagnosis was established with the Common Data Elements criteria[17].

Admissions with TBI were screened by lead author(RS) or the PRM team within 24 hrs. All follow-up appointments took place in the Brain Injury clinic, run by a Consultant in Rehabilitation Medicine(RS). These were arranged for 9-12 weeks post-injury. If any individuals were still in-patients at this time, then they were assessed on their ward. To encourage attendance, patients received texts and phone calls as well as a standard letter. Those who missed an appointment were called to re-arrange new appointments. The same clinician (RS) saw all patients. Injury features, such as GCS and CT findings and demographic factors such as employment and family support were noted. Past medical and psychiatric histories were also recorded. A definition of the latter was described as any individual who had seen a health professional for a psychiatric condition or received medication for a diagnosed psychiatric condition. Alcohol intoxication at time of injury was made from medical records or patient history.

Mechanism of TBI was classified by the method of the Trauma Audit and Research Network (TARN). This describes falls, assault, road traffic collisions (RTC), sports injuries and other

mechanisms which is usually injuries at work or falls over 2 metres[18]. CT changes were classified with the "overall appearance" method; this grades the CT abnormalities after TBI as normal, mild focal injury, medium focal injury or diffuse injury[19]. Cumulative Illness Rating Scale (CIRS)[20] was calculated at clinic and a score >10 established significant medical comorbidity. Socioeconomic status was established with the National Statistics Socio-Economic Classification (NS-SEC)[21]. Employment prior to injury was classed as retired, unemployed or working (including full-time students). Work status at follow-up was documented in three categories; unable to work, partial return and a complete return to work or the *capacity for work* in the case of retirees or unemployed.

All individuals were also followed up at one year and sent appointment reminders by letter, text and phone calls. Those who missed an appointment were again called by clinic staff to re-arrange appointment and to encourage follow-up.

The study was approved by the Teaching Hospital Trust and the University of Sheffield Ethics Committees (STH16208).

*Assessment questionnaires*

The primary outcome of depression was assessed with the HADS (Hospital Anxiety and Depression Scale)[22]. This is a self-filled questionnaire with 14 questions for anxiety and depression and produces scores for both ranged from 0-21. A HADS-D >8 has the best discriminant value for depression[23] and the scale has been validated in TBI populations[23,24]. In addition, the number with score HADS-D>11 was also recorded. This level identifies severe depression in some studies[23,25].

Other outcome questionnaires included a Rivermead Head Injury Follow-up Questionnaire(RHFUQ) and a Rivermead Post-concussion Symptom Score(RPCS). The RHFUQ is a ten item questionnaire of participation restriction or psychosocial function after TBI and the latter is a commonly used checklist of sixteen common head injury symptoms. Both are graded in Likert style from 0-4 resulting in scores out of 40 and 64 respectively. These measures are validated in TBI[25,26]. The Extended Glasgow Outcome Scale (GOSE) was used as a measure of overall global function [27].

*Analysis*

Comparison of follow-up and lost patients was carried out with a t-test or $\chi^2$-test as appropriate. Where assumptions for $\chi^2$-test were not met, a Fisher Exact test was utilised instead. Using HADS-D>8 as a level to signify depression, the depressed and non-depressed groups were initially compared for demographic and injury variables. In order to

determine the independent predictors of depression, a multivariable logistic regression model was created with depression as the outcome of interest and full entry method for all variables. All variables used in the univariable analysis, were also included in the multivariable model. With 15 independent variables used, it was estimated that the a study population over 450 participants would provide robust modelling (>30 cases/variable) Significance level was $p<0.05$ and all statistical analyses were performed using version 23 of SPSS.

## Results

*Demographics*

During the period of the study [08/13-07/15] 1289 individuals were admitted to the ED(Emergency Department) with an initial diagnosis of TBI. All had a minimum of one day stay in hospital. Exclusions due to previous TBI requiring hospitalisation, dementia or non-local residence came to 173 individuals. A clear TBI diagnosis by means of CDE criteria could not be made in a further 260 admissions[17]. This left a total of 856 cases that were given appointments for follow-up; at 10 weeks, 774 attended and were entered into the study. After one year, 38 individuals had died and 46 failed to attend in spite of repeated text messages, letters and phone calls. This resulted in a study population of 690 individuals with depression status at 1 year and 728 with a global outcome score(including death). This represents a follow-up success of 94.1% of the original group(Figure 1)

The cohort had a high proportion of mild TBI (44.8%) while moderate was 39.8% and severe 15.4%. This was mirrored in the short length of stay (LoS) with 2/3 having <5days.

Table 1 highlights the demographics of the cohort, in comparison with those who failed to attend at 1year. Those lost had less severe TBI (GCS 12.3 v 11.8) and were 6 years older. They had also exhibited lower questionnaire scores after 10 weeks implying lower levels of participation restriction, post-TBI symptoms and psychological distress.

*Depression and other outcomes*

Taking a cut-off of >8 to represent a case, the 10 week prevalence of depression was 56.1% and anxiety was 63% as previously reported[15]. If severe cases are estimated as a score >11, then 226 (29.2%) individuals had severe depression at 10 weeks. Over 90% of depression cases also had comorbid anxiety.

At 1 year, this prevalence decreased although it was still high; there was depression in 284 or 41.2%(95%CI 37.6-44.9) and anxiety in 293 or 42.3%(95%CI 38.8-46.2). With the higher cut-off, the prevalence of depression was 117 or 17.0%(95%CI 14.3-19.9) and for anxiety 149 or 21.6%(95%CI 18.7-24.8)

A comparison of the changes in depression between 10 weeks and 1 year found that many of those with initial depression had resolved (35.2%) but the majority of those with depression at 1 year, had also been depressed at 10 weeks (89.1%). However a small number of cases (10.9%) of depression at 1 year were in individuals who had not shown symptoms at 10 weeks.

With regards to other outcome questionnaires, scores had improved between 10 weeks and 1 year (Table 2) but there was still a high level of post-TBI symptoms and poor psychosocial outcomes; mean RPCS was 13.1(95%CI 12.3-14.0) and RHFUQ was 11.4(95% CI 10.6-12.1). The mean GOSE was 5.85(95% CI 5.72-5.98). A good outcome (both lower and upper) was only achieved in 23.1% at 10 weeks; this improved to 40.4% at 1 year. There were considerable differences in outcome between those with and without depression. (Table 2)

*Independent predictors*

A multivariable logistic regression model was calculated in which 1 year depression was the primary outcome. All independent variables were entered into this.

The regression model was highly significant ($p<0.001$). Nagelkerke R2 was 0.596 and Cox & Snell R2 was 0.400. The model correctly classified 81.6% of cases compared to 58.8% in the model with no predictors. The Hosmer-Lemeshow Test for goodness of fit was highly significant ($\chi2=2.516$, df8, $p=0.961$) and area under curve (AUC) was 0.901 (95% CI=0.879-0.924), $p<0.001$, indicating an excellent fit.

In this model, female gender (OR 2.089, 95%CI 1.210-3.606), previous psychiatric history (OR 3.364, 95%CI 1.934-5.850), alcohol intoxication (OR 2.909, 95%CI 1.664-5.087), abnormal CT scan and non-return to work after 1 year were associated with risk of depression. In the case of return to work, those who had a partial return had less depression than those who had not returned to work at all but themselves had more depression than those who had returned to full time previous employment. Hence there was a gradient effect of the extent of return to work. These features were therefore the

independent predictors of depression (Table 3). TBI severity was not significant (p=0.063) and CT scan abnormality barely reached significance (p=0.049).

Further inter-categorical examination of CT variable found that those with a normal scan, had a similar risk to those with a moderate or severe change. Those with mild changes had the lowest risk (OR 0.46).

By way of contrast, similar multivariable analysis on the 10 week data had found that both TBI severity [Odds ratio 0.806(95% CI 0.718-0.905), p<0.001] and CT abnormality [p=0.007] were highly significant risk factors; however severity had now dropped out of the model at 1 year and CT abnormality was barely significant[15].

## Discussion

The SHEFBIT study was designed to recruit and report on a truly representative population of TBI covering all types of severity and causes. It is hoped that the data presented constitutes a "real-life" study and will be valuable in the day to day management of TBI by busy clinicians, informing families and individuals with TBI, of the outcome. With respect to the primary aim, the prevalence of depression at 10 weeks was 56.3% but dropped to 41.2% at 1 year. The background level in the overall general population ranges between 4.8-10.1% depending on the country studied and the assessment tool used.[28,29]

A secondary study aim was to examine demographic/injury factors and identify those which may predict depression at 1 year. Positive associations were found for women, previous psychiatric history, alcohol excess at injury, severity of CT scan findings and in those with diminished work capacity. TBI severity did not show a significant association with depression risk. In contrast at 10 weeks, it had been highly significant.[15] In addition, the association of CT scan abnormality was barely significant at 1 year compared to 10 weeks. TBI severity and CT scans are closely correlated.

The finding that these acute injury parameters become less significant after time, is a key observation in this study of depression. It has long been hypothesised, that early outcomes after TBI are mediated by injury features and the extent of anatomical or physiological processes. However as time passes, outcome becomes more influenced by pre-morbid personality traits and coping mechanisms, as well as post-injury support mechanisms and other psychosocial features[30,31]. Our findings seem to support these theories.

The HADS has been validated in TBI12,[23,24]. Significantly, it minimises somatic questions with only one such question that asks about being "slowed down". There is a problem with many other clinical questionnaires which contain such "transdiagnostic" symptoms, common to both TBI and depression e.g. insomnia and feeling slowed down. Even the SCID(Structured Clinical Interview for DSM disorder), considered as the gold standard for diagnosis, has a number of somatic criteria[29] although it is recognised that detailed, structured interviews usually find lower prevalence of depression than self-reporting. 10 However such interviews take considerable resources and would be difficult to apply to large groups. Furthermore, many individuals with TBI are unlikely to cope with a long interview only to identify one sequela. The HADS enjoys considerable advantages over other tools in terms of time taken to complete. This study, in "real life" clinical situation, cannot boast adequate resources and staffing to incorporate long interviews into the clinic. This will be similar to most other TBI services.

The prevalence of 41.2% at 1 year falls in the mid-range of the TBI literature(range 14-77%)[8]. The average across over 100 studies was calculated as 31.7%[10]. These studies have considerable differences in selection of TBI cases, time from injury and diagnostic tools. As an example, some are solely in RTC victims or in litigants. Most studies are cross-sectional i.e. examine depression at a single time-point. Others exclude the elderly or only examine STBI. It is hoped that this study has overcome many of these weaknesses.

While we have shown a drop in depression by 1 year, the significance of this is difficult to gauge as 41% remains a very high prevalence. The exact direction in which depression changes after TBI is still unclear according to literature reviews[9,10]. While many studies show a drop in depression[4,6,32] there are also many that show a stable rate over time or even a rise[3,28,33]. Some show an initial drop in prevalence which then stabilises over 2-5 years[34]. What is certain, is that depression risk remains high up to 50 years after injury[35,36]. Follow-up of the cohort is ongoing and the aim is to report long-term data at 5 years or longer.

The secondary aim of the study was to look at the injury and demographic features which may predict depression risk. While many individual studies have identified associations with certain risk factors, , it is disappointing that reviews have concluded that no feature can be *consistently* found to be associated with risk of depression after TBI[8,10].

As an example of this difficulty, it may be expected that TBI severity may show a relationship to depression; but the literature is not so clear. Increasing TBI severity may increase[37], decrease[38-40] or show no relationship[4,11,41,42] to prevalence. Intuitively, it would seem that the amount of brain damage and physiological disruption would relate to the likelihood of depression. Hence it is unclear how an inverse relationship with TBI severity is possible. A

possible explanation is the concept of impaired self-awareness (ISA). This can be defined as an awareness of oneself prior to the injury and afterwards and implies an awareness of the long-term implications of that injury.[13] It is much more common in severe brain injuries and this may reduce the self-recognition of disability, the subjective level of complaints and hence the likelihood of depression[31]. Alternative theories highlight the importance of "survival spirit" in those with the worst injuries or the greater level of support that severe injury may receive[39].

Our results for TBI severity may partly explain why the literature differs so much. The finding that severity was highly significant at 10 weeks but no longer at 1 year, suggests that the time of assessment after injury, is important. To the best of our knowledge, we are unaware of any other study that has shown this change in significance of TBI severity in a prospective cohort. Coupled with the findings for CT abnormality, this perhaps highlights the importance of acute injury factors at an early stage but not at a later stage in generating depression. Landmark studies by *Jorge et al* have established the importance of specific anatomical lesions such as the left dorsolateral frontal cortex or basal ganglia and that these associations weaken with time. [6,43]

We also found that those with a successful return to work by 1 year, manifested less depression. However by contrast, pre-injury work status was not a risk factor unlike many other studies where unemployment carries a higher risk[4,33,42,44]. Alcohol intoxication[4,11,35] and psychiatric history[11,14] were strong risk factors and have been previously noted by others. These findings may afford an opportunity to focus interventions on a particular risk group. The use of the "overall appearance" system for classifying TBI scans has been validated in other studies and displays a relationship with functional outcome[19]. While CTs can be staged with alternative systems[45] these are less useful in a real-life TBI population, dominated by mild TBI and are utilised more commonly to time neurosurgical interventions.

A brief explanation of the CT results is necessary. It seems odd that those with a mild CT abnormality had a lower depression risk compared to individuals with a normal CT. One possibility is that the normal CT group contains a small number of people who skew the results. Previous studies have identified a group with minor TBI who present with a level of symptoms that bear little resemblance to apparent outcome.[8,9,31] Such people have been described as the "well worried".

The finding that women were at higher risk at both time points was important but it is difficult to draw any firm conclusions from this. It is possible that this only mirrors the fact that women experience more depression than men in the general population.[28,29] Others have noted a similar effect[3] but the opposite has also been found.[4,34]

There was no effect of socioeconomic status on risk of depression. Other non-significant variable were age,[3,34] aetiology of injury, pre-injury job status,[4,33,42,44] social isolation,[2] medical comorbidities, and warfarin treatment. All of these features have been associated with depression risk in some studies but there are always studies that find the converse. Reviews of the previous literature can be found which summarise this.[8-10]

This study has several strengths. The most important is the establishment of a very large, prospective cohort which is one of the largest ever collected. It features individuals with TBI which encompasses all severities and causes of the condition. A systematic effort to identify *all* admissions and to organise their follow-up, led to a well designed study. Only 5.9% of patients were lost to follow-up. Given the very high attrition rate in TBI studies (up to 70% at six months),[46] this is a key feature. The use of face to face interviews is another strength; many other have used phone follow.[3,42,47] Particular effort was made to include the elderly in the study population. This means that the cohort truly does represent all TBI. It should be relevant to all clinicians working in TBI. Unfortunately, many previous studies have recruited a select group e.g. volunteers, litigants, severe TBI or road traffic victims. Some have excluded all those with extracranial injury, past psychiatric history or elderly. Others have only included people with a psychiatric history. In addition most studies employ cross sectional or retrospective design rather than prospective recruitment.[8,10] The use of face to face clinics by the same interviewer should reduce inter-rater variability and allows for a consistent approach. Such measures were incorporated into this study in order to address the weaknesses of many other studies.

A couple of remaining weaknesses should however be noted. Some experts may question the use of the HADS rather than a structured DSM interview. While a single interviewer is a strength in many ways, it also risks a systematic bias in assessment. This study was in a civilian population and the results may bear no relevance to military TBI. There was no control group incorporated into design. A weakness of the “overall appearance” classification system for CT scan is that it does not recognise laterality of lesions which may be an important component of depression risk.[6]

Future work needs to be carried out to identify interventions that can work both at an acute and long-term stage. As depression seems to differ at these time points, the best interventions may also be different. Targeting those with particular higher risk factors may be a useful strategy and we have already incorporated earlier referral of those with past psychiatric history or alcohol intoxication in this way.

It is hoped to continue follow-up of this cohort although it is difficult to persuade individuals to attend follow-up as time since injury increases. However we hope to analyse future data and

reflect further on longer-term outcome after TBI. In particular, the extent of recovery on global outcome measures eg GOSE will be helpful in informing patients and families about prognosis. The proportion of individuals attaining good recovery in the literature ranges between 2.3-40%.[28,34,39]

It is important that we better understand the nature of depression after TBI and particularly to to identify patients at increased risk; this would allow us to target susceptible individuals with counselling and treatments including medication. To date, the identification of previous psychiatric history or alcohol intoxication as risks, has allowed for certain individuals to be targeted for more intense intervention. Ongoing evaluation of the SHEFBIT cohort will hopefully add to our understanding of TBI outcomes.

Declaration of Interests: the authors report no conflict of interests

**References**

1. Baguley IJ, Cooper J, Felmingham K. Aggressive behavior following traumatic brain injury: how common is common? J Head Trauma Rehabil 2006; 21: 45-56.

2. Bryant RA, O'Donnell ML, Creamer M, McFarlane AC, Clark CR, Silove D. The psychiatric sequelae of traumatic injury. Am J Psychiatry 2010; 167: 312-20.

3. Hart T, Hoffman JM, Pretz C, Kennedy R, Clark AN, Brenner LA. A longitudinal study of major and minor depression following traumatic brain injury. Arch Phys Med Rehabil 2012; 93: 1343-9.

4. Dikmen SS, Bombardier CH, Machamer JE, Fann JR, Temkin NR. Natural history of depression in traumatic brain injury. Arch Phys Med Rehabil 2004; 85: 1457-64.

5. Silver JM, McAllister TW, Arciniegas DB. Depression and cognitive complaints following mild traumatic brain injury. Am J Psychiatry 2009; 166: 653-61.

6. Jorge R, Robinson RG. Mood disorders following traumatic brain injury, Neurorehabilitation 2002; 17: 311-24.

7. Dyer JR, Williams R, Bombardier CH, Vannoy S, Fann JR. Evaluating the Psychometric Properties of 3 Depression Measures in a Sample of Persons With Traumatic Brain Injury and Major Depressive Disorder. J Head Trauma Rehabil. 2016; 31: 225-32.

8. Rosenthal M, Christensen BK, Ross TP, Depression following traumatic brain injury, Arch Phys Med Rehabil. 1998; 79: 90–103.

9. Rogers JM, Read CA. Psychiatric comorbidity following traumatic brain injury. Brain Inj. 2007; 21: 1321-33.

10. Guillamondegui OD, Montgomery SA, Phibbs FT, McPheeters ML, Alexander PT, Jerome RN, McKoy JN, Seroogy JJ, Eicken JJ, Krishnaswami S et al. Traumatic Brain Injury and Depression. Comparative Effectiveness Review No. 25. (Prepared by the Vanderbilt Evidence-based Practice Center under Contract No. 290-2007-10065-I.) AHRQ Publication No. 11-EHC017-EF. Available at: www.effectivehealthcare.ahrq.gov/reports/final.cfm.. Rockville, MD: Agency for Healthcare Research and Quality, April 2011.

11. Bombardier CH, Fann JR, Temkin NR, Esselman PC, Barber J, Dikmen SS. Rates of major depressive disorder and clinical outcomes following traumatic brain injury, JAMA 2010; 303: 1938-45.

12. Seel RT, Macciocchi S, Kreutzer JS. Clinical considerations for the diagnosis of major depression after moderate to severe TBI. J Head Trauma Rehabil 2010; 25: 99-112.

13. Ownsworth T, Fleming J, Haines T, Cornwell P, Kendall M, Nalder E, Gordon C. Development of depressive symptoms during early community reintegration after traumatic brain injury. J Int Neuropsychol Soc. 2011; 17: 112-9

14. Hibbard MR, Ashman TA, Spielman LA Chun D, Charatz HJ, Melvin S. Relationship between depression and psychosocial functioning after traumatic brain injury. Arch Phys Med Rehabil 2004; 85 (4 Suppl. 2): S43-53.

15. Singh R, Mason S, Lecky F. Dawson J. Prevalence of depression after TBI in a prospective cohort: The SHEFBIT study. Brain Inj. 2018; 32: 84-90.

16. Head injury Triage, assessment, investigation and early management of head injury in children, young people and adults Issued: January 2014 NICE clinical guideline 176 guidance.nice.org.uk/cg176

17. Menon DK, Schwab K, Wright DW, Maas AI. Position statement: Definition of traumatic brain injury. Arch Phys Med Rehabil 2010; 91: 1637-1640.

18. Lecky F, Woodford M, Yates DW. Trends in trauma care in England and Wales 1989-97. UK Trauma Audit and Research Network. Lancet 2000; 355: 1771-1775.

19. Wardlaw JM, Easton VJ, Statham P. Which CT features help predict outcome after head injury? J Neurol Neurosurg Psychiatry. 2002; 72: 188-92.

20. Linn BS, Linn MW, Lee G. Cumulative Illness Rating Scale. J Am Geriatr Soc 1968; 5: 622-6.

21. Chandola T, Jenkinson C. The new UK National Statistics Socio-Economic Classification (NS-SEC); investigating social class differences in self-reported health status. J Pub Health Med. 2000; 22: 182-90.

22. Zigmond A, Snaith RP. The Hospital Anxiety and Depression Scale. Acta Psych Scand 1983; 67: 361-370.

23. Dawkins N, Cloherty, ME, Gracey F, Evans JJ. The factor structure of the Hospital Anxiety and Depression Scale in acquired brain injury. Brain Inj 2006; 20: 1235-1239.

24. Whelan-Goodinson R , Ponsford J, Schönberger M. Validity of the Hospital Anxiety and Depression Scale to assess depression and anxiety following traumatic brain injury as compared with the Structured Clinical Interview for DSM-IV . J Affect Disorders 2009; 114: 94 – 102.

25. Crawford S, Wenden F, Wade DT. The Rivermead head injury follow-up questionnaire. A study of a new rating scale and other measures to evaluate outcomes after head injury. J Neurol Neurosurg Psychiatry 1996; 60: 510-14.

26. King N. Emotional, neuropsychological, and organic factors: their use in the prediction of persisting postconcussion symptoms after moderate and mild head injuries. J Neurol Neurosurg Psychiatry 1996; 61: 75-81.

27. Wilson JT, Pettigrew LE, Teasdale GM. Structured interviews for the Glasgow Outcome Scale and the extended Glasgow Outcome Scale: guidelines for their use. J Neurotrauma 1998; 15: 573-85.

28. Gould KR, Ponsford JL, Johnston L, Schonberger M. Relationship between psychiatric disorders and 1-year psychosocial outcome following traumatic brain injury. J Head Trauma Rehabil 2011; 26: 79-89

29. First MB, Spitzer RL, Gibbon M, Williams JBW. Structured clinical interview for DSM-IV-TR Axis I Disorders, research version, non-patient edition. (SCID-I/NP). New York 2002: Biometrics Research, New York State Psychiatric Institute.

30. Lishman WA. Physiogenesis and psychogenesis in the ‘ post-concussional syndrome’. Brit J Psych 1988; 153: 460-469.

31. Moldover JE, Goldberg KB, Prout MF. Depression after traumatic brain injury: A review of evidence for clinical heterogeneity. Neuropsychol Rev, 2004; 14: 143-54.

32. Ashman TA, Spielman LA, Hibbard MR, Silver JM, Chandna T, Gordon WA. Psychiatric challenges in the first 6 years after traumatic brain injury: cross-sequential analyses of Axis I disorders. Arch Phys Med Rehabil 2004; 85(4 Suppl 2): S36-42.

33. Franulic A, Carbonell CG, Pinto P, Sepulveda I. Psychosocial adjustment and employment outcome 2, 5 and 10 years after TBI. Brain Inj 2004; 18: 119-129.

34. Sigurdardottir S, Andelic N, Roe C, Schanke AK. Depressive symptoms and psychological distress during the first five years after traumatic brain injury: Relationship with psychosocial stressors, fatigue and pain. J Rehabil Med. 2013; 45: 808-14.

35. Holsinger T, Steffens DC, Phillips C, Helms MJ, Havlik RJ, Breitner JC, Guralnik JM, Plassman BL. Head injury in early adulthood and the lifetime risk of depression. Arch Gen Psych. 2002; 59: 17-22.

36. Koponen S, Taiminen T, Kurki T. MRI findings and Axis I and II psychiatric disorders after traumatic brain injury: a 30 year retrospective follow-up study. Psychiatry Res 2006; 146: 263-270.

37. Deb S, Lyons I, Koutzoukis C, Ali I, McCarthy G. Rate of psychiatric illness 1 year after traumatic brain injury. Amer J Psych 1999; 156: 374-8.

38. Hudak AM, Hynan LS, Harper CR, Diaz-Arrastia R. Association of depressive symptoms with functional outcome after traumatic brain injury. J Head Trauma Rehabil. 2012; 27: 87-98.

39. Siponkoski ST, Wilson L, von Steinbüchel N, Sarajuuri J, Koskinen S. Quality of life after traumatic brain injury: Finnish experience of the QOLIBRI in residential rehabilitation. J Rehabil Med. 2013; 45: 835-42.

40. van Reekum R, Bolago I, Finlayson MA, Garner S, Links PS. Psychiatric disorders after traumatic brain injury. Brain Inj 1996; 10:319-327.

41. Malec JF, Testa JA, Rush BK, Brown AW, Moessner AM. Self-assessment of impairment, impaired self-awareness, and depression after traumatic brain injury. J Head Trauma Rehabil 2007; 22: 156–66.

42. Seel RT, Kreutzer JS. Depression assessment after traumatic brain injury: an empirically based classification method. Arch Phys Med Rehabil 2003; 84: 1621-8.

43. Federoff JP, Starkstein SE, Forrester AW, Geisler FH, Jorge RE, Arndt SV, Robinson RG. Depression in patients with acute traumatic brain injury. Am J Psych 1992; 149: 918-23.

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44. van der Horn HJ, Spikman JM, Jacobs B, van der Naalt J. Postconcussive complaints, anxiety, and depression related to vocational outcome in minor to severe traumatic brain injury. Arch Phys Med Rehabil 2013; 94: 867-74.

45. Marshall LF, Marshall SB, Klauber, MR Van Berkum, Clark M, Eisenberg HM, Jane JA. A new classification of head injury based on computerized tomography. J. Neurosurg. 1991; 75: S14-S20.

46. Corrigan JD, Bogner JA, Mysiw JW, Clinchot D, Fugate L. Systematic bias in outcome studies of persons with traumatic brain injury. Arch Phys Med Rehabil 1997; 78: 132-7.

47. Kreutzer J, Seel R, Gourley E. The prevalence and symptom rates of depression after traumatic brain injury: a comprehensive examination Brain Inj 2001; 15: 563-576.

Figure 1: Study patients and follow-up numbers. Lost numbers and failed criteria explained in Results

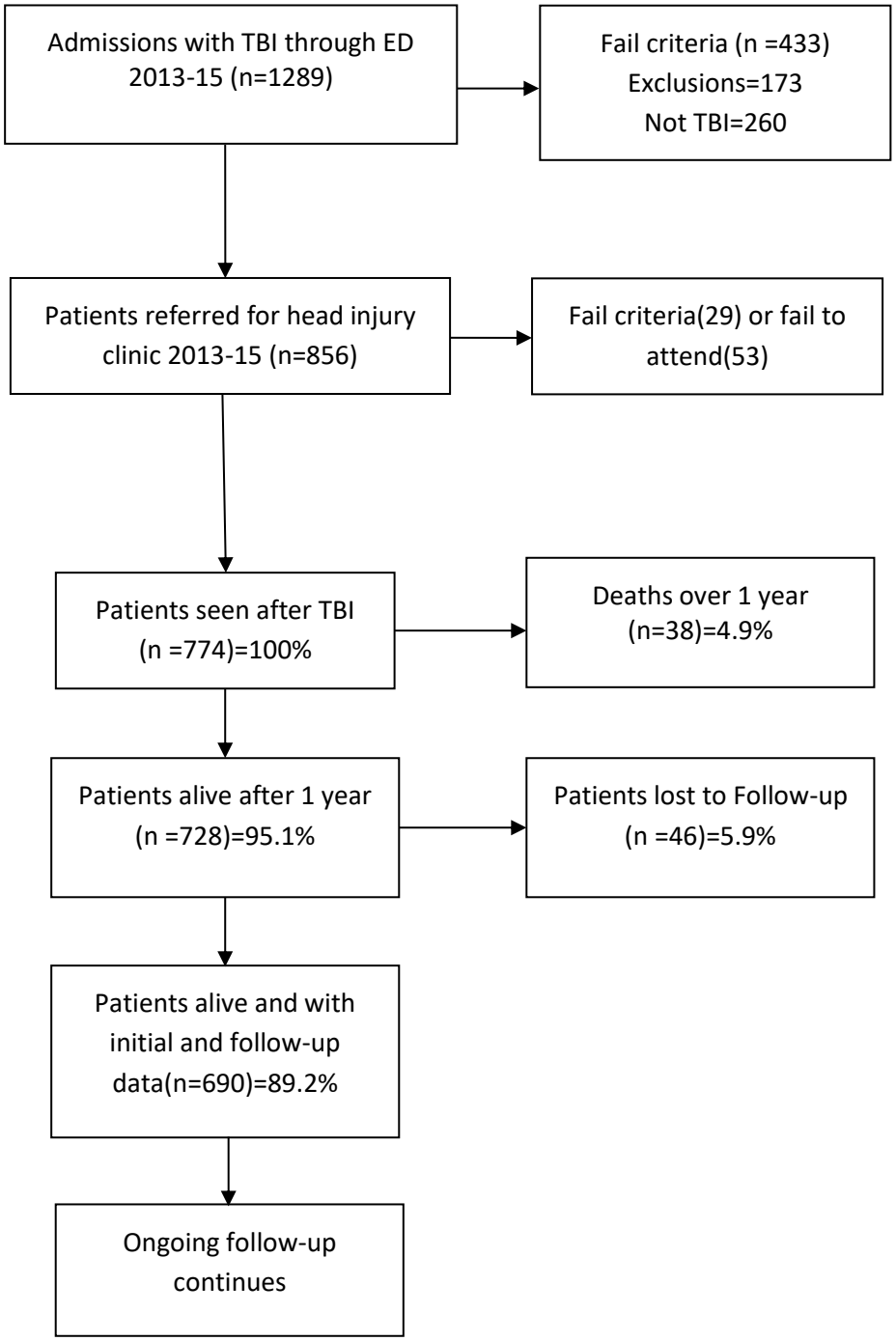

Table 1: cohort demographics and comparison to lost patients. RHFUQ Rivermead Head Injury Follow-up Questionnaire, RPCS Rivermead Post-concussion Score, GOSE Extended Glasgow Outcome Scale

| | Followed up n= 728 | lost at follow up n=46 | $\chi^2$ or t-test, df, p-value |
|---|---|---|---|
| **Mean Age yrs (SD)** | 46.5 (19.0) | 53.2 (21.5) | 5.3 df772 p=0.022* |
| **Gender** | | | |
| **Male N(%)** | 507 (69.6%) | 28(60.9) | 1.56 df1 p=0.212 |
| **Ethnicity N(%)** | | | |
| **White** | 678 (93.1) | 44 (95.7) | 2.12 df4 p=0.714 |
| **South Asian** | 33 (4.5) | 2 (4.3) | (Fisher Exact Test) |
| **Black** | 12 (1.6) | 0(0) | |
| **Oriental** | 3 (0.4) | 0 (0) | |
| **Other** | 2 (0.3) | 0 (0) | |
| **(Non-white)** | 50 (6.9) | 2 (4.3) | 0.51 df1 p=0.510 |
| **Social Class N(%)** | | | |
| **Professional** | 41 (5.5) | 2 (4.3) | 14.27 df8 p=0.887 |
| **Lower managerial** | 111 (15.2) | 12 (26.1) | (Fisher Exact Test) |
| **Intermediate** | 50 (6.9) | 5 (10.9) | |
| **Self-employed** | 58 (8.0) | 11 (23.9) | |
| **Lower supervisor** | 105 (14.4) | 5 (10.9) | |
| **Semi-routine** | 181 (24.9) | 7 (15.2) | |
| **Routine** | 101 (13.9) | 1 (2.2) | |
| **Never worked** | 42 (5.8) | 1 (2.2) | |
| **Students** | 39 (5.4) | 2 (4.3) | |
| **Employment N(%)** | | | |
| **Yes** | 492 (67.6) | 26 (56.5) | 5.22 df2 p=0.074 |
| **No** | 99 (13.6) | 5 (10.9) | |
| **Retired** | 137 (18.8) | 15 (32.6) | |
| **Social Isolation** | | | |
| **No** | 416 (57.1) | 27 (58.7) | 1.02 df2 p=0.599 |
| **Yes** | 296 (40.7) | 17 (37.0) | |
| **Nursing Home** | 16 (2.2) | 2 (4.3) | |
| **Aetiology N(%)** | | | |
| **Fall** | 263 (36.1) | 13 (28.3) | 3.4 df4 p=0.494 |
| **RTC** | 191 (26.2) | 15 (32.6) | |
| **Assault** | 137 (18.8) | 6 (13.0) | |
| **Sport** | 48 (6.6) | 4 (8.7) | |
| **Other(work)** | 59 (8.2) | 8 (17.4) | |
| **On Warfarin N(%)** | 61 (8.4) | 5 (10.9) | 0.344 df1 p=0.558 |
| **Any Comorbidity N (%)** | 237 (32.6) | 12 (26.1) | 0.829 df1 0.362 |
| **Alcohol at injury N (%)** | 199 (27.3) | 7 (15.2) | 3.25 df1 0.071 |
| **Previous Psych Hx N(%)** | 160 (22.0) | 9 (19.6) | 0.148 df1 0.701 |
| **Mean admission GCS** | 11.89 (3.0) | 12.3 (2.9) | 1.0 df772 0.313 |
| **Severity of TBI N(%)** | | | |
| **Severe** | 112 (15.4) | 6 (13.0) | 2.44 df2 p=0.295 |
| **Moderate** | 290 (39.8) | 14 (30.4) | |
| **Mild** | 326 (44.8) | 26 (56.6) | |
| **CT Scan Findings N(%)** | | | |
| **Nil** | 288 (39.6) | 18 (39.1) | 5.46 df3 p=0.141 |
| **Mild** | 142 (19.5) | 9 (19.6) | |
| **Moderate** | 231 (31.7) | 18 (39.1) | |
| **Diffuse** | 67 (9.2) | 1 (2.2) | |
| **Length of Stay, Days (SD)** | 8.8 (14.2) | 7.2 (12.1) | 0.54 df772 p=0.464 |

Table 2: Outcome measures at 10 weeks, 1 year and divided for depressed/non-depressed at 1 year. RHFUQ Rivermead Head Injury Follow-up Questionnaire, RPCS Rivermead Post-concussion Score, GOSE Extended Glasgow Outcome Score

| **Outcome Measure; mean(SD) or N(%)** | **10 weeks score** | **1 year score** | **1 yr score; depressed** | **1 yr score; Non-depressed** | **$\chi^2$ or t-test for depressed/ non-depress, p-value** |
|---|---|---|---|---|---|
| **Mean HADS depression (SD)** | 8.14(5.10) | 5.57(5.27) | 11.70(2.53) | 2.42(2.40) | -48.8, p<0.001* |
| **Mean HADS anxiety (SD)** | 8.56(5.27) | 6.03(5.51) | 12.01(2.97) | 3.03(3.07) | -38.73, p<0.001* |
| **Mean GOSE (SD)** | 5.44(1.33) | 5.85(1.7) | 4.82(0.71) | 7.02(1.06) | 30.67, p<0.001* |
| **Mean RHFUQ score (SD)** | 15.9(10.6) | 11.4(9.6) | 19.6(7.5) | 5.6(6.1) | -27.01, p<0.001* |
| **Mean RPCS (SD)** | 18.4(12.4) | 13.1(11.4) | 22.7(9.9) | 6.41(6.42) | -26.19, p<0.001* |
| **Employment or work capacity** | | | | | |
| **None** | 333(43.1) | 198(28.7) | 158(55.6) | 40(9.9) | 291.4, p<0.001* |
| **Partial** | 217(28.0) | 187(27.1) | 106(37.3) | 81(20.0) | |
| **Full** | 224(28.9) | 305(44.2) | 20(7.1) | 285(70.1) | |

Table 3: Multivariable Regression Model of 1 year Depression. Categories described in text. OR odds ratio, *significant for $p<0.05$

| | | | | *95% CI for OR* | |
|---|---|---|---|---|---|
| | **B** | **p-value** | **OR** | **Lower** | **Upper** |
| **Non-white Ethnicity** | -0.515 | 0.271 | 0.598 | 0.239 | 1.494 |
| **Female Gender** | 0.737 | **0.008*** | 2.089 | 1.210 | 3.606 |
| **Age at injury** | 0.007 | 0.489 | 1.007 | 0.988 | 1.026 |
| **Socioeconomic Class** | | 0.996 | | | |
| *Professional-baseline* | - | - | | | |
| *Lower Manager* | -0.291 | 0.606 | 0.747 | 0.247 | 2.259 |
| *Intermediate* | -0.091 | 0.888 | 0.913 | 0.258 | 3.228 |
| *Small Employer* | -0.035 | 0.955 | 0.965 | 0.283 | 3.294 |
| *Lower Supervisory* | -0.297 | 0.608 | 0.743 | 0.239 | 2.312 |
| *Semi-routine* | -0.279 | 0.604 | 0.757 | 0.264 | 2.168 |
| *Routine* | -0.213 | 0.710 | 0.808 | 0.264 | 2.480 |
| *Never Worked* | 0.199 | 0.796 | 1.221 | 0.269 | 5.539 |
| *Student* | -0.076 | 0.917 | 0.927 | 0.223 | 3.845 |
| **Pre-injury work** | | 0.588 | | | |
| *Employed-baseline* | - | - | | | |
| *Unemployed* | 0.386 | 0.310 | 1.472 | 0.698 | 3.103 |
| *Retired* | 0.180 | 0.693 | 1.198 | 0.489 | 2.936 |
| **Social Isolation** | | 0.189 | | | |
| *No- baseline* | - | - | | | |
| *Yes* | -0.305 | 0.204 | 0.737 | 0.461 | 1.180 |
| *Nurse home* | -1.361 | 0.135 | 0.256 | 0.043 | 1.527 |
| **Aetiology** | | 0.693 | | | |
| *Fall - baseline* | - | - | | | |
| *Assault* | -0.073 | 0.838 | 0.930 | 0.463 | 1.868 |
| *RTC* | 0.193 | 0.600 | 1.213 | 0.590 | 2.494 |
| *Sports* | 0.628 | 0.253 | 1.873 | 0.639 | 5.494 |
| *Other* | 0.193 | 0.636 | 1.213 | 0.545 | 2.696 |
| **GCS** | -0.116 | 0.063 | 0.891 | 0.788 | 1.006 |
| **Psychiatric Hx** | 1.213 | **0.001*** | 3.364 | 1.934 | 5.850 |
| **Warfarin** | 0.360 | 0.468 | 1.434 | 0.542 | 3.795 |
| **Comorbidity** | -0.130 | 0.659 | 0.878 | 0.492 | 1.567 |

| | | | | | |
|---|---|---|---|---|---|
| **Intoxicated** | 1.068 | **0.001*** | 2.909 | 1.664 | 5.087 |
| **CT Scan** | | **0.049*** | | | |
| *NAD-baseline* | - | - | | | |
| *Mild* | -0.761 | 0.042* | 0.467 | 0.225 | 0.972 |
| *Moderate* | 0.113 | 0.735 | 1.120 | 0.582 | 2.153 |
| *Severe* | 0.171 | 0.729 | 1.186 | 0.451 | 3.118 |
| **Return to Work** | | **0.001*** | | | |
| *No work-baseline* | - | - | | | |
| *Reduced return* | -1.076 | 0.001* | 0.341 | 0.203 | 0.572 |
| *Full return* | -3.535 | 0.001* | 0.029 | 0.015 | 0.056 |
| **Length of Stay** | -0.006 | 0.546 | 0.994 | 0.976 | 1.013 |
| **Constant** | 2.284 | 0.069 | 9.814 | | |