Early risk factors for depression, anxiety and post-traumatic distress after hospital admission for unintentional injury: multicentre cohort study

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Abstract

Objective

To quantify psychological morbidity and identify baseline factors associated with depression, anxiety and post-traumatic distress symptoms up to 12 months post-injury.

Methods

Multicentre cohort study of 668 adults, aged 16 to 70, admitted to 4 UK NHS hospital trusts. Data on injury, socio-demographic characteristics and health status was collected at recruitment. Depression, anxiety and post-traumatic distress were measured at 1, 2, 4 and 12 months post-injury. Multilevel linear regression assessed associations between patient and injury characteristics and psychological outcomes over 12 months follow-up.

Results

Depression, anxiety and post-traumatic distress scores were highest 1 month post-injury, and remained above baseline at 2, 4 and 12 months post-injury.

Moderate or severe injuries, previous psychiatric diagnoses, higher pre-injury depression and anxiety scores, middle age (45-64 years), greater deprivation and lower pre-injury quality of life (QoL) were associated with higher depression scores post-injury.

Previous psychiatric diagnoses, higher pre-injury depression and anxiety scores, middle age, greater deprivation and lower pre-injury QoL were associated with higher anxiety scores post-injury.

Traffic injuries or injuries from being struck by objects, multiple injures (≥ 3), being female, previous psychiatric diagnoses, higher pre-injury anxiety scores and greater deprivation were associated with higher post-traumatic distress scores post-injury.

Conclusion

A range of risk factors, identifiable shortly after injury, are associated with psychological morbidity occurring up to 12 months post-injury in a general trauma population. Further research is required to explore the utility of these, and other risk factors in predicting psychological morbidity on an individual patient basis.

Introduction

Worldwide, injuries result in more than 5 million deaths each year and account for 9% of all deaths.[1] Three quarters of these injuries are unintentional; most commonly caused by road traffic crashes and falls.[1] Injuries are a particular problem in working age adults; in England and Wales injuries result in more than 20,000 deaths per year, more than 10,000 of which occur between 15 and 64 years of age.[2] Injuries also place a considerable burden on health services, resulting in more than 730,000 hospital admissions in England in 2015/16 in those aged 16-69 years.[3]

With significant improvements in injury survival, the importance of psychological outcomes following injury are increasingly being recognised, affecting recovery[4, 5], quality of life[6] and return to work.[7] Systematic reviews show varying prevalences of psychological morbidity post-injury; estimated to range from 2-42% experiencing post-traumatic stress disorder (PTSD)[8, 9], 6-42% depression[10] and 4-24% anxiety[10]; and these conditions are commonly found to be comorbid[5, 8, 10]. The wide variation in prevalence rates may be due to differences in data collection tools, administration methods and timing of data collection in relation to the injury, differences in trauma populations including emergency department attenders or hospital admissions, injury mechanism and intent or demographic and cultural factors. Systematic reviews have also identified risk factors for psychological morbidity post-injury, including being female,[11-13] past psychiatric disorders,[11, 12, 14, 15] socioeconomic [11, 13, 14] and marital status,[11, 14] employment,[12] low social support,[11, 13, 15] injury type,[11] perceived threat to life,[11, 14, 15] peritraumatic dissociation,[11, 14, 15] pain,[11, 14] involvement in litigation,[11, 12, 15] and alcohol use during recovery.[14] Much of this literature focusses on PTSD[13-15] or specific injury types (e.g. road traffic crashes,[15] burns[12, 14]) and is limited by small sample sizes (<200 participants).[11, 12] In addition, the UK literature in this area is sparse and not contemporaneous.[16-20]

One UK study had developed a tool for predicting PTSD, anxiety and depression up to 3 months post-injury in emergency department attenders, using factors measured around the time of injury and up to one month later. Neuroticism scores, prior history of mental health problems and PTSD symptoms 1 month post-injury had high sensitivity in predicting the three outcomes, but also a high false positive rate, leading authors to conclude screening using the tool may not be acceptable to patients or cost effective.[21] In addition, performance of the tool amongst those admitted to hospital with an injury is unknown as is its ability to predict psychological outcomes beyond 3 months post-injury. Furthermore, its reliance on data collected one month post injury limits its usefulness in the acute hospital setting. Prediction tools have been developed for general trauma populations in other

countries,[22-24] but their generalisability to the UK is unclear due to differences in trauma populations, healthcare, compensation and legal systems.

The analyses presented in this paper aim to quantify psychological morbidity during the first 12 months post-injury and identify early factors, measurable around the time of the index admission, which are associated with symptoms of depression, anxiety and post-traumatic distress in the first 12 months post-injury. The paper draws on data collected among a general trauma population of working aged adults treated in the English NHS in the Impact of injury Study.[25]

Materials and methods

Study design

This was a multicentre longitudinal study of 668 patients recruited following hospital admission for unintentional injury.

Participants

Participants were 16-70 years old, admitted to one of 4 UK NHS hospital trusts in Nottingham, Leicester, Guildford or Bristol between June 2010 and June 2012. Eligible patients were recruited to the study within 3 weeks of injury either face-face, by post or by phone. Patients were excluded if they were not able to provide full consent, did not have a fixed address, or had a significant head injury (Glasgow Coma of <15 at presentation, amnesia or loss of consciousness) to avoid confusion with psychological sequelae of head injury. Initial quota sampling between June 2010 and May 2011 which was based on age, injury type and sex, was subsequently replaced with invitation of all eligible patients due to slower than expected recruitment. Further details of the study can be found in the published protocol.[25]

Measures

At recruitment, participants completed a self-administered questionnaire covering demographic characteristics (sex, age, marital status, ethnicity, employment status), injury characteristics (mechanism, location), pre-injury quality of life (EQ5D),[26] anxiety and depression (Hospital Anxiety and Depression Scale, HADS),[27] drug (Drug Abuse Screening Test, DAST)[28] and alcohol use disorders (Alcohol Use Disorders Identification test, AUDIT),[29] social functioning (Social Functioning Questionnaire, SFQ),[30] pre-injury visual analogue pain scale and long-term health conditions. Injury characteristics were also ascertained from medical records, including time spent in hospital, number of injuries, body part injured and injury severity measured by the Abbreviated

injury Scale (AIS).[31] The Index of Multiple Deprivation (IMD)[32] was used as a measure of socio-economic status. Psychiatric morbidity was also measured through a researcher administered Structured Clinical Interview (SCID)[33] which identified the number of psychiatric disorders in the 2 years pre-injury.

Participants were followed up at 1, 2, 4 and 12 months post-recruitment and completed postal questionnaires collecting data including the visual analogue pain scale, EQ5D, HADS, AUDIT, DAST, SFQ, Impact of Event Scale (IES) as a measure of PTSD,[34] life events,[35] health service use, compensation or litigation status, recovery expectations,[36] social support (Crisis Support Scale, CSS),[37] and changes in outlook (Positive and Negative Changes in Outlook, CiOQ).[38] The SCID was also administered at follow-up for participants who scored borderline or above thresholds for HADS, IES, AUDIT and DAST scales.

Data analysis

Characteristics of study participants were described using frequencies and percentages and means (standard deviations (SD)) or medians (interquartile ranges (IQR)) for continuous data as appropriate. These were compared descriptively between all study participants and those returning at least one follow-up questionnaire, as the latter formed the sample for the multilevel analyses presented in this paper. Univariate and multivariable multi-level linear regression models to account for repeated measures (observation at level 1, participant at level 2) calculated differences between means and 95% confidence intervals for each outcome separately (depression (HADS subscale), anxiety (HADS subscale)and post-traumatic distress (IES) at 1, 2, 4 and 12 months). Linearity of the relationship between continuous independent variables and the outcome variable was assessed by adding higher order terms to the model. Where there was evidence of non-linearity, continuous independent variables were categorised. Outcome scores were logarithmic transformed (natural logarithm + 1) as otherwise residual values were not normally distributed.

The analyses were carried out according to the statistical analysis plan written prior to undertaking analyses which detailed the variables considered for inclusion in the models and the model building process. Multivariable models were built for each outcome by firstly adding age, sex, study centre and follow-up time in one block and keeping these in the model regardless of statistical significance. This was followed by adding all variables measured at recruitment with a p-value of ≤0.2 on univariate analysis in a second block (considering number of psychiatric morbidities, depression (HADS subscale), anxiety (HADS subscale), AUDIT, DAST, long term conditions, EQ5D, length of

hospital stay, injury severity, number of injuries, body part injured, injury mechanism, location of injury, employment status, ethnic group, deprivation, marital status). Variables were then removed in order of least statistical significance first, with the significance of their removal tested using a likelihood ratio test (LRT) with a p-value of< 0.05 taken as significant. Once no more variables could be removed, those that had been removed were reassessed for inclusion, by adding them back into the model, one at a time and tested for statistical significance using a LRT. Age, sex, study centre and follow-up time were defined *a priori* as variables that should be accounted for in the analysis, to adjust for confounding effects of age and sex and any differences between study centres and to allow for analysis accounting for changes over time. The remaining variables were included in the final model only if statistically significant as the aim of these analyses was to assess which of these baseline variables were significantly associated with the outcomes. Collinearity was checked using variance inflation factors (VIFs). Interactions were assessed between age, sex and time and each of the other variables included in models with a p-value of <0.01 taken as significant.

We carried out complete case analyses and multiple imputation analyses to account for missing data. Multiple imputation with chained equations was used to impute any missing values for all 668 participants included in the study at baseline, assuming data was missing at random. The imputation model included study centre, age, sex, depression and anxiety scores at baseline and at 1, 2, 4 and 12 months post-injury, post-traumatic distress scores at 1, 2, 4 and 12 months, and all variables considered in the blocks described above, including those reported at baseline and at 1, 2, 4 and 12 months post-injury. Fifty imputed datasets were generated. The multiple imputation analyses were combined across the imputed datasets using Rubin's rules.[39] Figures are reported to 2 decimal places or where numbers are small, to one significant figure.

Ethical approval

Nottingham Research Ethics Committee 1 provided ethical approval for the study (number: 09/H0407/29).

Results

Participant characteristics

A total of 668 participants were recruited to the study. Follow-up rates ranged from 77% at 1 month to 63% at 12 months (figure 1). Characteristics of study participants are shown in table 1. Just over half (52%) of the 668 participants were male, 46% were aged 45-64 years and before the injury occurred 60% were in paid employment, 25% had a long term condition and 17% had at least one psychiatric diagnosis in the past 2 years. Fifty two percent had more than one injury, 74% had lower

limb or both upper and lower limb injuries and 64% were injured in falls. Injuries most commonly occurred on the road (30%) or at home (21%) and 23% of participants had a serious injury (AIS≥3). The median number of nights spent in hospital was 6 (IQR 3 to 10). Seventeen percent had at least one psychiatric diagnosis in the last 2 years and 25% had a long-term health condition. There were low pre-injury levels of symptoms for depression (mean 1.6, SD 2.7), anxiety (mean 3.1, SD 3.6), alcohol use disorders (mean 5.0, SD 4.9) and drug abuse disorders (mean 0.2, SD 0.9). Pre-injury health related quality of life was high (mean 0.92, SD 0.18). Although absolute differences were small, those returning at least one follow-up questionnaire were slightly more likely to be women, aged 45 and over, married and injured during a fall than all study participants.

Table 1. Characteristics of study participants

Characteristics	**All participants (n=668)** **Number (%[1]) unless otherwise specified**	**Participants completing at least one follow-up questionnaire (n=583) Number (%[1]) unless otherwise specified**
Participant characteristics at recruitment		
Centre	[0]	[0]
Nottingham	278 (41.6)	233 (40.0)
Leicester	167 (25.0)	142 (24.4)
Bristol	174 (26.1)	163 (28.0)
Guildford	49 (7.3)	45 (7.7)
Sex	[0]	[0]
Female	316 (47.3)	294 (50.4)
Male	352 (52.7)	289 (49.6)
Age	[0]	[0]
16-24	96 (14.4)	69 (11.8)
25-44	178 (26.7)	146 (25.0)
45-64	310 (46.4)	290 (49.7)
65-70	84 (12.6)	78 (13.4)
Ethnic group	[2]	[2]
White	634 (95.2)	554 (95.4)
Black or minority ethnic group	32 (4.8)	27 (4.6)
Deprivation score (IMD, 2010)	[37]	[14]
Mean (SD)	17.7 (13.8)	17.2 (13.6)
Median (IQR)	13.5 (7.4-22.9)	13.1 (7.3-22.6)
Marital status	[5]	[3]
Single	189 (28.5)	149 (25.7)
Married/partnership	360 (54.3)	327 (56.4)
Divorced/widowed	114 (17.2)	104 (17.9)
Employment	[8]	[6]
Paid employment	393 (59.6)	342 (59.3)
Not working due to illness or disability	32 (4.9)	28 (4.9)
Unemployed	26 (3.9)	22 (3.8)
At home and not looking for work	18 (2.7)	14 (2.4)
Retired	130 (19.7)	122 (21.1)
Other	61 (9.2)	49 (8.5)
Health status at recruitment		
Long term conditions	[6]	[6]
No	498 (75.2)	433 (75.0)
Yes	164 (24.8)	144 (25.0)

Number of psychiatric diagnoses in past 2 years	[0]	[0]
0	556 (83.2)	495 (84.9)
1	66 (9.9)	55 (9.4)
≥2	46 (6.9)	33 (5.7)
Pre-injury EQ5D	[7]	[6]
Mean (SD)	0.92 (0.18)	0.91 (0.19)
Median (IQR)	1 (0.85-1)	1 (0.85-1)
Pre-injury HADS depression score	[2]	[2]
Mean (SD)	1.6 (2.7)	1.6 (2.6)
Median (IQR)	0 (0-2)	0 (0-2)
Pre-injury HADS anxiety score	[2]	[2]
Mean (SD)	3.1 (3.6)	3.1 (3.6)
Median (IQR)	2 (0-5)	2 (0-5)
Pre-injury AUDIT score	[21]	[17]
Mean (SD)	5.0 (4.9)	4.8 (4.8)
Median (IQR)	4 (2-7)	4 (1-6)
Pre-injury DAST score	[7]	[5]
Mean (SD)	0.2 (0.9)	0.1 (0.6)
Median (IQR)	0 (0-0)	0 (0-0)
Characteristics of injury event		
Number of injuries	[0]	[0]
1	317 (47.5)	281 (48.2)
2	211 (31.6)	178 (30.5)
≥3	140 (21.0)	124 (21.3)
Body part injured	[0]	[0]
Lower limb	429 (64.2)	385 (66.0)
Upper limb	117 (17.5)	92 (15.8)
Upper and lower limbs	62 (9.3)	54 (9.3)
Other	60 (9.0)	52 (8.9)
Injury mechanism	[0]	[0]
Falls	425 (63.6)	386 (66.2)
Traffic	142 (21.3)	115 (19.7)
Struck	47 (7.0)	39 (6.7)
Other	54 (8.1)	43 (7.4)
Place of injury	[1]	[1]
Home	142 (21.3)	123 (21.1)
Work	63 (9.5)	54 (9.3)
Road	200 (30.0)	170 (29.2)
Countryside	76 (11.4)	69 (11.9)
Sports facilities	83 (12.4)	71 (12.2)
Other	103 (15.4)	95 (16.3)
Injury severity	[2]	[2]
Minor	44 (6.6)	31 (5.3)
Moderate	471 (70.7)	414 (71.3)
Serious or worse	151 (22.7)	136 (23.4)
Nights in hospital	[21]	[17]
Mean (SD)	7.3 (5.9)	7.4 (5.9)
Median (IQR)	6 (3-10)	6 (3-10)

[ ] shows number of missing values. [1] Percentages do not include missing values. SD= Standard deviation. IQR= Interquartile range. IMD= Index of Multiple Deprivation. EQ5D= EuroQol five dimensions questionnaire. HADS= Hospital Anxiety and Depression Scale. AUDIT= Alcohol Use Disorder Identification Test. DAST= Drug Abuse Screening Test.

Prevalence of depression, anxiety and post-traumatic distress

HADS depression and anxiety subscale and IES scores over time are shown in figure 2.

Supplementary table 1 reports prevalence of depression, anxiety and PTSD over time. Fifteen

percent of participants had HADS depression subscale scores ≥11 (i.e. meeting case definition) one month post-recruitment, reducing to 12%, 8% and 7% at 2, 4 and 12 months follow-up respectively. Only 2% reported pre-injury HADS depression subscale scores ≥11. The prevalence of anxiety (case definition i.e. HADS anxiety subscale score ≥11) was similar ranging from 15%, 12%, 10%, to 11% at 1, 2, 4 and 12 months follow-up respectively, with 5% reporting pre-injury scores ≥11. The prevalence of moderate or severe post-traumatic distress (IES scores ≥26) was higher and reduced more slowly; ranging from 24%, 23%, 17% and 17% at 1, 2, 4 and 12 months follow-up respectively. Supplementary table 2 reports trajectories in case status over time for participants who completed all four follow-up questionnaires.

Risk factors for depression

Table 2 shows results of the multivariable multilevel analysis for factors associated with the HADS depression subscale score during the 12 month follow-up period. Those aged 16-24, 25-44 and ≥65 had significantly lower depression scores than those aged 45-64 years. Increasing levels of deprivation were associated with higher depression scores. Significantly higher depression scores were found in those with ≥2 recent past psychiatric diagnoses compared to none, those with lower pre-injury quality of life compared to those with an EQ5D score of 1 and those with moderate or serious injury compared to minor injuries. Those with higher pre-injury depression scores had significantly higher depression scores during follow-up than those with lower pre-injury depression scores; as did those with higher pre-injury anxiety scores. The mean VIF for the multivariable model was 1.24. Findings were mainly robust to missing data, except those relating to age groups 16-24 and 25-44 and serious injury, which did not remain statistically significant in the analyses using multiply imputed data.

Table 2: Risk factors for depression score following injury

Characteristics	**Ln HADS depression score Adjusted regression coefficient and 95% CI**	
	Complete case analysis (n=558 subjects)	**Multiply imputed data (n=668 subjects)**
Centre		
Nottingham	Reference	Reference
Leicester	-0.003 (-0.13, 0.13)	-0.006 (-0.13, 0.12)
Bristol	-0.10 (-0.22, 0.03)	-0.11 (-0.23, 0.01)
Guildford	-0.40 (-0.60, -0.19)	-0.37 (-0.57, -0.17)
Sex†		
Female	Reference	Reference
Male	-0.05 (-0.15, 0.06)	-0.04 (-0.14, 0.06)
Age†		
45-64	Reference	Reference
16-24	-0.18 (-0.35, -0.01)	-0.13 (-0.29, 0.03)
25-44	-0.14 (-0.26, -0.01)	-0.09 (-0.21, 0.03)
65-70	-0.17 (-0.33, -0.02)	-0.15 (-0.30, -0.0003)

Follow-up time		
1 month	Reference	Reference
2 months	-0.23 (-0.29, -0.17)	-0.22 (-0.30, -0.15)
4 months	-0.50 (-0.56,-0.44)	-0.47 (-0.55, -0.39)
12 months	-0.67 (-0.73, -0.61)	-0.60 (-0.70, -0.50)
Deprivation score (IMD)†*	0.004 (0.0002, 0.008)	0.004 (0.0001, 0.008)
Number of psychiatric diagnoses in the past 2 years		
0	Reference	Reference
1	0.01 (-0.17, 0.18)	-0.002 (-0.17, 0.16)
≥2	0.35 (0.12, 0.58)	0.33 (0.11, 0.55)
EQ5D at recruitment†		
Score=1	Reference	Reference
Score<1 (-0.074 to 0.883)	0.19 (0.06, 0.32)	0.14 (0.02, 0.26)
Tertiles pre-injury HADS depression score†		
Score=0	Reference	Reference
Score=1	0.27 (0.12, 0.41)	0.23 (0.09, 0.36)
Score>1 (1.17 to 18)	0.33 (0.19, 0.47)	0.33 (0.19, 0.46)
Pre-injury HADS anxiety score*	0.03 (0.01, 0.05)	0.026 (0.009, 0.043)
Injury severity		
Minor	Reference	Reference
Moderate	0.32 (0.08, 0.56)	0.23 (0.009, 0.44)
Serious	0.29 (0.03, 0.54)	0.22 (-0.02, 0.45)

Reference category for age chosen to be the 45-64 age group as this had the highest frequency of participants

† Significant interaction between risk factor and follow-up time. See supplementary table 3.

* Coefficient reflects the increase in the outcome variable per 1 unit increase in the risk factor.

IMD= Index of Multiple Deprivation. EQ5D= EuroQol five dimensions questionnaire. HADS= Hospital Anxiety and Depression Scale.

Overall R^2 for the complete case analysis 0.28

Significant interactions between risk factor variables are shown in supplementary table 3. Compared to females, males had significantly lower depression scores at 1 month follow-up and significantly higher depression scores at 12 months follow-up. Compared to those aged 45-64, those aged 16-24 and 25-44 had significantly lower depression scores at later time points (2, 4 and 12 months) whilst those aged ≥65 had significantly lower scores only at 1 month follow-up. Those with higher deprivation scores had significantly higher depression scores at 4 and 12 months follow-up and the difference increased in magnitude over time. Compared to those with an EQ5D score of 1, those with lower quality of life scores had significantly higher depression scores at 4 and 12 months follow-up. Lastly, those in the highest two tertiles of pre-injury depression scores had significantly higher depression scores at almost all follow-up time points, and the difference increased in magnitude over time. Multiple imputation analysis showed interactions between age and time, deprivation and time and pre-injury depression score and time no longer remained statistically significant.

Risk factors for anxiety

Table 3 shows results of the multivariable analysis for factors associated with the HADS anxiety subscale score during the 12 month follow-up period. Those aged ≥65 had significantly lower anxiety scores than those aged 45-64 years. Increasing levels of deprivation were associated with higher

anxiety scores. Significantly higher anxiety scores were found in those with ≥2 recent past psychiatric diagnoses compared to none. A higher pre-injury quality of life score was associated with lower anxiety scores. Those with higher pre-injury anxiety scores had significantly higher anxiety scores during follow-up than those with lower pre-injury anxiety scores, as did those with higher pre-injury depression scores. The mean VIF for the multivariable model was 1.24. Findings were mainly robust to missing data, except in the multiple imputation analysis males had a significantly lower anxiety score than females and the relationship between pre-injury quality of life and anxiety no longer remained significant.

Table 3: Risk factors for anxiety following injury

Characteristics	**Ln HADS anxiety score Adjusted regression coefficient and 95% CI**	
	Complete case analysis (n=557 subjects)	**Multiply imputed data (n=668 subjects)**
Centre		
Nottingham	Reference	Reference
Leicester	0.09 (-0.04, 0.22)	0.08 (-0.05, 0.20)
Bristol	-0.12 (-0.25, 0.01)	-0.12 (-0.25, 0.002)
Guildford	-0.35 (-0.56, -0.15)	-0.33 (-0.54, -0.13)
Sex		
Female	Reference	Reference
Male	-0.10 (-0.20, 0.01)	-0.11 (-0.21, -0.003)
Age		
45-64	Reference	Reference
16-24	0.01 (-0.16, 0.18)	0.03 (-0.13, 0.20)
25-44	-0.09 (-0.22, 0.04)	-0.04 (-0.16, 0.08)
65-70	-0.22 (-0.37, -0.06)	-0.21 (-0.37, -0.06)
Time		
1 month	Reference	Reference
2 months	-0.18 (-0.24, -0.11)	-0.19 (-0.28, -0.11)
4 months	-0.32 (-0.38, -0.25)	-0.29 (-0.38, -0.20)
12 months	-0.36 (-0.42, -0.29)	-0.31 (-0.41, -0.21)
Deprivation score (IMD) †*	0.006 (0.002, 0.01)	0.005 (0.001, 0.009)
Number of psychiatric diagnoses in past 2 years		
0	Reference	Reference
1	0.14 (-0.04, 0.32)	0.09 (-0.08, 0.25)
≥2	0.51 (0.28, 0.75)	0.40 (0.19, 0.61)
Pre-injury EQ-5D†*	-0.33 (-0.65, -0.002)	-0.28 (-0.58, 0.02)
Tertiles pre-injury HADS depression score		
1 (0)	Reference	Reference
2 (1)	0.27 (0.12, 0.42)	0.21 (0.07, 0.35)
3 (1.17 to 18)	0.19 (0.05, 0.34)	0.20 (0.05, 0.34)
Tertiles pre-injury HADS anxiety score		
1 (0-1)	Reference	Reference
2 (2-4)	0.33 (0.20, 0.46)	0.29 (0.16, 0.41)
3 (5-18)	0.59 (0.44, 0.74)	0.52 (0.38, 0.66)

Reference category for age chosen to be the 45-64 age group as this had the highest frequency of participants

† Significant interaction between risk factor and time. See supplementary table 3.

* Coefficient reflects the increase in the outcome variable per 1 unit increase in the risk factor.

IMD= Index of Multiple Deprivation. EQ5D= EuroQol five dimensions questionnaire. HADS= Hospital Anxiety and Depression Scale.

Overall R^2 for the complete case analysis 0.28

Significant interactions between risk factor variables are shown in supplementary table 3. Those with higher deprivation scores had significantly higher anxiety scores at 4 and 12 months follow-up but not at 1 or 2 months. Those with higher quality of life scores pre-injury had significantly lower anxiety scores at 4 and 12 months follow-up. Multiple imputation analysis showed the interaction between deprivation and time no longer remained significant.

Risk factors for post-traumatic distress

Table 4 shows results of the multivariable analysis for factors associated with the IES score during the 12 month follow-up period. Males had significantly lower IES scores during follow-up than females. Those in the two most deprived quintiles of deprivation scores had significantly higher IES scores than those in the least deprived quintile. Significantly higher IES scores were found in those with ≥2 recent past psychiatric diagnoses compared to none. An increasing pre-injury anxiety score was associated with significantly higher IES scores during follow-up. Those with ≥3 injuries had significantly higher IES scores than those with single injuries. Those with road traffic injuries and those injured by striking or being struck by objects had significantly higher IES scores than those injured during falls. The mean VIF for the multivariable model was 1.17. No significant interactions were found and multiple imputation analysis showed very similar results.

Table 4: Risk factors for PTSD following injury

Characteristics	Ln IES score Adjusted regression coefficient and 95% CI	
	Complete case analysis (n=561 subjects)	**Multiply imputed data (n=668 subjects)**
Centre		
Nottingham	Reference	Reference
Leicester	-0.19 (-0.44, 0.06)	-0.19 (-0.43, 0.05)
Bristol	-0.25 (-0.48, -0.01)	-0.26 (-0.48, -0.03)
Guildford	-0.65 (-1.03, -0.27)	-0.57 (-0.94, -0.19)
Sex		
Female	Reference	Reference
Male	-0.34 (-0.53, -0.14)	-0.29 (-0.48, -0.10)
Age		
45-64	Reference	Reference
16-24	0.16 (-0.16, 0.48)	0.23 (-0.08, 0.54)
25-44	-0.14 (-0.38, 0.09)	-0.04 (-0.27, 0.18)
65-70	-0.17 (-0.46, 0.12)	-0.13 (-0.41, 0.16)
Time		
1 month	Reference	Reference
2 months	-0.29 (-0.40, -0.18)	-0.28 (-0.43, -0.12)
4 months	-0.52 (-0.64, -0.41)	-0.44 (-0.59, -0.29)
12 months	-0.49 (-0.60, -0.37)	-0.32 (-0.48, -0.16)
Deprivation score (IMD)		
Quintile 1 (least deprived)	Reference	Reference
Quintile 2	0.27 (-0.02, 0.56)	0.25 (-0.03, 0.53)
Quintile 3	0.14 (-0.15, 0.44)	0.16 (-0.13, 0.45)
Quintile 4	0.37 (0.06, 0.67)	0.37 (0.07, 0.67)

Quintile 5 (most deprived)	0.43 (0.12, 0.75)	0.52 (0.20, 0.83)
Number of psychiatric diagnoses in past 2 years		
0	Reference	Reference
1	-0.10 (-0.43, 0.23)	-0.13 (-0.44, 0.17)
≥2	0.64 (0.20, 1.08)	0.54 (0.14, 0.95)
Pre-injury HADS anxiety score*	0.09 (0.06, 0.11)	0.08 (0.05, 0.11)
Number of injuries		
1	Reference	Reference
2	0.16 (-0.06, 0.37)	0.13 (-0.07, 0.34)
≥3	0.38 (0.11, 0.65)	0.26 (0.007, 0.52)
Injury mechanism		
Falls	Reference	Reference
Traffic	0.43 (0.16, 0.70)	0.41 (0.15, 0.67)
Struck	0.43 (0.04, 0.83)	0.43 (0.06, 0.79)
Other	0.02 (-0.35, 0.39)	0.09 (-0.27, 0.45)

Reference category for age chosen to be the 45-64 age group as this had the highest frequency of participants
Reference category for injury mechanism chosen to be falls as this had the highest frequency of all injury mechanisms
* Coefficient reflects the increase in the outcome variable per 1 unit increase in the risk factor.
IMD= Index of Multiple Deprivation. EQ5D= EuroQol five dimensions questionnaire. HADS= Hospital Anxiety and Depression Scale.
Overall R^2 for the complete case analysis 0.18

Discussion

We found symptoms of depression, anxiety and post-traumatic distress, sufficient to reach case definitions, are common in a general population of adults aged 16 to 70 admitted to hospital with injuries in the UK, and these persist for at least 12 months in a sizeable proportion, particularly for post-traumatic distress. Similar risk factors were found for symptoms of depression and anxiety post-injury: middle age, higher pre-injury symptoms of anxiety or depression, having 2 or more recent psychiatric diagnoses before injury, poorer quality of life before injury and higher levels of deprivation. More severe injuries were associated with symptoms of depression post-injury. Increased levels of post-traumatic distress were associated with road traffic injuries, injuries caused by striking or being struck by objects and suffering multiple injuries, higher pre-injury anxiety scores, 2 or more recent psychiatric diagnoses and higher levels of deprivation.

Comparisons to previous research

We were unable to find any recent UK studies with which to compare our findings. Our prevalence of depression 12 months post-injury is the same (7%) as a 2001 study reporting findings from a sub-sample of 106 adults with road traffic injuries admitted for at least 3 nights, but lower for anxiety (11% vs. 16%) and post-traumatic distress (17% vs. 28%).[18] We found a slightly lower prevalence of depression (8% vs. 9%) and anxiety (10% vs. 14%) and a considerably lower prevalence of PTSD (17% vs. 39% moderate-severe avoidance symptoms, 31% moderate-severe hyperarousal symptoms and 38% moderate-severe intrusion symptoms on the IES) 4 months post-injury than a study of 215 men admitted to hospital in 1996 with unintentional or intentional injury.[17] Variation in factors

associated with psychological outcomes may explain differences between previous UK studies and ours, including study populations (e.g. gender), injury mechanism or intent, injury severity or length of hospitalisation, follow-up time points or measurement tools for PTSD.[11, 40-42]. The importance of psychological outcomes has gained wider recognition since these studies were published,[43] which may have led to service development, potentially impacting on the prevalence of psychological morbidity.

Our findings of greater psychological morbidity in females, those with previous psychiatric illness and from more disadvantaged areas confirm, in a UK context, the findings of systematic reviews mainly comprising studies from other countries.[11-15] Age at trauma has been found to be associated with PTSD in some populations but not others.[44] We found middle aged adults (45-64) were more likely to experience symptoms of anxiety or depression than older adults (aged ≥65), but no relationship between age and symptoms of post-traumatic distress; possibly due to differences in patient characteristics between ours and other studies (e.g. injury severity or type (such as gunshot wounds[45]) or intensive care admission[46]).

Our finding that pre-injury anxiety and depression scores were associated with post-injury anxiety, depression and post-traumatic distress scores independent of previous psychiatric diagnoses is consistent with Mason and colleagues finding that anxiety and depression reported "within days" of hospital admission were associated with minor psychiatric disorders and symptoms of PTSD at 6 and 18 months post-injury.[16] In terms of injury mechanism, the literature mainly focusses on PTSD in road traffic crash survivors[15] and psychiatric symptoms amongst those suffering burns.[12, 14, 47] We found injury mechanism was associated with higher scores for PTSD symptoms in road traffic injuries and injuries involving striking or being struck by objects. There is inconsistent evidence that injury severity is associated with psychological outcomes.[11, 15, 47] This is in keeping with our findings that injury severity was associated with depression but not with anxiety or post-traumatic distress.

Although previous studies have found lower socioeconomic status is associated with a greater risk of PTSD post-injury,[48] our findings relating to increasing area level deprivation being associated with greater symptoms of depression, anxiety and PTSD appear new in the UK context. This is unsurprising given socioeconomic disadvantage increases exposure and vulnerability to adverse social, economic and environmental circumstances and reduces access to supports and buffers, resulting in an increased risk of mental health disorders.[49] However, it suggests area level

deprivation should be taken into account when assessing need for, commissioning and providing psychological care post-injury.

Previous studies have found comorbid conditions present at the time of injury increase the risk of PTSD post-injury,[40, 50] but our finding that poorer quality of life pre-injury, rather than comorbidity, was associated with depression and anxiety scores post-injury is a further new finding in the UK setting. Chronic health conditions such as cancer, heart disease, musculoskeletal disorders, respiratory disorders, neurological disorders and diabetes are associated with adverse psychological outcomes and the National Institute for Health and Care Excellence recommends screening to identify depression in these population groups.[51] Our findings suggest traumatic injuries should also be added to this list of conditions.

Our study failed to find significant associations between marital status[11, 14], employment[12], pain[11, 13, 14] and psychological morbidity. It is possible that our adjustment for history of psychiatric diagnoses and for pre-injury depression and anxiety scores, the use of different tools to measure pain, or differences in study populations, injury type and severity may account for differences between our study and previous studies. Also the statistical power may be low for some of these comparisons where numbers in categories are relatively small.

Strengths and limitations

Compared to the current UK literature, our study was larger than some studies,[16, 17, 20] included both sexes[16, 17] and a wider range of unintentional injuries[18, 20] resulting in hospital admission in working-age adults.[16, 17, 19, 20] Our study was not restricted to those with very severe injuries requiring intensive care admission,[52, 53] which has in itself been found to be associated with PTSD.[46] We focussed on hospital admissions rather than emergency department attendances, as these provide greater opportunities for services to identify and intervene for at risk patients. We recruited from 4 UK study centres, covering geographically and ethnically diverse populations. We measured outcomes using standardised data collection tools, validated for use in trauma populations,[41] at multiple time points up to one year post-injury and achieved fairly high follow-up rates.

As in all cohort studies, selection and response bias are potential problems. Excluding those found to be ineligible, we recruited 30% of patients approached to take part in the study. For ethical reasons, we were not allowed to collect data on characteristics of those not agreeing to participate. It is

therefore difficult to know the extent to which non-participants differed from participants in terms of risk factors or psychological morbidity. Losses to follow-up can introduce bias if non-responders differ from responders in terms of risk factors or psychological morbidity. We found characteristics were similar between those who returned at least one follow-up questionnaire (i.e. responders) and all participants (responders and non-responders), although slightly fewer younger participants returned follow-up questionnaires (age 16-24 comprised 14% of participants and 12% of responders; aged 25-44 comprised 27% of participants and 25% of responders) as did male participants (males comprised 53% of participants and 50% of responders) and single participants (single people comprised 29% of participants and 26% of responders). We undertook multiple imputation analyses and showed the majority of main effect findings were similar in the complete case and multiple imputation analyses. There were a small number of differences between main effects in the complete case and multiple imputation analyses, possibly indicating some response bias, e.g. differences relating to age in the depression analysis and sex in the anxiety analysis. In addition, several of the interactions did not remain significant in the multiple imputation analysis and these should be viewed as hypothesis generating and interpreted with caution.

Few study participants belonged to a black or ethnic minority group, which may limit the generalisability of our findings. Although our study included a wide range of injuries, occurring at a variety of locations, the numbers of participants with some specific injury mechanisms (e.g. mechanisms other than falls, road traffic or striking injuries) or locations (e.g. workplace injures) are small, limiting power to detect significant associations.

The proportion of variance explained by the risk factors included in our models ranged from 0.18 for post-traumatic distress to 0.28 for anxiety and depression. This is lower than the proportion of variance explained in models for predicting anxiety (0.5) and PTSD (0.6), but similar to that for depression (0.3) in a UK study of emergency department attenders with unintentional injury.[21] Other studies aimed at developing tools to predict risk of PTSD or depression in general trauma populations have not reported the proportion of variance explained by their models.[22-24] Our results suggest that other factors, in addition to those measured in our study may be important in identifying patients who are likely to develop depression, anxiety or PTSD post injury. Possible factors include intensive care admission, positive test for blood alcohol or history of substance use disorder,[24] prior exposure to trauma, subjective responses to the injury, acute traumatic stress reactions, appraisals of acute stress reactions, maladaptive coping responses, perceived social

support and resource loss.[22, 23] The use of newer approaches, such as machine learning algorithms may also enhance prediction of post trauma mental health problems.[54] .

Pre-injury psychiatric symptoms, quality of life and pain were measured retrospectively after injury. Our pre-injury EQ5D utility index score (0.92) was higher than UK population norms, [55] a finding similar to previous injury studies.[56] Our pre-injury anxiety and depression scores were also lower than recent UK normative data.[57] This may reflect recall bias, response shift, or different health states in those who do and do not sustain injuries requiring hospital admission.[58, 59] Our study may therefore underestimate the pre-injury prevalence of these factors, reducing power to detect associations with psychological outcomes.

Implications for practice and research

A range of risk factors, identifiable shortly after injury, are associated with psychological morbidity occurring up to 12 months post-injury in a general trauma population. Further research is required to explore the utility of these, and other risk factors in predicting psychological morbidity on an individual patient basis. Risk factors for psychological morbidity and opportunities to intervene may change over the recovery period. It would therefore be useful to explore associations between factors present later in the recovery period and subsequent psychological morbidity.

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Highlights

- Caseness for depression and anxiety were 15% each in UK adults 1 month after injury
- Caseness for moderate-severe post-traumatic distress was 24% in UK adults 1 month after injury
- Caseness reduced to 7%, 11% and 17% respectively at 12 months
- Similar factors were associated with symptoms of depression and anxiety after injury
- Different factors were associated with symptoms of post-traumatic distress after injury

Figure 1: Flow diagram of study recruitment and follow up

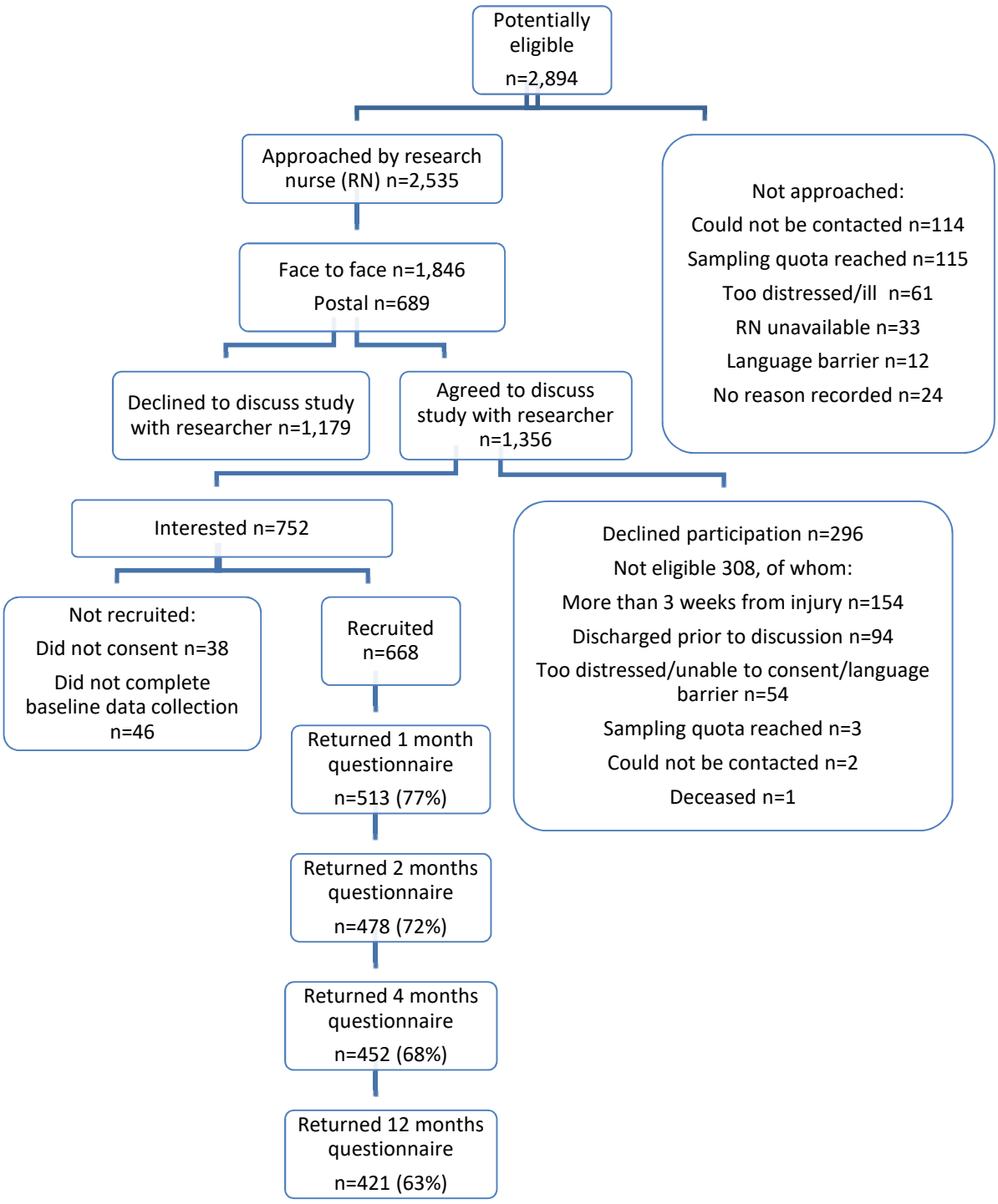
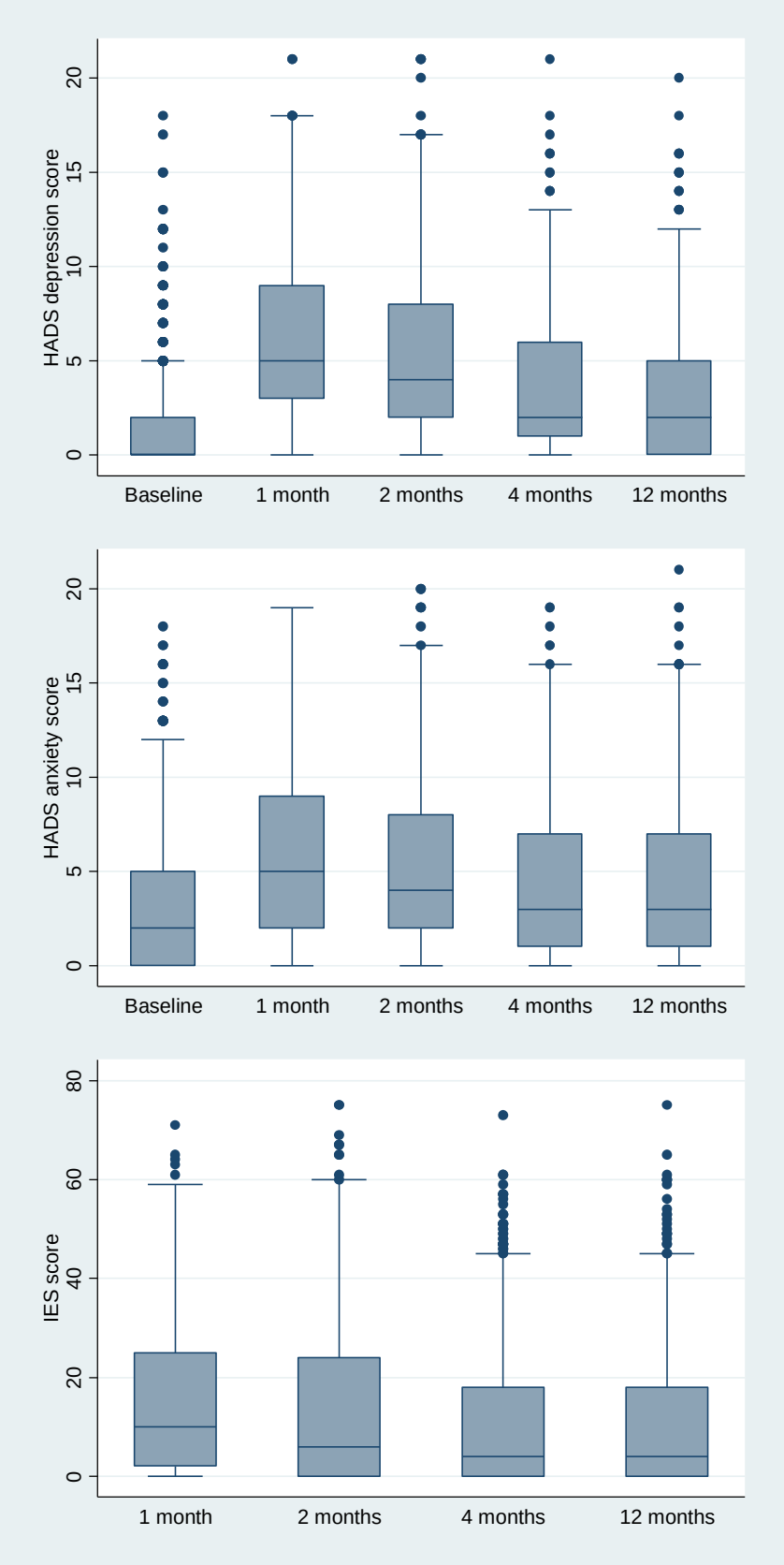


Figure 2: Depression, anxiety and IES scores in the 12 months following an injury



Note: Impact of Event Scale (IES) not measured at recruitment.

Supplementary Table 1: Depression, anxiety and IES scores in the 12 months following injury

Time point (months)	Number of subjects completing questionnaire (%)	HADS depression score			HADS anxiety score			IES score[#]		
		Mean (SD)	Median (IQR)	Number (%)* classified as case, score ≥11	Mean (SD)	Median (IQR)	Number (%)* classified as case, score ≥11	Mean (SD)	Median (IQR)	Number (%)* with moderate or severe symptoms on IES scale (≥26)
Recruitment	668 (100%)	1.6 (2.7)	0 (0-2)	11 (1.7)	3.1 (3.6)	2 (0-5)	34 (5.1)	-	-	-
1	513 (76.8)	6.0 (4.3)	5 (3-9)	76 (14.8)	5.8 (4.3)	5 (2-9)	79 (15.4)	16.0 (16.7)	10 (2-25)	121 (23.6)
2	478 (71.6)	5.1 (4.3)	4 (2-8)	59 (12.3)	5.0 (4.4)	4 (2-8)	58 (12.1)	14.1 (17.1)	6 (0-24)	108 (22.6)
4	452 (67.7)	3.8 (3.9)	2 (1-6)	38 (8.4)	4.4 (4.2)	3 (1-7)	44 (9.7)	11.4 (15.8)	4 (0-18)	77 (17.0)
12	421 (63.0)	3.3 (3.8)	2 (0-5)	30 (7.1)	4.4 (4.3)	3 (1-7)	46 (10.9)	11.8 (15.7)	4 (0-18)	71 (16.9)

*Percentage of those completing the questionnaire at time point

[#]IES was not measured at recruitment

Supplementary table 2. Trajectory of case status for depression, anxiety and PTSD in participants who completed all follow-up questionnaires, and excluding participants with missing data at one or more time points during follow-up.

	Case status by follow-up time					
	Meets case definition for depression (HADS score≥11)					
Depression[a]	1 month	2 months	4 months	**12 months**	**N**	**(%)**
	Case	Case	Case	Case	6	1.9
	Case	Case	Case	Non-case	9	2.9
	Case	Case	Non-case	Non-case	10	3.2
	Case	Non-case	Non-case	Case	2	0.6
	Case	Non-case	Non-case	Non-case	18	5.8
	Non-case	Case	Case	Case	1	0.3
	Non-case	Case	Non-case	Non-case	4	1.3
	Non-case	Non-case	Case	Case	3	1.0
	Non-case	Non-case	Case	Non-case	1	0.3
	Non-case	Non-case	Non-case	Case	4	1.3
	Non-case	Non-case	Non-case	Non-case	253	81.4
Total cases (%)	45 (14.5)	30 (9.6)	20 (6.4)	16 (5.1)		
	Meets case definition for anxiety (HADS score≥11)					
Anxiety[b]	1 month	2 months	4 months	12 months	N	(%)
	Case	Case	Case	Case	4	1.4
	Case	Case	Case	Non-case	5	1.7
	Case	Case	Non-case	Case	1	0.3
	Case	Case	Non-case	Non-case	3	1.0
	Case	Non-case	Case	Case	2	0.7
	Case	Non-case	Non-case	Case	4	1.4
	Case	Non-case	Non-case	Non-case	12	4.1
	Non-case	Case	Case	Non-case	2	0.7
	Non-case	Case	Non-case	Case	2	0.7
	Non-case	Case	Non-case	Non-case	5	1.7
	Non-case	Non-case	Case	Case	1	0.3
	Non-case	Non-case	Case	Non-case	4	1.4

	Non-case	Non-case	Non-case	Case	7	2.4
	Non-case	Non-case	Non-case	Non-case	243	82.4
Total cases (%)	31 (10.5)	22 (7.5)	18 (6.1)	21 (7.1)		
	Meets case definition for PTSD (IES score≥26)					
PTSD[c]	1 month	2 months	4 months	12 months	N	(%)
	Case	Case	Case	Case	19	6.7
	Case	Case	Case	Non-case	8	2.8
	Case	Case	Non-case	Case	5	1.8
	Case	Case	Non-case	Non-case	9	3.2
	Case	Non-case	Case	Case	1	0.4
	Case	Non-case	Case	Non-case	3	1.1
	Case	Non-case	Non-case	Case	1	0.4
	Case	Non-case	Non-case	Non-case	13	4.6
	Non-case	Case	Case	Case	1	0.4
	Non-case	Case	Case	Non-case	1	0.4
	Non-case	Case	Non-case	Case	4	1.4
	Non-case	Case	Non-case	Non-case	5	1.8
	Non-case	Non-case	Case	Case	3	1.1
	Non-case	Non-case	Case	Non-case	2	0.7
	Non-case	Non-case	Non-case	Case	9	3.2
	Non-case	Non-case	Non-case	Non-case	198	70.2
Total cases (%)	59 (20.9)	52 (18.4)	38 (13.5)	43 (15.2)		

[a] 311 participants without depression at baseline completed all follow-up questionnaires and had no missing data for depression scores. A further 4 participants who completed all follow-up questionnaires had depression at baseline.

[b] 295 participants without anxiety at baseline completed all follow-up questionnaires and had no missing data for anxiety scores. A further 11 participants who completed all follow-up questionnaires had anxiety at baseline.

[c] 282 participants completed all follow-up questionnaires and had no missing data

Supplementary table 3: Significant interactions in models for predicting depression and anxiety following injury (complete case and multiple imputation analyses)

		Ln HADS depression score (coefficient and 95% CI)				
Characteristic	**Category**	**1 month**	**2 months**	**4 months**	**12 months**	**P value†**
Sex	Females	Reference	Reference	Reference	Reference	
Complete case	Males	-0.18 (-0.31, -0.06)	-0.10 (-0.23, 0.03)	0.003 (-0.13, 0.13)	0.15 (0.02, 0.28)	0.0004
Multiple imputation	Males	-0.17 (-0.30, -0.05)	-0.10 (-0.23, 0.03)	-0.01 (-0.14, 0.12)	0.13 (-0.008, 0.27)	0.003
Age	45-64	Reference	Reference	Reference	Reference	
Complete case	16-24	-0.05 (-0.25, 0.15)	-0.26 (-0.47, -0.05)	-0.24 (-0.45, -0.03)	-0.19 (-0.42, 0.04)	0.0005
	25-44	0.06 (-0.09, 0.21)	-0.17 (-0.32, -0.01)	-0.17 (-0.33, -0.01)	-0.36 (-0.52, -0.19)	
	65+	-0.22 (-0.40, -0.03)	-0.18 (-0.37, 0.01)	-0.16 (-0.35, 0.02)	-0.17 (-0.36, 0.02)	
Multiple imputation	16-24	-0.05 (-0.26, 0.15)	-0.19 (-0.40, 0.01)	-0.15 (-0.35, 0.05)	-0.14 (-0.37, 0.09)	0.37
	25-44	0.04 (-0.11, 0.19)	-0.13 (-0.30, 0.03)	-0.09 (-0.26, 0.07)	-0.19 (-0.35, -0.02)	
	65+	-0.23 (-0.42, -0.04)	-0.14 (-0.33, 0.06)	-0.14 (-0.33, 0.05)	-0.10 (-0.29, 0.10)	
Deprivation (IMD)*						
Complete case	Continuous covariate	0.0003 (-0.004, 0.005)	0.003 (-0.001, 0.008)	0.005 (0.0005, 0.010)	0.007 (0.002, 0.012)	0.002
Multiple imputation		0.001 (-0.003, 0.006)	0.004 (-0.001, 0.008)	0.005 (-0.0003, 0.010)	0.006 (0.001, 0.011)	0.11
EQ-5D	Score=1	Reference	Reference	Reference	Reference	
Complete case	Score <1	0.13 (-0.02, 0.29)	0.05 (-0.11, 0.21)	0.25 (0.09, 0.41)	0.34 (0.17, 0.50)	<0.0001
Multiple imputation	Score <1	0.09 (-0.06, 0.25)	0.05 (-0.11, 0.20)	0.18 (0.02, 0.34)	0.24 (0.08, 0.41)	0.007
Pre-injury HADS depression score	Score=0	Reference	Reference	Reference	Reference	
Complete case	Score=1	0.30 (0.13, 0.47)	0.16 (-0.02, 0.33)	0.27 (0.09, 0.44)	0.37 (0.19, 0.55)	0.006
	Score >1	0.28 (0.12, 0.44)	0.28 (0.11, 0.45)	0.40 (0.24, 0.57)	0.36 (0.19, 0.53)	
Multiple imputation	Score=1	0.24 (0.07, 0.41)	0.17 (0.01, 0.34)	0.23 (0.05, 0.41)	0.26 (0.08, 0.43)	0.13
	Score >1	0.25 (0.09, 0.41)	0.30 (0.13, 0.47)	0.41 (0.25, 0.58)	0.34 (0.15, 0.52)	
		Ln HADS anxiety score (coefficient and 95% CI)				
Characteristic	**Category**	**1 month**	**2 months**	**4 months**	**12 months**	**P value†**
Deprivation (IMD)*						
Complete case	Continuous covariate	0.003 (-0.002, 0.007)	0.004 (-0.001, 0.009)	0.010 (0.005, 0.015)	0.008 (0.003, 0.014)	0.002
Multiple imputation		0.002 (-0.003, 0.007)	0.004 (-0.002, 0.009)	0.008 (0.003, 0.014)	0.007 (0.001, 0.012)	0.05
EQ-5D*						
Complete case	Continuous covariate	0.04 (-0.37, 0.44)	-0.26 (-0.64, 0.12)	-0.48 (-0.89, -0.07)	-0.59 (-0.99, -0.18)	0.003
Multiple imputation		0.05 (-0.33, 0.43)	-0.23 (-0.59, 0.13)	-0.38 (-0.75, 0.002)	-0.57 (-0.95, -0.19)	0.004

The reference category for age was chosen to be the 45-64 age group as this had the highest frequency (n=310, 46%) of participants.

* Coefficient reflects the increase in the outcome variable per 1 unit increase in the predictor variable

† The p-value for the complete case analysis is for the likelihood ratio test between models with and without the interaction term, with p<0.01 taken as significant. The p-value for the multiple imputation analysis is for the Wald test, testing whether coefficients for each level of the interaction are all equal to zero.

IMD= Index of Multiple Deprivation. EQ5D= EuroQol five dimensions questionnaire. HADS= Hospital Anxiety and Depression Scale.

Overall R^2 for the complete case analysis for HADs depression was 0.30, for HADs anxiety the value was 0.28.