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Embedded rehabilitation in major trauma: Retrospective pre-post observational study of service and patient outcomes

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Abstract

Introduction
Major trauma describes serious and often multiple injuries where there is a strong possibility of death or residual disability. There is little robust evidence on the effects of embedded rehabilitation within the trauma care pathway. Trauma rehabilitation services therefore remain fragmented and poorly integrated. This study aimed to determine changes in hospital length of stay (LoS), intensive care unit (ICU) LoS, 30-day mortality and Glasgow Outcome Scale following implementation of an embedded rehabilitation service into a Major Trauma Centre (MTC).

Methods
Retrospective pre-post observational study of a rehabilitation service introduced into an MTC, consisting of a dedicated 10-bedded inpatient unit, co-ordinating rehabilitation hub, and specialist multi-disciplinary outpatient clinic. Overall hospital LoS, ICU LoS, 30-day mortality and GOS were selected as outcome measures. Patient characteristics (age, sex, injury mechanism, injury severity score, Glasgow Coma Scale, and most injured body region) were compared and controlled for when analysing outcomes.

Results
The study cohort included 6,484 patients, of which 4,298 were pre-intervention and 2,186 post-intervention. Patients in the post-intervention cohort were older than those in the pre-intervention cohort (58.3 compared to 56.6, $p<0.001$) and had higher injury severity scores (48.7% >15 compared to 43.9% >15). Moderate but significant changes to the most injured body region were also observed ($p<0.001$), with fewer injuries affecting the limbs (25.8% to 24.9%), spine (15.3% to 12.1%), multiple locations (11.3% to 10.7%), abdomen (2.7% to 2.4%) and face/other (1.9% to 1.5%) and more injuries affecting the head (27.5% to 31.5%) and chest (15.6% to 16.9%). Controlling for changes to patient characteristics between the two time periods, there was a reduction in overall hospital LoS of 2.56 days (b=-2.56, $p<0.001$) and ICU LoS of 0.94 days (b=-0.96, $p<0.001$). There was a 31% reduced chance of 30-day mortality in post-intervention patients (OR=0.69, 95%CI=0.54 to 0.88), and almost two times higher relative chance of GOS Good Recovery (RR=1.94, CI=1.51 to 2.49).

Discussion
Embedded rehabilitation is an important and necessary component of an effective trauma system that is associated with improved service and patient outcomes. Future research should examine prospectively how a dedicated rehabilitation service affects medium- and long-term patient-centred outcomes.

Highlights

- This is the first study to examine the impact of an embedded rehabilitation service following major trauma and therefore makes a major contribution to knowledge in the field of major trauma care and rehabilitation.
- Patients were significantly older post-intervention by 1.7 years, and there was a non-significant 3.6% increase in falls less than 2m, and significant increases in head (4.0%) and chest (1.1%) being the most severely injured body region.
- Controlling for changes to patient characteristics, introduction of a rehabilitation service into the major trauma centre was associated with a reduction in hospital length of stay of 2.56 days, a reduction in intensive care unit length of stay of 0.94 days, a 31% reduced chance of 30-day mortality in post-intervention patients and almost two times higher relative chance (1.94) of a Glasgow Outcome Score of Good Recovery.
- This study demonstrates that embedded rehabilitation is an important and necessary component of an effective trauma system that can lead to improved service and patient outcomes. The findings of this study are relevant to how major trauma is managed internationally.

Introduction

Major trauma describes serious and often multiple injuries where there is a strong possibility of death or residual disability. Estimates in 2010 placed the number of major trauma cases in England at 20,000 per year[1]. An additional 28,000 individuals were not classified as major trauma, but identified as having significant rehabilitation needs. It is predicted that by 2030 the leading causes of traumatic death and injury (road traffic collisions, violence and suicide) will increase substantially[2], making major trauma a significant and increasing public health concern worldwide[3]. Traumatic injuries place a significant burden on health and social care resources; the annual National Health Service (NHS) cost of care in the first 12 months following major trauma is estimated at £1.53 billion in England[4]. This figure does not take into account societal knock-on effects such as unemployment, reduced productivity and loss of earnings which place considerable demands on the UK economy.

Changes to the English trauma system in 2012 resulted in a hub and spoke model of 27 major trauma centres and multiple coordinating trauma units. A growing and substantial body of evidence exists to support the effectiveness of this model in high income countries,[5-10] with a reported reduction in mortality of approximately 20%.[11] The National Audit Office[1] acknowledges that effective rehabilitation is an essential part of the care pathway for individuals following traumatic injury. Despite such observations, evidence to support the general provision of rehabilitation following major trauma is limited. Systematic reviews[12, 13] have identified no randomised controlled trials to support the provision of rehabilitation following traumatic injury, although one has since been published[14]. Consequently, rehabilitation services for this patient group remain fragmented, poorly integrated and not part of a joined-up care pathway[15].

This paper reports the findings from a retrospective pre-post observational study that aimed to determine changes in patient length of hospital stay, intensive care unit length of stay, 30 day mortality and Glasgow Outcome Score following the introduction of a dedicated

rehabilitation service into a major trauma centre in North East England. The data used in this study were obtained from the Trauma and Audit Research Network (TARN). TARN has Patient Information Advisory Group (PIAG) Section 60 approval for research and audit.

Methods

The study utilised a retrospective pre-post observational design, which has been recognised as a suitable study design for determining associations before and after intervention in trauma care.[16]

Study setting and intervention

The Royal Victoria Infirmary Great North Trauma and Emergency Centre became a dedicated Level 1 MTC in April 2012. It is one of two MTCs in the Northern Trauma Network, serving a population of 3 million adults and children across the North East of England, North Cumbria and parts of North Yorkshire.

A dedicated rehabilitation service was established at the Royal Victoria Infirmary in November 2016, which aims to deliver a range of timely interventions at an appropriate level of intensity, frequency and complexity to maximise the opportunity for optimal function and recovery following major trauma. Operating through a centralised hub-and-spoke arrangement, the rehabilitation service provides a range of clinical services to reduce the burden of major trauma on local health and public services and consists of a purpose-built 10-bedded rehabilitation unit, a co-ordinating rehabilitation hub and specialist multi-disciplinary outpatient clinic.

The dedicated therapy team is funded through specialist commissioning in response to a local gap analysis of rehabilitation provision[15] Embedded rehabilitation in the MTC is provided in accordance with an agreed service specification set out by the specialist commissioners and quantified through submission of a quarterly activity report to the local

clinical commissioning group. The therapy team consists of one whole time equivalent (wte) Consultant Allied Health Professional, Rehabilitation Leads (2.0 wte), Occupational Therapy (5.0 wte), Physiotherapy (4.5 wte), Speech and Language Therapy (1.3 wte), Dietetics (0.5 wte), Psychology (1.0 wte), Social Work (1.0 wte) and Generic Rehabilitation Support (1.0 wte). Specialist input is provided by a consultant in rehabilitation medicine, older people's medicine and surgeons, who remain actively involved in an individual's care throughout the rehabilitation process. In year 1 (December 2016 – November 2017), 311 adult patients (mean age 53.6 years, range 18-94, SD=19.8) were discharged from the service, of which 133 (42.8%) were female. In year 2 (December 2017 – November 2018), 316 adult patients (mean age 55.5 years, range 18-96, SD=19.5) were discharged from the service, of which 119 (37.7%) were female. Finally in year 3 (December 2018 – November 2019), 278 patients (mean age 57.7, range 18-100, SD=18.6) were discharged from the service, of which 126 (45.3%) were female.

The therapy team complete a rehabilitation prescription for all patients admitted to the MTC as part of the best practice tariff for trauma within two to four calendar days of admission. This document requires assessment and ongoing coordination of an individual's physical, functional, vocational, educational, cognitive, psychological and social needs following traumatic injury and results in a holistic, interdisciplinary rehabilitation implementation and support plan based on goals identified by the patient and their family members or carers. Rehabilitation interventions are delivered in the most appropriate environment for the patient. Individuals with complex multidisciplinary rehabilitation needs (approximately one third of patients admitted to the MTC each year) are admitted to the inpatient rehabilitation unit, where they receive a minimum of two, thirty minute therapy sessions each day, delivered in a one-to-one or group setting. All patients admitted to the inpatient unit are allocated a keyworker from the therapy team to coordinate their rehabilitation programme. The patient's progress is reviewed and discussed at a weekly multidisciplinary team meeting. Proactive liaison with local community services helps to facilitate timely, coordinated discharge from

acute rehabilitation beds. Ongoing follow-up in the specialist multidisciplinary outpatient clinic ensures that individuals continue to receive the longer-term rehabilitation and support needed to return to employment, vocational or purposeful activity and study.

Study cohorts

Data were obtained from the Trauma and Audit Research Network (TARN) to cover the period from which the MTC was established, from April 2012 to December 2018. All MTC patients aged 18 years of age and over admitted to hospital were included in the analysis. Children (aged 17 years and below) were excluded from the analysis as the rehabilitation service was commissioned for individuals aged 18 years and over.

Outcomes

Our primary outcomes were hospital length of stay (LoS), Intensive Care Unit (ICU) LoS, 30 day mortality and Glasgow Outcome Score (GOS). Length of stays were measured in discrete days and 30 day mortality was measured dichotomously as alive or dead after 30 days of admission. Glasgow Outcome Score, which is a validated measure of patient recovery from trauma[17], was measured on a 5-point Likert scale, which was transformed to a 4-point Likert scale due to low patient numbers (n=4) in the 'prolonged disorder of consciousness category'. We merged this category with 'death' as neither category would require ongoing rehabilitation.

Statistical analyses

Continuous variables (age, hospital length of stay, ICU length of stay) were tested for normal distribution using the Kolmogorov-Smirnov (K-S) test. All variables were not normally distributed, $P<0.001$). Non-parametric tests (Mann-Whitney U, Pearson Chi-square) were therefore used to test differences between pre- and post-intervention groups. Linear regression was used to fit models for hospital and ICU length of stay and logistic regression analysis for the binary outcome, 30-day mortality. Summary statistics of individual level

patient's data of the four outcomes, Hospital LoS, ICU LoS, 30-day mortality, and GOS, were produced. Pairwise associations of the observed patients' characteristics were computed.

The statistical significance of associations between potential risk factors and the four outcomes were explored with chi-square (χ^2) and Mann–Whitney *U*-tests, as appropriate. Multivariate regression models were used to evaluate the significance of regression coefficients and beta regression coefficients are reported with the associated standard errors for the outcomes LS and ICU-LS. Adjusted Odd Ratios (ORs) of 30-day mortality risk were obtained from standard logistic regression models and relative risk (chance) ratios of GOS were also obtained from multinomial logistic regression model with 'death and prolonged disorder of consciousness' used as the reference category. Analyses were conducted using Stata 14 software. Goodness of fit was judged visually and according to the Likelihood Ratio test (LR).

Results

A total of 6,484 patients (4,298 (66.3%) pre-intervention, 2,186 (33.7%) post-intervention) were included in the study. Of these, 2,340 patients (1,564 (66.8%) pre-intervention, 776 (33.2%) post-intervention) attended the ICU. The mean age of patients was 57.2 years (SD=21.3) and there were fewer females (n=2,427, 37.4%) compared to males (n=4,057, 62.6%). Falls <2m constituted nearly half (n=2,854, 44.0%) of the injury mechanisms, followed by vehicle incident / collision (n=1,554, 24.0%) and fall >2m (n=1,256, 19.4%).

Patient characteristics

Pre- and post-intervention

Various characteristics of patients differed pre- and post-intervention. Post-intervention patients were older (M=58.3) than pre-intervention patients (M=56.6; U=4915369.5, p=0.002), had a higher injury severity score (median=13) than pre-intervention patients (median=14; U=4896239, p=0.005). There were also significant changes to the most injured

body region (x2=22.623, df=7, p=0.002), with particular reductions in spinal injuries (15.3% to 12.1%) and increases to head injuries (27.5% to 31.5%). There was no difference in gender pre- and post-intervention (x2=0.031, df=1, p=0.861), nor in Glasgow Coma Scale (u=5102930, p=0.351). There were also non-significant (x2=14.649, df=8, p=0.066) but clinically meaningful changes to the mechanism of injury, particularly a proportional increase in falls <2m (42.8% to 46.4%), and proportional decreases in falls >2m (20.0% to 18.3%) and vehicle incident / collision (24.9% to 22.3%). Characteristics of patients, including pre- and post-intervention comparisons, are presented in Table 1.

Hospital Length of Stay

Following introduction of the rehabilitation service, an overall reduction in hospital length of stay of 0.94 days (b=-0.94, SD=0.35) was identified (Table 2).

Characteristics

Increases to age were associated with increased hospital LoS, with an increase of 0.12 days hospital LoS (SD=0.01) for each additional year in age. There were no changes to hospital LoS based on patients' gender (b=0.32, SD=0.51). Fall >2m (b=-1.42, SD=0.68) and stabbing injuries (b=-4.23, SD=1.58) were associated with reduced hospital length of stay of over one day and four days respectively when using Fall <2m as reference point, and crush injuries (b=8.42, SD=3.1) were associated with increased hospital LoS of over eight days.

Severity of injury was also associated with an increased hospital LoS. Using injury severity scores (ISS) 1-8 as reference, those with ISS 9-15 had an increased hospital length of stay of 2.8 days (SD=0.71), whereas those with ISS >15 have an increased hospital length of stay of 7.2 days (SD=0.80). Location of most injuries on the body were also associated with changes to hospital LoS. When using injuries to the spine as a reference, there were significant changes to hospital LoS. There was an increased hospital LoS of nearly three days for limb (b=2.76, SD=0.82), a decreased hospital LoS of over four days for chest (b=-

4.28, SD=0.92) and a decreased hospital LoS of over seven days for other / face (b=-7.66, SD=2.03). For every increase to the patient's Glasgow Coma Scale, there was a reduction in hospital LoS of over half a day (b=-0.61, SD=0.08).

Intensive Care Unit (ICU) length of stay

Following introduction of the rehabilitation service, an overall reduction in ICU length of stay of 0.94 days (b=-0.94, SD=0.35) was identified (Table 3).

Characteristics

Increases to age were significantly associated with increased ICU length of stay ($p<0.05$), with an increase of 0.03 days (SD=0.01) for each additional year of age. There was no change to ICU LoS based on gender (b=-0.82, SD=0.38). No injury mechanisms were associated with an increased ICU LoS. Injury severity score of >15 was associated with an increased ICU LoS of 2.39 days (SD=0.85) compared to an ISS of 1-8. No difference was identified for an ISS of 9-15.

Location of most injuries on the body were also associated with changes to ICU LoS. When using injuries to the spine as a reference, every other location independently had a reduced ICU LoS. The majority (Head, Multiple, Chest, Abdomen) had a reduction of between three and four days, whilst limbs had a reduction of nearly five days (b=-4.95, SD=0.90) and other / face had a reduction of nearly six days ICU LoS (b=-5.99, SD=1.34). For every point increase to patients' Glasgow Coma Scale, there was a reduction in ICU LoS of just over a third of a day (b=-0.37, SD=0.04).

30-day mortality

Pre- and post-intervention

Following introduction of the rehabilitation service a 31% reduced chance of 30-day mortality was identified in post-intervention patients (OR=-0.69, CI=-0.54 to -0.88) (Table 4).

Characteristics

For every additional year of age, there was a 5% increased chance of mortality at 30 days (OR=1.05, CI=1.04 to 1.06). Gender was not associated with changes to the chance of 30-day mortality when comparing males to females (OR=0.92, CI=0.72 to 1.17), pre-intervention (OR=0.83, CI 0.61 to 1.12) or post-intervention (OR=1.13, CI=0.74 to 1.72).

Glasgow Outcome Score

Pre- and post-intervention

When comparing post-intervention to pre-intervention and using Death as the reference group (table 5), the relative chance of Good Recovery is almost two times greater (RR=1.94, CI=1.51 to 2.49). A similar, but smaller relative chance was also observed for Moderate Disability (RR=1.81, CI=1.40 to 2.35). There was no observed change to the relative risk of Severe Disability (RR=1.10, CI=0.84 to 1.43).

Characteristics related to Glasgow Outcome Score

Age was related to Glasgow Outcome Score, with younger people more likely to experience Good Recovery (RR=0.93, CI=0.92 to 0.93), Moderate Disability (RR=0.95, CI=0.95 to 0.96) or Severe Disability (RR=0.97, CI=0.96 to 0.98) when compared to the reference group of Death. Injuries mechanism of a blow is related to Severe Disability (RR=2.10, CI=1.05 to 4.21), whereas fall >2m is related to Good Recovery (RR=1.44, CI=1.04 to 1.99) when using fall <2m as reference. A higher Glasgow Coma Scale is related to improved recovery across all three Glasgow Outcome Scores of Severe Disability (RR=1.22, 1.19 to 1.27), Moderate Disability (RR=1.40, CI=1.35 to 1.46) and Good Recovery (RR=1.63, CI=1.57 to 1.69), with an increasing relative chance for each category. Using Spine as the reference for the most severely injured body region, all other body regions (Head, Limbs, Multiple, Chest, Abdomen, Other/face) were related to a decreased relative risk of Severe Disability, suggesting that spinal injuries are the greatest contributor to Severe Disability. No body

region was specifically related to Moderate Disability, and injuries mostly to the Head resulted in improved relative risk of Good Recovery (RR=3.46, CI=2.13 to 5.62) when using Spine as the reference.

Discussion

This is the first study to examine the relationship between a dedicated rehabilitation service following major trauma and patient and service outcomes, therefore making a major contribution to knowledge in the field of major trauma care and rehabilitation. We identified that the introduction of a rehabilitation service into the major trauma centre was associated with a reduction in hospital length of stay of 2.56 days, a reduction in intensive care unit length of stay of 0.94 days, and almost two times higher relative chance (1.94) of a Glasgow Outcome Score of Good Recovery. Whilst the uncontrolled 30-day mortality increased by 0.4% pre- and post-intervention, this does not consider that post-intervention patients were significantly older and presented significantly more often with higher injury severity scores. Once these were controlled for, we observed a 31% reduced chance of 30-day mortality post-intervention. Overall, the findings suggest that embedded rehabilitation is an important and necessary component of an effective trauma system.

There is a substantial and growing international body of evidence from high-income countries to indicate that unexpected survivorship has increased as a result of whole system changes in modern trauma care[11]. Our study adds additional important findings at the forefront of research into major trauma rehabilitation and provides evidence that the improved survivorship is associated with a range of improved short-term patient and service outcomes when supported by dedicated rehabilitation provision, as described in this study. It may be that provision of early coordinated rehabilitation, with input from specialist medical and surgical teams, results in a reduction in secondary complications, such as chest, urinary or wound infections, multi-organ failure, deep vein thrombosis or pulmonary embolus, and

that this could account, in part, for the improvements in patient and service outcomes following the introduction of the dedicated rehabilitation service. Closer collaborative working with the nurse-led specialist pain service since the major trauma rehabilitation service was established could also have resulted in improved pain management following major trauma, facilitating access to early rehabilitation in an acute inpatient setting.

An ongoing challenge in modern trauma care is to identify which interventions translate into improved patient outcomes and then to provide consistent, timely access to those interventions for the trauma population[18]. Large registry data sets and audit data, including TARN, can help to meet this challenge[19]. Whilst the improvements to outcomes identified in this study are substantial, the study design does not allow us to attribute cause and effect. Multidisciplinary rehabilitation following major trauma addresses an individual's comprehensive needs for physical, functional and emotional support, information and advice, practical help with vocational issues, housing, benefits and care support needs in a hospital and community setting. The coordination role provided by the dedicated therapy team across the MTC through completion of the rehabilitation prescription increases the identification and assessment of individuals who would benefit from a range of therapeutic interventions from appropriately trained clinicians and professional services. Consequently, we anticipate the changes to outcomes to not only be due to changes to rehabilitation, but to actually reflect the wider cultural change in modern trauma care involving greater integration of supportive and associated services, resulting in improved multidisciplinary team working[20-22]. It is also possible that other factors contributed to improved outcomes but were not able to be studied, such as improved expertise, equipment changes and improvements to the identification and management of trauma prior to arrival.

All complex interventions are inextricably linked to the environments, cultures and systems into which they are placed, making precise causal relationships challenging to establish. Nevertheless our findings provide strong evidence to inform practice, policy and

commissioning for individuals requiring rehabilitation following major trauma. Our findings also highlight the need for future experimental studies to test causal relationships and to better understand how the aforementioned broader factors contribute to outcomes such as a pragmatic cluster randomised control trial that is able to account for the real-world conditions in which rehabilitation is delivered.

Of the injury locations examined in the current study, we identified that spinal injuries provide a higher relative chance of a Glasgow Outcome Score of severe disability compared to other body locations, and also increased intensive care unit length of stay of between 3 and 6 days. Together, these findings suggest that when the spine is the most severely injured body region, this can act as a surrogate marker for both severity of trauma and likely functional outcome. However, length of stay was longer when limbs were the most injured body region, with an increased length of stay of 2.76 days compared to spinal injuries. Previous analyses of extremity injuries in major trauma have found a similar pattern[23]. At a local level, these likely reflect the complex inpatient rehabilitation requirements of this patient group in relation to mobility, function and safety currently provided within our MTC as part of the dedicated multidisciplinary trauma pathway[24].

Major trauma has typically been considered a disease of the young[25], however, our findings support other studies that have identified the changing nature of major trauma[11], specifically that trauma patients are becoming older. It is unclear whether these trends observed in the data are because greater numbers of older adults are actually suffering from major trauma or because the detection and reporting of traumatic injuries in this population group have improved[26]. Nevertheless, in many countries, older adults comprise the most rapidly expanding section of the population. Advances in medical care mean that many older adults are experiencing better health, mobility and independence, increasing their exposure to the possibility of injury. Frailty is also a factor; the likelihood of falls and significant injury increasing with age, while physiological reserve and the ability to recover is diminished[27].

Consequently, our findings support claims that urgent rapid action is required to meet what is likely to be a sustained and unrelenting increase in the volume and complexity of trauma cases in older adults[28], where multidisciplinary acute care, embedded rehabilitation and secondary fracture prevention are becoming an increasingly important feature of modern trauma service throughout the developed world.

Using routinely collected data, it would appear embedded rehabilitation is associated with improved patient morbidity following major trauma, as measured by Glasgow Outcome Score. Despite such observations, little is known about the multidimensional effects that traumatic injury has on outcomes important to patients and their family members[29]. As survival from injury improves with modern trauma care and we are faced with a more complex and ageing patient population, medium and long-term patient-centred outcomes (such as overall level of function, disability, quality of life and employment status) should become the focus of modern trauma care. Chronic pain, post-traumatic stress, poor mental health and functional disability are all reported to be high following major trauma[30]. The findings of this study could inform future research on developing a core outcome set to measure physical, functional and psychosocial wellbeing following major trauma, and prospectively evaluate the impact of specific rehabilitation interventions in relation to these patient-centred outcomes over the medium to long-term. Studies in Australia[31] and the United States[32] have shown early promise, but there is a need to conduct similar studies in the English trauma system. International consensus surrounding the comprehensive measurement of function, disability, health and quality of life outcomes as clinical trial end-points and performance indicators for rehabilitation research is necessary.

Conclusions

There is increasing acceptance that the trauma systems model in high-income countries enhances population health through an organised system of injury prevention, acute medical care and rehabilitation that is fully integrated into the public health system of a community.

We have produced a novel set of results demonstrating that the introduction of a dedicated rehabilitation service into our major trauma centre was associated with improvements in hospital length of stay, intensive care unit length of stay 30-day mortality and patient morbidity as measured by Glasgow Outcome Score. Other variables may have also contributed to these improved outcomes, so future research using a study design capable of determining causation should examine prospectively how a dedicated rehabilitation service affects outcomes, including medium- and long-term patient-centred outcomes that were not examined in this study. This is a necessary pre-requisite for implementing, testing, refining, and further embedding rehabilitation interventions into the major trauma pathway.

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Table 1: Characteristics of patients pre- and post-introduction of major trauma rehabilitation service

Characteristics	Overall (N=6,484)	Pre (n=4,298)	Post (n=2,186)	P value
Mean age, years (SD)	57.2 (21.3)	56.6 (21.3)	58.3 (21.3)	0.002*
Sex				0.861
Female	2,427 (37.4%)	1,612 (37.5%)	815 (37.3%)	
Male	4,057 (62.6%)	2,686 (62.5%)	1,371 (62.7%)	
Attended ICU	2,340 (36.1%)	1,564 (36.4%)	776 (35.5%)	0.480
Injury mechanism				0.066
Fall <2m	2,854 (44.0%)	1,839 (42.8%)	1,015 (46.4%)	
Fall >2m	1,256 (19.4%)	857 (20.0%)	399 (18.2%)	
Vehicle incident / collision	1,554 (24.0%)	1,067 (24.9%)	487 (22.3%)	
Stabbing	182 (2.8%)	114 (2.7%)	68 (3.1%)	
Blow	397 (6.1%)	260 (6.1%)	137 (6.3%)	
Crush	37 (0.6%)	29 (0.7%)	8 (0.4%)	
Blast / Shooting / Other	199 (3.1%)	127 (3.0%)	72 (3.3%)	
Injury severity score band				0.001*
1-8	1,153 (17.8%)	787 (18.3%)	366 (16.7%)	
9-15	2,381 (36.7%)	1,626 (37.8%)	755 (34.5%)	
>15	2,950 (45.5%)	1,885 (43.9%)	1,065 (48.7%)	
Mean Glasgow Coma Scale (SD)	13.6 (3.3)	13.5 (3.3)	13.6 (3.2)	0.351
Most severely injured body region				0.002*
Spine	921 (14.2%)	656 (15.3%)	265 (12.1%)	
Head	1,870 (28.8%)	1,182 (27.5%)	688 (31.5%)	
Limbs	1,652 (25.5%)	1,108 (25.8%)	544 (24.9%)	
Multiple	718 (11.1%)	484 (11.3%)	234 (10.7%)	
Chest	1,041 (16.0%)	672 (15.6%)	369 (16.7%)	
Abdomen	169 (2.6%)	116 (2.7%)	53 (2.4%)	
Other/face	113 (1.7%)	80 (1.9%)	33 (1.5%)	
Outcomes				
Hospital length of stay, mean (SD)	15.7 (21.4)	16.6 (23.9)	13.9 (15.2)	-**
ICU length of stay, mean (SD)	6.0 (9.2)	6.3 (9.7)	5.4 (7.8)	-**
Alive after 30 days	5,968 (92.0%)	3,936 (91.6%)	2,032 (92.0%)	-**
Glasgow Outcome Score				-**
Death***	555 (8.7%)	397 (9.3%)	158 (7.4%)	
Severe disability	803 (12.6%)	589 (13.8%)	214 (10.0%)	
Moderate disability	1,263 (19.8%)	825 (19.4%)	438 (20.6%)	
Good recovery	3,763 (58.9%)	2,446 (57.5%)	1,317 (61.9%)	

* significant at alpha level of 0.05
** see subsequent tables for results of regression analyses comparing outcomes
*** 4 patients had ‘prolonged disorder of consciousness’ and so were combined with the ‘Death’ category

Table 2: Regression coefficient of overall hospital length of stay

Variable	Overall (N=6,484)
Mean age, years (SD)	0.12 (0.01)*
Sex (SD)	
Female	-
Male	0.32 (0.51)
Injury mechanism (SD)	
Fall <2m	-
Fall >2m	-1.42 (0.68)*
Vehicle incident / collision	0.82 (0.67)
Stabbing	-4.23 (1.58)*
Blow	-1.82 (3.1)
Crush	8.42 (3.1)*
Blast / Shooting / Other	0.66 (1.45)
Injury severity score band (SD)	
1-8	-
9-15	2.8 (0.71)*
>15	7.2 (0.80)*
Mean Glasgow Coma Scale (SD)	-0.61 (0.08)*
Most severely injured body region (SD)	
Spine	-
Head	-1.74 (0.93)
Limbs	2.76 (0.82)*
Multiple	1.33 (0.99)
Chest	-4.28 (0.92)*
Abdomen	-2.04 (1.49)
Other/face	-7.66 (2.03)*
Post-intervention (SD)	
No	-
Yes	-2.56 (0.49)*

* significant at alpha level of 0.05

Table 3: Regression coefficient of Intensive Care Unit length of stay

Variable	Overall (N=6,484)
Mean age, years (SD)	0.03 (0.01)*
Sex (SD)	
Female	-
Male	-0.82 (0.38)
Mechanism of injury (SD)	
Fall <2m	-
Fall >2m	0.26 (0.50)
Vehicle incident / collision	1.01 (0.49)
Stabbing	-1.16 (0.94)
Blow	0.14 (0.71)
Crush	3.90 (2.19)
Blast / Shooting / Other	1.49 (0.91)
Injury severity score band (SD)	
1-8	-
9-15	-0.10 (0.90)
>15	2.39 (0.85)*
Mean Glasgow Coma Scale (SD)	-0.37 (0.04)*
Most severely injured body region (SD)	
Spine	-
Head	-3.99 (0.79)*
Limbs	-4.95 (0.90)*
Multiple	-3.04 (0.87)*
Chest	-3.89 (0.81)*
Abdomen	-3.50 (1.04)*
Other/face	-5.99 (1.34)*
Post-intervention (SD)	
No	-
Yes	-0.94 (0.35)*

* significant at alpha level of 0.05

Table 4: Odds Ratios and 95% Confidence Intervals of 30-day mortality of patients

Variable	Overall (N=6,484)
Mean age, years	1.05 (1.04 to 1.06)*
Sex	
Female	1.00
Male	0.92 (0.72 to 1.17)
Injury mechanism	
Fall <2m	1.00
Fall >2m	0.81 (0.59 to 1.10)
Vehicle incident / collision	0.91 (0.65 to 1.28)
Stabbing	1.28 (0.56 to 2.90)
Blow	0.48 (0.25 to 0.90)
Crush	0.64 (0.10 to 3.88)
Blast / Shooting / Other	0.86 (0.44 to 1.69)
Injury severity score band	
1-8	1.00
9-15	1.63 (0.98 to 2.71)
>15	5.60 (3.39 to 9.23)*
Mean Glasgow Coma Scale	0.71 (0.69 to 0.73)*
Most severely injured body region	
Spine	1.00
Head	0.55 (0.35 to 0.89)*
Limbs	0.92 (0.56 to 1.51)
Multiple	0.99 (0.58 to 1.69)
Chest	0.73 (0.44 to 1.20)
Abdomen	1.28 (0.53 to 3.09)
Other/face	2.73 (1.16 to 6.42)*
Post-intervention	
No	1.00
Yes	0.69 (0.54 to 0.88)*

* significant at alpha level of 0.05

Table 5: Relative Risk and 95% confidence interval (CI) of Glasgow Outcome Score (GOS) of patients

	Severe disability	Moderate disability	Good recovery
Mean age, years (SD)	0.97 (0.96 to 0.98)*	0.95 (0.95 to 0.96)*	0.93 (0.92 to 0.93)*
Sex			
Female	1.00	1.00	1.00
Male	1.12 (0.86 to 1.46)	1.26 (0..97 to 1.64)	1.01 (0.79 to 1.30)
Injury mechanism			
Fall <2m	1.00	1.00	1.00
Fall >2m	1.20 (0.86 to 1.69)	1.27 (0.91 to 1.79)	1.44 (1.04 to 1.99)*
Vehicle incident / collision	1.30 (0.90 to 1.89)	1.19 (0.82 to 1.73)	1.29 (0.91 to 1.83)
Stabbing	1.26 (0.50 to 3.18)	0.51 (0.18 to 1.40)	1.0 (0.41 to 2.46)
Blow	2.10 (1.05 to 4.21)*	1.47 (0.70 to 3.10)	3.47 (1.77 to 6.78)
Crush	1.41 (0.16 to 12.5)	1.40 (0.17 to 11.7)	3.62 (0.50 to 26.0)
Blast / Shooting / Other	0.89 (0.42 to 1.86)	0.85 (0.41 to 1.78)	0.97 (0.49 to 1.92)
Injury severity score band			
1-8	1.00	1.00	1.00
9-15	0.95 (0.56 to 1.64)	0.65 (0.39 to 1.07)	0.54 (0.33 to 0.89)*
>15	0.65 (0.38 to 1.12)	0.17 (0.10 to 0.29)*	1.63 (1.57 to 1.69)*
Mean Glasgow Coma Scale	1.22 (1.19 to 1.27)*	1.40 (1.35 to 1.46)*	1.63 (1.57 to 1.69)*
Most severely injured body region			
Spine	1.00	1.00	1.00
Head	0.60 (0.37 to 0.97)*	1.52 (0.91 to 2.51)	3.46 (2.13 to 5.62)*
Limbs	0.44 (0.26 to 0.73)*	1.36 (0.83 to 2.24)	1.00 (0.62 to 1.63)
Multiple	0.42 (0.24 to 0.74)*	1.13 (0.64 to 1.97)	1.17 (0.68 to 2.01)
Chest	0.35 (0.20 to 0.60)*	1.27 (0.74 to 2.17)	2.58 (1.54 to 4.30)
Abdomen	0.20 (0.07 to 0.47)*	0.66 (0.25 to 1.75)	0.87 (0.35 to 2.16)
Other/face	0.17 (0.06 to 0.47)*	0.57 (0.21 to 1.52)	0.45 (0.17 to 1.19)
Post-intervention			
No	1.00		
Yes	1.10 (0.84 to 1.43)	1.81 (1.40 to 2.35)*	1.94 (1.51 to 2.49)*

***** significant at alpha level of 0.05