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Predictors of discharge destination in patients with major traumatic injury: Analysis of Oklahoma Trauma Registry

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ABSTRACT

Background: The ability to predict the need for discharge of trauma patients to a facility may help shorten hospital stay. This study aimed to determine the predictors of discharge to a facility and develop and validate a predictive scoring model, utilizing the Oklahoma Trauma Registry (OTR).
Methods: A multivariate analysis of the OTR 2005–2013 determined independent predictors of discharge to a facility. A scoring model was developed, and positive and negative predictive values (PPV and NPV) were evaluated for 2014 patients.
Results: 101,656 patients were analyzed. The scoring model included age≥50 years, lower extremity fracture, ICU stay≥5 days, pelvic fracture, intracranial hemorrhage, congestive heart failure, cardiac dysrhythmia, history of CVA or TIA, and ISS≥15, spine fracture, diabetes mellitus, hypertension, ischemic heart disease, and chronic obstructive pulmonary disease. Applying the model to 2014 patients, PPV for predicting discharge to a facility was 84.9% for scores≥15, and NPV was 90.5% for scores<8.
Conclusion: A scoring model including age, trauma severity, types of injury, and comorbidities could predict discharge of trauma patients to a facility. Further studies are needed to refine the efficacy of the model.

Introduction

A substantial portion of patients with traumatic injuries require long term inpatient care and rehabilitation after discharge. Discharge placement can be challenging in trauma patients due to the high acuity of presenting illness, along with frequent socio-economic challenges and lack of payor source.[1,2]

Often, the need for discharge to a facility is not identified until the patient has been transferred out of the ICU and after resolution of acute issues. This can subsequently delay discharge and increase direct costs for hospitalization and acute rehabilitation care.[3,4] In one study, the underlying cause of delay in discharge was found to be most often the lack of available rehabilitation bed on the day that the discharge was ordered, with these delays resulting in more than $14,000 increase in average hospital costs per patient. Patients in the delayed group often needed more ICU level care, had orthopedic injuries, or were uninsured.[5] A predictive algorithm to identify patients in need of placement earlier may shorten the length of stay and decrease the cost of care for trauma patients by identifying the need for post-acute care services.

The Oklahoma Trauma Registry (OTR) has been developed to collect information about injured patients from all state-licensed acute care hospitals, and has been used for the improvement of the Oklahoma trauma system. This study aimed to determine the independent predictors of discharge to a facility and to develop and validate a predictive scoring model for patients with major trauma, based on analysis of the Oklahoma Trauma Registry (OTR). Predictive factors were incorporated into a scoring system to identify patients at risk of hospital discharge to another facility (skilled nursing facility, rehabilitation, or long-term acute care centers).

Material and methods

De-identified data from the OTR were provided by the

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Oklahoma State Department of Health, and dates from 2005 to 2014 were used for this study. Oklahoma state hospital standards (Section 310: 667-59-1) require all hospitals to submit trauma registry data to the OTR. All hospitals submit the required data electronically for cases that meet inclusion criteria on a monthly basis. There were 110 hospitals classified as trauma centers which submitted data to the OTR, including 1 level I, 2 level II, 27 level III, and 80 level IV classified trauma centers.

Inclusion criteria

The OTR dataset includes patients with a trauma diagnosis including ICD-9 codes 800.00–959.9 and with major severity (Abbreviated Injury Scale severity value ≥ 3, Injury Severity Score ≥ 9, Trauma and Injury Severity Score (TRISS) or Burn Survival Probability < 0.90, or death). Based on OTR inclusion criteria, one of the following was also required to include a patient in the trauma registry: 1) length of hospital stay $\geq$48 h; 2) dead on arrival or death in the hospital, 3) hospital transfer, 4) admission to intensive care unit (ICU), or 5) surgery on the head, chest, abdomen, or vascular system. Isolated orthopedic injuries to extremities that met severity criteria were included if they were due to causes other than same level falls. All patients in the OTR dataset were included unless they met the exclusion criteria.

Exclusion criteria

Exclusion criteria of the OTR include 1) isolated orthopedic injury to the extremities due to same level falls (E885.9), 2) overexertion injuries, 3) injury caused by pre-existing condition, e.g. osteoporosis (fracture), 3) injuries more than 30 days old, 4) poisonings and toxic events (ICD 960–989.9), 5) submersion injuries (994.1), 6) foreign body (leading to choking or otherwise), 7) strangulation, asphyxiation, or anoxic brain death (994.7), and 8) electrocution (ICD 994.8). This study only excluded patients with unknown discharge disposition (N = 140, 0.1%) and patients with mortality (N = 5,753, 5.3%).

Patient classification

Patients were categorized based on discharge disposition. Surviving patients were categorized by 1) discharge to home, and 2) discharge to a facility (skilled nursing facility, rehabilitation, or long-term acute care centers).

Statistical analysis

Descriptive statistics were calculated for the study variables. For continuous variables, mean and standard deviation (SD) were calculated, and frequencies and proportions were calculated for categorical variables. Chi-square test was used to determine association between discharge disposition and other categorical study variables. Student's t-test or Mann-Whitney *U* test was used for continuous variables when appropriate. Independent factors predicting discharge to a facility were identified by performing multivariate analysis on 2005–2013 patients. Logistic regression analysis was used considering "discharge disposition to a facility" as an outcome and including all other variables with p-value <0.1 in univariate analysis as independent variables. A backward selection procedure with a significance level of 0.1 was applied to obtain a parsimonious solution to the association between discharge disposition and predictor variables.

Considering the independent predictors of discharge to a facility and their clinical relevance, a scoring model was made predicting "discharge disposition to a facility". Each factor was given a score based on the calculated odds ratios, and the total score for each patient was considered as the summation of individual scores for each patient. Receiver operating characteristic (ROC) curve was used to evaluate the overall accuracy of the scoring model. Area under the curve (AUC) was calculated to examine the predictive accuracy of the scoring model in correctly identifying patients discharged to a facility. Youden index and other functions of sensitivity and specificity were used to obtain optimal cutoff scores (<8, 8–14, and >14). The scoring model was subcategorized to three ranges (<8, 8–14,>14), and positive and negative predictability of each range were evaluated for 2014 patients; Cochrane-Armitage trend tests were used to evaluate the association between discharge to facility and categorized scores. Logistic regression analysis was performed to obtain odds ratios and 95% confidence intervals (95%CI). All analyses were carried out using SAS, Version 9.4 (SAS Institute Inc., Cary NC) and IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY, USA). A significance level of 0.05 was used for statistical significance.

Results

101,656 patients were analyzed. Patients included 63,376 male (62.3%), mean age of 42.8 ± 26.1 years, and mean injury severity score of 9.8 ± 8. 23,482 patients (23.1%) were discharged to a facility. Univariate analysis of the patient demographics, mechanisms of injury, comorbidities and injuries are shown in Tables 1 and 2.

Multivariate analysis of OTR 2005-2013 indicated that age, injury severity score (ISS), and the specific type of injuries and comorbidities can independently predict the need for discharge to a facility (Table 3). A scoring model was created considering age $\geq$50 years, lower extremity fracture, ICU stay $\geq$5 days, pelvic fracture, intracranial hemorrhage, congestive heart failure, cardiac dysrhythmia, history of CVA or TIA, ISS $\geq$15, spinal fracture, diabetes mellitus, hypertension, ischemic heart disease, and chronic obstructive pulmonary disease (Table 4). Overall accuracy (AUC) of the scoring model was 0.86 (95%CI: 0.85, 0.86) in correctly identifying patients discharged to a facility. Based on ROC curve and functions of sensitivity and sensitivity, such as Youden's Index (J) and distance to 0.1 (d), (supplemental figure and table), the optimal cutoff scores of 8 and 14 were selected for this trauma discharge prediction scoring model.

Predictability of the model was evaluated by applying the model to patients admitted in 2014. Scores >14 had an 84.9% positive predictive value in the 2014 dataset, and scores <8 had 90.5% negative predictive value for need for placement to a facility (Table 5). The Results of the Cochrane-Armitage trend test indicated significantly progressive effects of scoring risk categories for discharge to facility (Score <8: 9.46%, Score 8–14: 61.11%, Score =>15: 84.91%, p-trend <0.001). Similarly, results of the logistic regression analysis showed that patients with a score of 8–14 were 15.03 (95%CI: 13.56, 16.66) times more likely to discharge to a facility compared to those with a score less than 8. Patients who had a score of 15 or greater had 53.81 (95%CI: 25.26, 114.59) times likelier discharge to facility than those who had scores less than 8.

Discussion

Traumatic injuries remain a leading cause of morbidity and mortality in patients requiring emergent hospitalization. Multiple challenges in the care of these patients still exist despite improvements in pre-hospital care, care within the initial "golden hour", and subsequent ICU and acute hospital-based care. For patients who survive their injuries, there are often difficulties in facilitating discharge and post-acute care. These are often further

Table 1
Comparison of demographics, comorbidities, and mechanism of injury in trauma patients with discharge to home versus facility (OTR 2005–2014).

	Discharge to home N = 78,174	Discharge to facility N = 23,482	P value[a]
Age, mean ± SD (year)	37.3 ± 23.6	64.8 ± 23.3	<0.001
Gender, N (%)			<0.001
Female	25,445 (32.5%)	12,835 (54.7%)	
Male	52,729 (67.5%)	10,647 (46.3%)	
Race, N (%)			<0.001
White	60,401 (77.3%)	20,477 (87.2%)	
Black	6549 (8.4%)	1042 (4.4%)	
American Indian	5404 (6.9%)	937 (4%)	
Other	5820 (7.4%)	1026 (4.4%)	
Co-morbidities, N (%)			
Diabetes Mellitus	3431 (4.4%)	3248 (13.8%)	<0.001
Hypertension	9627 (12.3%)	8374 (35.7%)	<0.001
CKD	458 (0.6%)	800 (3.4%)	<0.001
Dialysis	115 (0.1%)	164 (0.7%)	<0.001
Ischemic Heart Disease	1895 (2.4%)	2463 (10.5%)	<0.001
History of MI	416 (0.5%)	439 (1.9%)	<0.001
Cardiac dysrhythmias	1266 (1.6%)	2221 (9.5%)	<0.001
Heart failure	842 (1.1%)	1763 (7.5%)	<0.001
COPD	2702 (3.5%)	2030 (8.6%)	<0.001
Chronic liver disease	212 (0.3%)	132 (0.6%)	<0.001
History of TIA/CVA	341 (0.4%)	658 (2.8%)	<0.001
Mechanism, N (%)			<0.001
Fall	23,546 (30.1%)	14,444 (61.5%)	
MVC	19,527 (25%)	4698 (20%)	
Motorcycle	4156 (5.3%)	887 (3.8%)	
Pedestrian	1719 (2.2%)	481 (2%)	
Stabbing	4325 (5.5%)	336 (1.4%)	
GSW	3395 (4.3%)	372 (1.6%)	
Altercation	2833 (3.6%)	183 (0.8%)	
Struck	4061 (5.2%)	378 (1.6%)	
Other	14,612 (18.7%)	1703 (7.3%)	

[a] Student's *t*-test was used for age, whereas, chi square test of independence was used for all other variables. OTR: Oklahoma Trauma Registry; CVA: Cerebrovascular Accident; TIA: Transient Ischemic Attack; COPD: Chronic Obstructive Pulmonary Disease.

exacerbated by patient comorbidities, social situation, drug or substance abuse, and lack of social and family support.

Several studies have evaluated discharge dispositions in trauma patients. Previously, the length of ICU stay, region of injury, and comorbidities such as diabetes mellitus and coagulopathy have been found to be predictors of non-home discharge in trauma patients. Prior studies have also included the development of a predictive scoring model.[3,6,7] A large portion of the Oklahoma trauma population is categorized as geriatric trauma with an increasing incidence of fall as the mechanism of injury.[8] Increasing age predicts discharge to a rehabilitation facility or other non-home location. Several studies have looked at the association between age and discharge disposition, with the intent of identifying disposition early and decreasing hospital costs and length of stay.[4] Frailty index has been found to be predictive of non-home discharge, with a worsening index strongly predictive of death or discharge to a skilled nursing facility.[9] Perioperative hypotension has also been found to contribute to increased length of stay and non-home discharge in geriatric patients.[10]

In addition to geriatric patients, other specific subsets of trauma patients have unique predictors that have implications for hospital discharge. In patients with traumatic brain injury, the presenting

Table 2
Comparison of injuries and hospital outcomes in trauma patients with discharge to home versus facility (OTR 2005–2014).

	Discharge to home N = 78,174	Discharge to facility N = 23,482	P value[a]
Injuries, N (%)			
Skull/facial fracture	12,002 (15.3%)	2680 (11.4%)	<0.001
Intracranial bleeding	11,946 (15.3%)	5463 (23.3%)	<0.001
Spinal fracture	8941 (11.4%)	4229 (13%)	<0.001
Nerve/spinal cord injury	1530 (2%)	540 (2.3%)	<0.001
Rib fracture	9415 (12%)	3485 (14.8%)	<0.001
Pneumothorax/Hemothorax	7323 (9.4%)	2170 (9.2%)	0.559
Liver injury	1965 (2.5%)	523 (2.2%)	0.013
Spleen injury	2318 (3%)	636 (2.7%)	0.040
Kidney injury	1016 (1.3%)	301 (1.3%)	0.832
Gastrointestinal injury	1522 (1.9%)	308 (1.3%)	<0.001
Pelvic fracture	3732 (4.8%)	2961 (12.6%)	<0.001
Upper extremity fracture	15,642 (20%)	3912 (16.7%)	<0.001
Lower extremity fracture	14,640 (18.7%)	11,311 (48.2%)	<0.001
Injury Severity Score, median (IQR)	16 (14)	18 (16)	<0.001
Admit to ICU, N (%)	19,646 (25.1%)	8572 (36.5%)	<0.001
ICU days, median (IQR)	2 (2)	6 (11)	<0.001
Length of stay (day), median (IQR)	2 (3)	6 (7)	<0.001

[a] Mann-Whitney *U* test was used for injury severity score, admit to ICU, ICU days, and length of stay, and chi-square test of independence was used for types of injuries. OTR: Oklahoma Trauma Registry; IQR: interquartile range.

Table 3
Predictors of discharge to a facility in trauma patients based on multivariate analysis (OTR 2005–2013).

Factors	Odds Ratio	95% CI	P Value
Age ≥ 50 years	5.203	4.979–5 .438	<0.001
Lower extremity fracture	3.704	3.550–3.865	<0.001
ICU stay ≥ 5 days	3.494	3.356–3.638	<0.001
Pelvic fracture	2.529	2.369–2.701	<0.001
History of CVA or TIA	2.109	1.817–2.448	<0.001
Cardiac dysrhythmias	2.002	1.841–2.177	<0.001
Heart failure	1.831	1.660–2.020	<0.001
Intracranial Hemorrhage	1.681	1.593–1.773	<0.001
ISS ≥ 15	1.550	1.472–1.633	<0.001
Spine fracture	1.450	1.374–1.529	<0.001
Hypertension	1.324	1.264–1.388	<0.001
Ischemic Heart Disease	1.214	1.126–1.309	<0.001
COPD	1.202	1.116–1.294	<0.001
Diabetes Mellitus	1.103	1.035–1.176	0 .002

OTR: Oklahoma Trauma Registry; CI: confidence interval; ISS: Injury Severity Score; COPD: Chronic Obstructive Pulmonary Disease.

GCS score can be a factor impacting discharge planning.[11] Approximately 34% of the Oklahoma population is categorized as obese, and this problem continues to affect the US population at epidemic rates. One study found that obesity could be a protective factor for injury due to falls, but is also associated with an increased length of stay and likelihood of discharge to a non-home location when compared to non-obese fall victims.[12] Traumatic amputees are another patient group with discharge disposition affected by multiple factors. Discharge location after traumatic amputation is influenced by payer source, proximity and level of amputation, and co-existing severe injuries to other body systems.[2]

Finding an appropriate facility for disposition for many trauma patients can be challenging due to the factors outlined above. Each patient has individual special needs, and discharge to home or to a facility has multiple medical, social, and healthcare-system related factors that must be taken into account to ensure appropriate post-discharge care to meet those patient care needs. Factors that are taken into account include the type of injury, patient and family preferences, proximity to home, and insurance coverage. Many trauma patients are often transferred from lower acuity facilities to major trauma centers for tertiary services that are not available in rural settings. This often poses a challenge to balance the need for specialist follow-up near the tertiary center with social and family needs that may be better met by having a patient closer to home where tertiary services are not readily available.

Table 4
Scoring model for prediction of discharge disposition of trauma patient to a facility.

Factors	Score
Age ≥50 years	5
ICU stay ≥5 days	3
Injuries	
Lower extremity fracture	4
Intracranial hemorrhage	2
Pelvic fracture	2
Spine fracture	1
Injury Severity score ≥15	1
Comorbidities	
Congestive heart failure	2
Cardiac dysrhythmia	2
History of CVA or TIA	2
Diabetes mellitus	1
Hypertension	1
Ischemic heart disease	1
Chronic Obstructive Pulmonary Disease	1

CVA: Cerebrovascular Accident; TIA: Transient Ischemic Attack.

In this study data from a statewide database were analyzed to examine which patient factors are predictive of discharge to a care facility, with subsequent creation of a scoring system to predict which patients will require subsequent care at a facility. In this model patients are categorized to one of 3 different subgroups. Patients with scores of 7 or less had a very low probability of need for placement to a facility (<10%). Patients with a score of 8–14 are more likely to require placement in a facility, and patients with a score of 15 and higher are highly likely to require discharge to a facility (85%). Based on this data, recommendations are made for each subgroup based on the predictive values (Table 5). Patients with low risk can be assessed in a case-based approach for possible placement to a facility. Higher risk patients (score ≥15) may benefit the most if they are assessed early during their hospitalization, and all possible post-discharge facilities are considered to facilitate patient discharge when medically appropriate.

For patients who fall in the intermediate risk group, it may be of benefit to assess them intermittently to evaluate what disposition will be required after hospital discharge. Some patients will have modifiable risk factors and may make rapid clinical improvement during the early hospitalization, making the need for facility care unlikely. For other patients, the only individual score that may change during hospitalization is the length of ICU stay. Patients who stay in the ICU for 5 days or more will have an increase in their total score and a greater likelihood of care at a facility after discharge. This reinforces the need to continually evaluate hospital course, patient functional status, level of recovery, and family support, as these are factors that must be taken into account and can affect discharge needs.

This predictive score can be readily used during hospitalization to reliably predict which patients will likely need to be discharged to a facility after their acute hospitalization. Most of the factors included in this score are known on admission, and can provide a baseline score to facilitate discussions regarding disposition planning. For patients who have a mid-range score, the duration of ICU stay can be used as a clinical indicator to alert the care team that there may be a need for multidisciplinary discussion to assess the type of facility needed after discharge.

This is a state-based research study proposing a clinical scoring tool to predict post-hospital discharge disposition for trauma patients. Beaulieu et al. performed a similar study using data from 2836 trauma patients at single hospital where they found that gender, age, length of ICU and hospital stay, and some comorbidities (neurologic, coagulopathy, and diabetes mellitus) could independently predict discharge to a facility. They provided a scoring model with categories of likelihood for non-home discharge.[3] Our Results are similar using data from 110 hospitals with inclusion of types of traumatic injuries over ten years, with a higher predictive value of the model (85% vs 75%).

There are other studies that evaluate discharge predictors in specific trauma subgroups. Cuthbert et al. studies traumatic brain injuries and found Glasgow Coma Scale (GCS) and length of hospital stay as the most important factors associated with discharge to a facility.[11] Dunham et al. studied geriatric trauma patients and showed that discharge to a nursing home or a long-term acute care facility was independently associated with lower preinjury daily living activity score, higher age, lower discharge GCS, dementia, and the number of comorbidities.[13] El-Beheiry et al. found that ISS is the only independent factor associated with discharge disposition in blunt traumatic thoracic aortic injuries.[14] James et al. studied fall victims in a single center and found that length of hospital stay, age, length of ICU stay, injury severity, number of comorbidities, Medicare insurance, fracture, and ambulation status were associated with discharge to a facility.[15] The aforementioned studies are valuable because they focus on specific variables related to each

Table 5
Oklahoma trauma discharge prediction scoring model.

Score	Predictive value for discharge to facility	OR (95%CI) of discharge to facility	Recommendations
≤7	9.5% discharge to facility	Reference	- Low risk for placement needs - Case-based assessment - Consider hospital course and socioeconomic status
8–14	61.1% discharge to facility	15 (13.6–16.7)	- Intermittent evaluation every 1–2 days - Assess placement options 1) in higher scores (>10) 2) if the score increased by prolonged ICU stay, or 3) inadequate social support
≥15	84.9% discharge to facility	53.8 (25.3–114.6)	- Start early assessment for placement options - Make preliminary arrangements with payers and facilities

subgroup. Because our study reviews data from a state-based trauma registry and can be applied to all trauma patients with only limited exclusion criteria, we believe that it can be a useful addition to these studies. Our model can be easily implemented as a hospital protocol and is readily available for case managers and social workers. It can also be integrated into electronic medical record software to provide real time assessments for all team members.

There are some limitations to this study. It is retrospective and does not include specific details regarding socioeconomic status and level of family support. The data is from the state of Oklahoma, and the predictive factors may not be the same when applied to other locations with different populations, access to rehabilitation facilities, and insurance plans. Sacks et al. showed insurance status is a predictor of discharge disposition, based on a study of the National Trauma Data Bank 2002–2006.[16] Another limitation is the timeline of the study. This study used a 2005–2013 dataset to create the scoring system and then verified it on 2014 data. Future studies using updated data may be helpful to revise the model. The model has also not been prospectively utilized in the clinical setting. Similar studies using national and other prospectively collected data may provide additional information to add to this model. Prospective studies can better control for confounding factors and consider additional socioeconomic variables. A randomized trial comparing using the model versus traditional planning would be helpful to evaluate the direct impact this model has on hospital length of stay and the cost of care.

Conclusions

This analysis of data from the Oklahoma trauma registry from 2005 to 2014 demonstrates that age, ISS ≥15, ICU stay ≥5 days, specific injuries (lower extremity fracture, pelvic fracture, intracranial hemorrhage, spinal fracture), and certain comorbidities (diabetes mellitus, hypertension, ischemic heart disease, congestive heart failure, cardiac dysrhythmia, history of CVA or TIA, and chronic obstructive pulmonary disease) can predict the need for discharge to a facility in trauma patients. A scoring model using these factors can predict the discharge disposition and facilitate discharge planning. Early utilization of this scoring system and identification of at-risk patients may shorten hospital stay and decrease cost of care for trauma patients.

Conflict of interest disclosures

None.

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Appendix A. Supplementary data

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