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# The differential associations of preexisting conditions with trauma-related outcomes in the presence of competing risks

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ABSTRACT

*Introduction:* Pre-existing chronic conditions (PECs) pose a unique problem for the care of aging trauma populations. However, the relationships between specific conditions and outcomes after injury are relatively unknown. Evaluation of trauma patients is further complicated by their discharge to care facilities, where mortality risk remains high. Traditional approaches for evaluating in-hospital mortality do not account for the discharge of at-risk patients, which constitutes a competing risk event to death. The objective of this study was to evaluate associations between 40 PECs and two clinical outcomes in the context of competing risks among older trauma patients.
*Methods:* This retrospective study evaluated blunt-injured patients aged 55 years and older admitted to a level I trauma centre in 2006–2012. Outcomes were hospital length of stay (HLOS) and in-hospital mortality. Survivors were classified as discharges home or discharges to care facilities. Competing risks regression was used to evaluate each PEC with in-hospital mortality, accounting for discharges to care facilities as competing events. Competing risk estimates were compared to Cox model estimates, for which all survivors to discharge were non-events. Analyses were stratified using injury-based mortality risk at a 50% cutpoint (high versus low).
*Results:* Among 4653 patients, 176 died in-hospital, 3059 were discharged home, and 1418 were discharged to a care facility. Most patients (98%) were classified with a low mortality risk. Only haemophilia and coagulopathy were consistently associated with longer HLOS. In the low-risk subgroup, in-hospital mortality was most strongly associated with liver diseases, haemophilia, and coagulopathy. In the high-risk group, Parkinson's disease, depression, and cancers showed the strongest associations. Accounting for the competing event altered estimates for 12 of 19 significant conditions.
*Conclusions:* Excess mortality among patients expected to survive their injuries may be attributable to complications resulting from PECs. Discharges to care facilities constitute a bias in the evaluation of in-hospital mortality and should be considered for the accurate calculation of risk. In conjunction with injury measures, consideration of PECs provides physicians with a foundation to plan clinical decisions in older trauma patients.



## Introduction

Older adults comprise a growing proportion of patients entering trauma centres, doubling from 12.1% to 24.6% over the last decade [1–3]. This is significant because older trauma patients historically require more resource-intensive care and experience worse outcomes than those of similarly injured younger patients [4–9]. Outcomes research is often focused on the evaluation of death at the time of discharge as the primary indicator of quality of care. Recent research suggests that mortality risk remains high in patients discharged to care facilities [10–13]. The discharge of a high-risk patient, in effect, acts as a competing risk event to in-hospital mortality which is formally defined as any event that prevents the observation of the event of interest or modifies the

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chance that the event occurs [14]. Failure to account for competing risks leads to inaccurate associations [15].

Recent literature has alluded to the management of pre-existing chronic conditions (PECs) as a premier facet of care to better insure positive outcomes among older trauma patients [16,17]. However, specific conditions have seldom been targeted as little is known about the relationship between PECs and trauma outcomes [18–20]. The objective of this study was to evaluate an array of PECs among older trauma patients and their association with two outcomes used to measure trauma care: hospital length of stay (HLOS) and in-hospital mortality in a competing risk scenario.

## Methods

### Study design and setting

With the approval of the Scripps Health Office for the Protection of Research Subjects, we conducted a retrospective study among patients admitted to Scripps Mercy Hospital, a verified urban Level I Trauma Centre in San Diego, California, United States during a seven-year period beginning in January 1, 2006 to December 31, 2012. The Scripps Mercy Hospital trauma registry was used to identify all unique blunt-injured trauma patients aged 55 years and older. Exclusions were made for patients who were discharged or died within 6 h after admission.

### Data sources and measures

The index admission for eligible patients was the most recent trauma visit, for which basic demographics, injury characteristics, clinical variables, and outcomes were identified from the trauma registry. Registry data were supplemented using the corporate Enterprise Data Warehouse (EDW; via IBM Cognos Connection v. 10.2) queried for International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) procedure and diagnosis codes used for billing. Among deaths, medical records and audit logs were reviewed to identify the presence of withdrawal of care and these methods have been previously defined [2].

Twenty-one PECs coded and captured by the trauma registry and an additional 19 non-overlapping PECs defined by Elixhauser Comorbidity Scale were abstracted for each patient using ICD-9-CM diagnosis codes (definitions in Appendix Table E1) [21]. The Elixhauser Comorbidity Scale was developed in 1998 to measure total disease burden using 30 weighted conditions, and has been maintained by the United States Agency for Healthcare Research, Healthcare Cost and Utilization Project. Conditions were selected based on having an overall prevalence $\geq$0.5% in the sample population. Patients were coded as having a condition based on physician diagnosis or medication use indicating illness. Metabolic panels performed on all patients upon admission were used to identify liver, kidney, heart, or muscle conditions. Blood tests were used to evaluate coagulation time, blood sugar levels, and anaemia. For patients with multiple trauma admissions, only demographic and injury characteristics from the most recent visit were used. Data on PECs captured during previous visits were carried forward to the most recent admission.

The primary outcomes were in-hospital mortality and HLOS. Total HLOS was calculated in hours from the time and date of admission to the time and date of discharge. For patients who survived to discharge, disposition was categorised as either discharge to home (with or without assistance) or discharge to a care facility (skilled nursing facility [SNF], hospice, long-term acute care, rehabilitation facility, or behavioural health unit). Patients who left against medical advice were classified as discharged home.

### Data analysis

Distributional differences in injury-related factors and chronic condition prevalence by discharge disposition were identified using the Chi-square test, ANOVA, and Kruskal-Wallis tests, as appropriate. Pairwise differences between discharge to care facility and in-hospital death were analysed with Chi-square tests, *t*-tests, and rank-sum tests. Values were reported as means with standard deviations (SD), medians with interquartile ranges (IQR), or proportions. Prevalence is displayed as cases per 1000 trauma patients and the number of cases can be calculated by multiplying each PEC-specific prevalence rate by the total population. Age- and gender-adjusted prevalence of PECs stratified by discharge disposition was calculated using logistic regression. The Trauma Mortality Prediction Model (TMPM) injury-based probability of death value was calculated for all patients using Abbreviated Injury Scale codes from the trauma registry [22]. These TMPM values were used to evaluate injury severity because it has been extensively validated and demonstrated as superior to other methods of measuring injury burden [23,24]. Due to skew of the TMPM variable, values are shown as median (IQR). For modelling purposes, this variable was log-transformed.

Cox proportional hazards regression was used to assess the associations between PECs and in-hospital mortality. Fine and Gray proportional hazards regression for competing risks was used to evaluate PECs and in-hospital mortality accounting for discharge to care facility as a competing event [25]. Competing risks regression considers the sub-hazard distribution (also known as a cause-specific hazard) for the competing event to produce a sub-hazard ratio (sHR), which is the ratio of the hazard of failing from the primary outcome of interest instead of the competing event. Specifically, the sHR is the ratio of the hazards comparing the cumulative incidence functions for in-hospital mortality based on presence versus the absence of a chronic condition. Due to a violation of the proportional hazards assumption by the TMPM probability of death variable, models were stratified by probability of death at a 50% cutoff, selected to evaluate PECs in two distinct groups of patients: those with a high injury-based expected mortality (TMPM probability of death $\geq$50%) and those with a low injury-based expected mortality (TMPM probability of death $<$50%). In all models, patient age at admission and log-transformed TMPM probability of death were used for adjustment as continuous covariates. Fine and Gray model estimates that differed by $\pm$10% from the Cox estimates were considered significant, indicating that the magnitude of risk significantly changed after accounting for the competing event.

The HLOS variable was log-transformed due to skew. To evaluate PECs associated with HLOS, mixed-effects linear regression models were constructed. The fixed effects were: age, log-transformed TMPM probability of death, admission verbal Glasgow Coma Scale (GCS) score, and admission systolic blood pressure. These variables were selected by having a statistically significant bivariate relationship with HLOS. Admission year was included as a random effect owing to the potential for unobserved heterogeneity among covariates and HLOS by calendar year. Statistical significance was defined with a $p < 0.050$. All data were managed and analysed using Stata/SE v. 12.0 (StataCorp LLC, College Station, TX).

## Results

A total of 4653 unique patients met all inclusion criteria. During the study period, the number of older trauma patients increased annually. Two hundred and seventy-six (5.9%) patients had more than one trauma admission and 4358 (93.7%) had at least one PEC. Patients were predominantly white (76.8%), insured (94.5%), and had a low probability of death (98.0%) as predicted by the TMPM