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Re-triage Moderates Association between State Trauma Funding and Lower Mortality of Trauma Patients

Meilynn Shi, BA[a], **Susheel Reddy, MPH**[a,b], **Al'ona Furmanchuk, PhD**[c,d], **Jane L. Holl, MD, MPH**[e], **Renee Y. Hsia, MD, MSc**[f,g], **Robert C. Mackersie, MD**[h], **Karl Y. Bilimoria, MD, MS, FACS**[i], **Anne M. Stey, MD, MSc**[a,b]

[a]Department of Surgery, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

[b]Surgical Outcomes and Quality Improvement Center, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

[c]Division of General Internal Medicine and Geriatrics, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

[d]Center for Health Information Partnerships, Institute for Public Health and Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

[e]Department of Neurology, Center for Healthcare Delivery Science and Innovation, University of Chicago, Chicago, IL, USA

[f]Department of Emergency Medicine, School of Medicine, University of California San Francisco, San Francisco, CA, USA

[g]Philip R. Lee Institute for Health Policy Studies, University of California San Francisco, San Francisco, CA, USA

[h]Department of Surgery, School of Medicine, University of California San Francisco, San Francisco, CA, USA

[i]Department of Surgery, School of Medicine, Indiana University, Indianapolis, IN, USA

Abstract

Background: Severely injured patients who are re-triaged (emergently transferred from an emergency department to a high-level trauma center) experience lower in-hospital mortality. Patients in states with trauma funding also experience lower in-hospital mortality. This study examines the interaction of re-triage, state trauma funding, and in-hospital mortality.

Corresponding Author: Anne M. Stey, 676 N. St. Clair, Suite 650, Chicago, IL 60611, Phone: 312-695-2963, Fax: 312-926-7404, as013j@gmail.com.

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Study Design: Severely injured patients (Injury Severity Score >15) were identified from 2016–17 Healthcare Cost and Utilization Project State Emergency Department Databases and State Inpatient Databases in five states (FL, MA, MD, NY, WI). Data were merged with the American Hospital Association Survey and state trauma funding data. Patients were linked across hospital encounters to determine if they were appropriately field triaged, field under-triaged, optimally re-triaged, or sub-optimally re-triaged. A hierarchical logistic regression modeling in-hospital mortality was used to quantify the effect of re-triage on the association between state trauma funding and in-hospital mortality, while adjusting for patient and hospital characteristics.

Results: A total of 241,756 severely injured patients were identified. Median age was 52 years (IQR: 28, 73) and median ISS was 17 (IQR: 16, 25). Two states (MA, NY) allocated no funding, while three states (WI, FL, MD) allocated $0.09-$1.80 per capita. Patients in states with trauma funding were more broadly distributed across trauma center levels, with a higher proportion of patients brought to Level III, IV, or non-trauma centers, compared to patients in states without trauma funding (54.0% vs. 41.1%, p<0.001). Patients in states with trauma funding were more often re-triaged, compared to patients in states without trauma funding (3.7% vs. 1.8%, p<0.001). Patients who were optimally re-triaged in states with trauma funding experienced 0.67 lower adjusted odds of in-hospital mortality 95% CI: 0.50–0.89), compared to patients in states without trauma funding. We found that re-triage significantly moderated the association between state trauma funding and lower in-hospital mortality (p=0.018).

Conclusion: Severely injured patients in states with trauma funding are more often re-triaged and experience lower odds of mortality. Re-triage of severely injured patients may potentiate the mortality benefit of increased state trauma funding.

Keywords

Re-triage; Trauma Funding; Trauma Systems; Mortality; Traumatic Injury

INTRODUCTION

Successful trauma systems coordinate timely triage and care of injured patients from the moment of injury.[1] Regionalization of trauma care has lowered mortality of injured patients by getting the right patients to the right place at the right time.[2–11] However, field triage remains imperfect, making timely and accurate re-triage an important step in trauma care. Between 29% and 62% of severely injured patients, especially minorities, women, and older adults, are under-triaged in the field and transported to non-trauma and low-level trauma centers.[12–16] Under-triaged patients experience higher mortality, while those who are rapidly re-triaged from non-trauma and low-level trauma centers to high-level trauma centers experience mortality similar to those taken directly to high-level centers.[17–19] Yet, 57% to 63% of severely injured, under-triaged patients are never re-triaged.[18, 20]

The American College of Surgeons Committee on Trauma (ACSCOT) and the Centers for Disease Control and Prevention (CDC) have established guidelines for field triage.[1, 21, 22] However, there are currently no national re-triage guidelines. Instead, re-triage and timeliness of re-triage varies widely by state.[23] Differing amounts of state funding for trauma care and systems may contribute to this variation. Funding plays an important role in supporting centers that provide trauma care and infrastructure that ensures that the right patient gets to the right place at the right time.[10, 11] We have previously shown that state trauma funding is associated with decreased adjusted in-hospital mortality of injured patients.(Byskosh A, Shi M, Helenowski I, Holl J, Hsia R, Liepert A, et al. Is State Trauma Funding Associated with Mortality Among Injured Hospitalized Patients? Manuscript submitted to Health Services Research.)

This study examines (1) the association between state trauma funding and rates of re-triage, and (2) the role of re-triage as a moderator of the association between state trauma funding and adjusted in-hospital mortality of severely injured patients. We hypothesize that (1) state trauma funding is associated with higher rates of re-triage, and (2) re-triage is a positive moderator of the association between state trauma funding and lower adjusted in-hospital mortality of severely injured patients.

MATERIALS AND METHODS

Design and Setting

We conducted a retrospective, observational, cohort study of severely injured patients (Injury Severity Score (ISS) >15) who were field triaged or re-triaged in five U.S. states (Florida, Massachusetts, Maryland, New York, Wisconsin), from January 1, 2016 to December 31, 2017. These states were included in our study because (1) they consistently report data to the Healthcare Cost and Utilization Project (HCUP) and provide a VISITLINK number that enables patient linkage between emergency department (ED) and inpatient encounters; (2) they consistently report data to the American Hospital Association (AHA) Annual Survey and provide an AHA hospital identifier (AHAID) that allows linkage of patient-level and hospital-level data; and (3) they capture the greatest number of patients and greatest degree of geographic diversity.

Data sources

Data were collected from four sources: HCUP State Emergency Department Database (SEDD),[24, 25] HCUP State Inpatient Databases (SID),[26, 27] AHA Annual Survey, and publicly available state reports of state trauma funding. The analysis for this study was done in 2021 when data from 2018, 2019, and 2020 were not yet available. Furthermore, the COVID-19 pandemic substantially changed triage practices and mortality rates across the country. The findings from 2020 would not be representative of normal conditions.

State trauma funding reports were obtained by searching each state's health department website for any documents with details about funding specifically for trauma care and systems. Funding for under-compensated trauma care (e.g., "trauma *care* funding") and funding for agencies responsible for coordinating regional trauma systems (e.g., "trauma *system* funding") were included. Funding for Emergency Medical Services (EMS) systems, which involves different funding mechanisms, was not included. If no reports were found online, a Freedom of Information Act (FOIA) request or an open records request was submitted to the state's health department, requesting any documents detailing funding for trauma system administration and/or trauma care compensation. If reports were found online, a FOIA request or an open records request was also submitted to the state's health department to confirm the data. If no response to a FOIA request or an open record request was received after multiple attempts, officials at the state's health department were contacted by telephone and/or email. The presence of funding and amounts of funding by calendar year were abstracted from these reports and communications (see Table, Supplemental Digital Content 1, which lists annual state trauma funding amounts). Funding amounts were translated into per capita funding based on U.S. Census data from the corresponding year.[28] Funding data were then merged with patient-level data from the 2016–17 SEDD and SID and with hospital data from the 2016 AHA Annual Survey, using the AHAID.[29]

Participants

Patients with the following criteria were included: (1) an International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) Clinical Classifications Software Refined (CCSR) body system classification of "INJ" (Injury, poisoning and certain other consequences of external causes) as the principal diagnosis; (2) a primary ICD-10-CM injury diagnosis; (3) a non-zero Abbreviated Injury Scale (AIS) score; and (4) an ISS >15, a common criterion used to define major trauma patients.[21] Patients without an ICD-10-CM classification of "INJ" (N=1365700); missing a primary ICD-10-CM injury diagnosis (N=344); with an AIS=0 (N=3544334); and/or with an ISS ≤15 (N=9046129) were excluded. Patients with multiple distinct hospital encounters were characterized with data from their final encounter. Patients who had an inter-facility transfer (inpatient to inpatient transfer greater than or equal to one day from injury) were excluded, due to the wide variability in characterization of inter-facility transfers (N=543).

Primary Outcome

The primary outcome was in-hospital mortality. In-hospital mortality was determined by an "expired" vital status at discharge from the last hospital encounter. All deaths were assigned to the hospital at which they occurred, regardless of whether it was in the ED or inpatient setting. Patients with non-survivable injuries (ISS=75) were excluded.

Moderator

The moderator of interest was re-triage. Re-triage status was determined for each patient by linking the patient across all hospital encounters using the patient's identifier (VISITLINK) and characterizing re-triage status based on an HCUP-provided admission date surrogate variable, length of stay, AHAID, and state-determined trauma center level designations.[30] Each patient encounter was characterized by destination (Level I or II trauma center vs. non-trauma or Level III or IV trauma center) and re-triage (yes vs. no). This characterization was used to create four re-triage status groups: (1) appropriate field triage, (2) field under-triage, (3) optimal re-triage, and (4) sub-optimal re-triage (see Figure, Supplemental Digital Content 2, which provides a conceptual representation of our re-triage status characterizations). Severely injured patients brought to an ED at or directly admitted to a Level I or II trauma center with no subsequent transfer were defined as appropriate field triage. Severely injured patients brought to an ED at or directly admitted to a Level III, IV, or non-trauma center with no subsequent transfer were defined as field under-triage. Severely injured patients emergently transferred from any ED to a Level I or II trauma center within one day were defined as optimal re-triage.[21] Severely injured patients emergently transferred from any ED to a Level III, IV, or non-trauma center within one day were defined as sub-optimal re-triage. If a patient encounter ended in transfer to post-acute care at a skilled nursing facility, an intermediate care facility, or home health or hospice care, the encounter was characterized based on the hospital encounter prior to the transfer. Patients who did not meet one of the four above re-triage status groups were considered “Other” and were excluded from the analyses.

Primary Predictor

The predictor of interest is state trauma funding. State trauma funding was hypothesized to be associated with lower in-hospital mortality because of its role in trauma care compensation and infrastructure development. State trauma funding status was determined by the per capita state trauma funding, as described above (see Table, Supplemental Digital Content 1, which lists annual state trauma funding amounts). Due to the limited number of states for which per capita state trauma funding could be determined, states were dichotomized into states with and without trauma funding.

Covariate Variable Definition

Patient covariates include age, sex, race, primary payer, ISS, Elixhauser Comorbidity Index, and length of stay. These variables were collected from the SID and SEDD databases. Age was categorized (<18 years, 18–36 years as reference, 37–57 years, 58–75 years, and >75 years) due to the non-linear association with mortality. Sex was defined as male and female with male as reference. Race was defined as White as reference, Black, Hispanic, Asian/Pacific Islander, Native American, and Other, as defined by SEDD/SID. Primary payer was defined as private insurance as reference, Medicaid, Medicare, self-pay, no charge, and other, as defined by SEDD/SID. Patient ISS and Elixhauser Comorbidity Index were calculated to control for injury severity and patient comorbidity, respectively. ISS was calculated using R statistical software (ICDPIC-R) for each SEDD/SID record, with the highest value selected if there were multiple hospital encounters.[31] Elixhauser Comorbidity Index was calculated for each SEDD/SID record using a standard package for ICD-10CM codes.[32–34] Hospital covariates were abstracted from the AHA Annual Survey and included state-determined trauma center level designation, bed size, and medical school affiliation of the first hospital at which patients received care. Trauma center level state designations were categorized into three groups: Level I, Level II, or Level III/IV/Non-trauma center. Hospital bed size was defined as <100 beds as reference, 100–199 beds, 200–299 beds, 300–399 beds, 400–499 beds, and ≥500 beds.[31]

Statistical Analysis

Frequencies of patient covariates (age, sex, race, primary payer status, ISS, Elixhauser Comorbidity Index, length of stay) were calculated and compared by state trauma funding status using Pearson’s chi-square tests (for nominal data) or the chi-square correlation statistic (for characteristics that were ordinal in nature). Frequencies of hospital covariates (trauma center level designation, bed size, medical school affiliation) were calculated and compared by state trauma funding status using the same methods. Frequencies of appropriate field triage versus field under-triage, and optimal re-triage versus sub-optimal re-triage were calculated and compared by state trauma funding status, using Pearson's chi-square tests.

All tests comparing unadjusted in-hospital mortality rates by both state trauma funding status and re-triage status were performed using Pearson's chi-square tests. Rates of unadjusted in-hospital mortality were calculated for patients who were appropriately field triaged, field under-triaged, optimally re-triaged, and sub-optimally re-triaged. The rates across these groups were compared. Homogeneity of associations between re-triage status and mortality identified within each of the two state trauma funding status groups was tested using a test of a three-way interaction between state trauma funding, re-triage, and unadjusted in-hospital mortality in a log-linear model.

Hierarchical logistic regression was used to model in-hospital mortality and quantify whether re-triage moderated the association between state trauma funding and adjusted in-hospital mortality, while adjusting for the patient-level fixed effects of age, sex, race, primary payer, ISS, and Elixhauser Comorbidity Index. Hospital-level fixed effect effects were included to adjust for bed size and medical school affiliation. A state trauma funding by re-triage status interaction term was introduced to model the role of re-triage as a moderator. An intercept term defined by hospital ID was included as the sole random effect.. Shrinkage of random hospital estimates was applied using empirical Bayes estimation.

RESULTS

This study included a total of 241,756 patients with an ISS >15 who were triaged in five U.S. states: Florida, Massachusetts, Maryland, New York, and Wisconsin. Two states (Massachusetts, New York) had no state trauma funding in 2016 and 2017 (see Table, Supplemental Digital Content 1, which lists annual state trauma funding amounts). Three states (Wisconsin, Florida, Maryland) had $0.09, $0.38, and $1.80 per capita state trauma funding in 2016, and $0.09, $0.60, and $1.64 per capita state trauma funding in 2017.

Age categories were evenly distributed and similarly distributed between patients in states with trauma funding and patients in states without trauma funding (Table 1).

Distribution by race differed by state trauma funding status ($p<0.001$) with the proportion of white (65.8% vs. 61.7%) and black (18.7% vs. 13.6%) patients slightly higher in states with trauma funding. Distribution by insurance status also differed by state trauma funding status ($p < 0.0001$). States with trauma funding had a lower percentage of Medicaid (18.6%, vs. 23.4%) and a higher percentage of self-pay (10.7% vs. 5.9%) patients. Patients in states with trauma funding differed by distribution of trauma center level designations ($p < 0.001$) with a higher percentage at Level III, IV, or non-trauma centers (54.0% vs. 41.1%).

Patients in states with trauma funding were more often field under-triaged (55.5% vs. 41.8%, $p<0.001$) compared to patients in states without trauma funding (Table 2).

Accordingly, patients in states with trauma funding were more often re-triaged overall (3.7% vs. 1.8%, $p<0.001$) compared to patients in states without trauma funding. However, re-triaged patients in states with trauma funding were less often optimally re-triaged to Level

I or II trauma centers (76.5% vs. 92.3%, p<0.001) compared to re-triaged patients in states without trauma funding.

Appropriately field triaged patients experienced similar unadjusted in-hospital mortality rates by state trauma funding status, at 4.6% in states without trauma funding compared to 5.2% in states with trauma funding (Table 3).

Field under-triaged patients also experienced similar unadjusted in-hospital mortality rates by state trauma funding status, at 1.5% in states without trauma funding compared to 1.7% in states with trauma funding. However, re-triaged patients in states with trauma funding experienced lower unadjusted in-hospital mortality (4.7% when optimally re-triaged and 4.8% when sub-optimally re-triaged) compared to re-triaged patients in states without trauma funding (6.3% when optimally re-triaged and 9.3% when sub-optimally re-triaged). Notably, re-triaged patients in states with trauma funding experienced an unadjusted in-hospital mortality rate similar to appropriately field triaged patients. Testing for homogeneity of odds ratios confirms an association between re-triage and unadjusted in-hospital mortality that differs between states with and without state trauma funding (p=0.0009).

When in-hospital mortality was adjusted for age, sex, race, primary payer, ISS, Elixhauser Comorbidity Index, bed size, medical school affiliation, and re-triage status, patients in states with trauma funding had 0.73 lower adjusted odds of in-hospital mortality (95% CI: 0.60–0.89) compared to patients in states without trauma funding (Table 4).

A test of a re-triage by state trauma funding interaction term confirmed that re-triage significantly moderates this association (p=0.0374) (Table 5).

There was no association between state trauma funding and adjusted in-hospital mortality (OR: 0.98, 95% CI: 0.82–1.17) for appropriately field triaged patients. The same was true for field under-triaged patients (OR: 0.90, 95% CI: 0.77–1.05). The strongest association between state trauma funding and decreased adjusted in-hospital mortality was among re-triaged patients, who had 0.70 lower adjusted odds of in-hospital mortality if optimally re-triaged (95% CI: 0.53–0.92) and 0.46 lower adjusted odds of in-hospital mortality if sub-optimally re-triaged (95% CI: 0.23–0.89).

DISCUSSION

Using trauma care and systems funding data available from five diverse states, we found that patients in states with trauma funding were more evenly distributed across trauma center levels, as well as more frequently re-triaged. Patients who were re-triaged in states with trauma funding experienced similar unadjusted in-hospital mortality to patients who were appropriately field triaged. We also saw that rates of under-triage and re-triage increased with age. This is likely because elderly patients present with more comorbidities[35] and with more severe injuries even with low-energy mechanisms,[14] making it less likely for mortality to be averted even with timely and definitive high-level trauma care. Moreover, we found that severely injured patients who were re-triaged experienced lower in-hospital mortality in states with trauma funding compared to those in states without trauma funding.

Our analyses demonstrate that re-triage significantly moderates the association between state trauma funding and decreased adjusted in-hospital mortality.

Our findings are similar to those of Newgard et al.,[18] which demonstrated that trauma patients who are re-triaged from the ED to Level I or II trauma centers experience reduced odds of mortality compared to patients who are not re-triaged. Our finding that patients experience the most reduction in adjusted in-hospital mortality when re-triaged in states with trauma funding, along with our finding that re-triaged patients experience similar in-hospital mortality to appropriately field triaged patients, suggest that state trauma funding drives trauma systems to coordinate re-triage more efficiently. State trauma funding may provide trauma systems with more financial support to integrate all hospitals in the trauma system and develop more coordinated triage and care efforts to ensure that the right patient gets to the right place at the right time. We were not able to distinguish between trauma care funding and trauma system funding in this study, but the importance of re-triage as a systems-level process may indicate that more emphasis be placed on trauma system funding.

Leveraging all hospitals in the trauma system, including low-level and non-trauma centers, is important because it reduces the risk of overwhelming high-level trauma centers with patients who could be managed at lower-level centers with equal outcomes and lower costs.[14, 36, 37] In this study, we saw that some patients were re-triaged to low-level trauma centers. We do not know why this phenomenon is happening. However, based on our qualitative work, we suspect that these re-triages occur because of personal relationships with clinicians at these low-level trauma centers who are able to provide the necessary care these specific patients require. We believe these data highlight an opportunity to better understand the capacity for trauma care at low-level trauma centers, which represent a heterogenous group with underestimated capacity. Utter et al.[9] found that severely injured patients experienced a reduced odds of mortality when hospitalized in states with inclusive trauma systems that provide and coordinate care among all acute care facilities, not just among trauma centers. These findings raise the question of how to balance field triage and re-triage of patients, while optimizing resources across the entire trauma system. Quantitative data from other groups suggest that timely re-triage, under two hours, is associated with equivalent mortality to patients directly field triaged to high-level trauma centers.[19] We found it compelling that in our study, re-triaged patients in funded state trauma systems also had equivalent mortality to those directly field triaged to high-level trauma centers.

Despite the importance of inclusive trauma systems, development of such systems remains limited. Many efforts to institutionalize trauma system development over the past four decades have lost momentum in large part due to inadequate funding.[38–41] Some states have not been able to gather enough revenue for funding, and some states have not been able to establish a stable source of funding or an optimal mechanism for the distribution of funds.[42–45] For instance, some states that fund their trauma system with tobacco taxes have collected less revenue in recent years due to a decline in cigarette smoking.[44] Lin et al.[46] recently identified legislation in 29 states allocating funding for trauma systems but encountered limited access to detailed information about trauma funding. Even among states with more transparent trauma funding reporting, Lin et al.[46] found wide variation in funding amounts and funding sources. We found that states that allocate funding for trauma care and systems experience higher rates of re-triage and lower rates of in-hospital mortality. Not only does this suggest that state trauma funding can improve patient outcomes and efficiency of the trauma system, but it also reiterates the importance of transparent trauma funding reporting. This study provides a stepping stone in better understanding how trauma funding should be allocated.

This study has several important limitations. Data on state trauma funding are not easily accessible or even available. While some states publish reports with details about the source and distribution of trauma funding, some states do not report any data on trauma funding. For the five states included in this study, funding data was verified by cross-referencing legislation, budget reports, trauma system planning documents, open records requests, and information from direct communication with public health officials. However, we were not able to definitively distinguish between trauma *care* and trauma *system* funding. This distinction is important for guiding policy recommendations but currently poorly documented. In addition, re-triage protocols vary among Emergency Medical Services regions and states. We determined re-triage based on ISS, as has been done in previous studies,[21] but this characterization is limited. ISS is based on diagnostic codes and is not used in clinical practice, but this was the best indicator we could use based on the available SID and SEDD data[30]. The five states we analyzed in our study cover a broad range of regions varying in population density and urbanicity. We accounted for population density by translating funding amounts into per capita dollars. We were not able to account for urbanicity of injury due to limited data pertaining to patient injury location in the SID and SEDD databases. Rural areas face unique obstacles and develop different policies to adapt to their needs. Interestingly, we have observed in our previous work that rural areas actually have better re-triage practices (more frequently re-triage and a greater proportion of re-triages are optimal) than urban areas.[47] Our study is the first to uncover a broader trend in re-triage rates positively moderating the association between state trauma funding and lower mortality. Trauma center level designation in the study was also based on state designations. However, state designation varies among states and may not align with the American College of Surgeons trauma center verification standards, complicating our characterization of field triage an re-triage even further. This study also only included data from five states due to limited state-level HCUP data and thus is not likely representative of all states. We chose five states that capture a broad range of demographics, geography, and urbanicity. SID and SEDD data are also primarily captured for administrative purposes and may not fully reflect the clinical complexity of each patient.[48] We attempted to control for clinical complexity by calculating the Elixhauser Comorbidity Index[32–34] to adjust for comorbidities and by calculating the ISS[31] to adjust for injury severity. Our analysis uses the AHA Annual Survey. As these are survey data, they present a risk of response bias, responder fatigue, and inaccuracies or inconsistencies in reporting. Nonetheless, the AHA data are the most complete data available about hospital structural measures. Lastly, when applying inferential statistics to the sample sizes presented here, p-values commonly considered to be significant often accompany effect sizes or differences that are less than relevant clinically. Despite this, we opted to include and use these p-values as larger p-values commonly considered non-significant do remain informative. Still, the clinical or scientific relevance of the estimates accompanying p-values should be strongly considered when attempting to draw inferences from these results. For this reason, we presented accompanying estimated effect sizes whenever citing p-values in this text.

CONCLUSION

Traumatic injury remains the leading cause of years of potential life lost before age 70.[49] However, as many as 20% of deaths from trauma could be prevented with more optimized trauma systems.[50] This includes developing robust infrastructure that coordinates timely field triage and re-triage of severely injured patients. Using trauma care and systems funding data available from five diverse states, we found that patients in states with trauma funding were more evenly distributed across trauma center levels, as well as more frequently re-triaged. Understanding how to effectively and efficiently re-triage patients requires first a more nuanced understanding of current re-triage practices among various regions. We recently summarized re-triage practices across the country.[51] The next step is determining evidence-based re-triage practices that are both standardized and flexible to regional resources.

Re-triage is only efficient and effective when hospitals are well-integrated into the trauma system with shared protocols and lines of communication. Such infrastructure requires adequate and stable funding for trauma system development, especially given the high medical needs and societal burdens that come with traumatic injury. This study shows that re-triage and trauma funding both contribute to broader utilization of the entire trauma system and lower in-hospital mortality of trauma patients. We thus encourage policymakers to develop robust regional re-triage protocols and direct increased funding towards optimizing coordination of the entire trauma system. This will push forward trauma system development and further improve mortality outcomes for injured patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. National Academies of Sciences, Engineering, Medicine. A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury. Berwick D, Downey A, Cornett E, editors. Washington, DC: The National Academies Press; 2016. 530 p.
2. Mullins RJ, Veum-Stone J, Helfand M, Zimmer-Gembeck M, Hedges JR, Southard PA, et al. Outcome of hospitalized injured patients after institution of a trauma system in an urban area. Jama. 1994;271(24):1919–24. Epub 1994/06/22. doi: 10.1001/jama.1994.03510480043032. [PubMed: 8201736]

3. Mullins RJ, Mann NC. Population-based research assessing the effectiveness of trauma systems. J Trauma. 1999;47(3 Suppl):S59–66. Epub 1999/09/25. doi: 10.1097/00005373-199909001-00013. [PubMed: 10496613]

4. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. J Trauma. 1999;47(3 Suppl):S46–55. Epub 1999/09/25. doi: 10.1097/00005373-199909001-00011. [PubMed: 10496611]

5. Nathens AB, Jurkovich GJ, Rivara FP, Maier RV. Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation. J Trauma. 2000;48(1):25–30; discussion -1. Epub 2000/01/27. doi: 10.1097/00005373-200001000-00005. [PubMed: 10647561]

6. Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. J Trauma. 2006;60(2):371–8. doi: 10.1097/01.ta.0000197916.99629.eb. [PubMed: 16508498]

7. Durham R, Pracht E, Orban B, Lottenburg L, Tepas J, Flint L. Evaluation of a mature trauma system. Ann Surg. 2006;243(6):775–83. doi: 10.1097/01.sla.0000219644.52926.f1. [PubMed: 16772781]

8. MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, et al. A national evaluation of the effect of trauma-center care on mortality. N Engl J Med. 2006;354(4):366–78. doi: 10.1056/NEJMsa052049. [PubMed: 16436768]

9. Utter GH, Maier RV, Rivara FP, Mock CN, Jurkovich GJ, Nathens AB. Inclusive trauma systems: do they improve triage or outcomes of the severely injured? J Trauma. 2006;60(3):529–37. Epub 2006/03/15. doi: 10.1097/01.ta.0000204022.36214.9e. [PubMed: 16531850]

10. Maxson T, Mabry CD, Sutherland MJ, Robertson RD, Booker JO, Collins T, et al. Does the Institution of a Statewide Trauma System Reduce Preventable Mortality and Yield a Positive Return on Investment for Taxpayers? J Am Coll Surg. 2017;224(4):489–99. doi: 10.1016/j.jamcollsurg.2016.12.042. [PubMed: 28284471]

11. Porter A, Karim S, Bowman SM, Recicar J, Bledsoe GH, Maxson RT. Impact of a statewide trauma system on the triage, transfer, and inpatient mortality of injured patients. J Trauma Acute Care Surg. 2018;84(5):771–9. Epub 2018/02/02. doi: 10.1097/ta.0000000000001825. [PubMed: 29389839]

12. Nakamura Y, Daya M, Bulger EM, Schreiber M, Mackersie R, Hsia RY, et al. Evaluating age in the field triage of injured persons. Ann Emerg Med. 2012;60(3):335–45. Epub 2012/05/29. doi: 10.1016/j.annemergmed.2012.04.006. [PubMed: 22633339]

13. Vassar MJ, Holcroft JJ, Knudson MM, Kizer KW. Fractures in access to and assessment of trauma systems. J Am Coll Surg. 2003;197(5):717–25. Epub 2003/10/31. doi: 10.1016/s1072-7515(03)00749-x. [PubMed: 14585404]

14. Xiang H, Wheeler KK, Groner JI, Shi J, Haley KJ. Undertriage of major trauma patients in the US emergency departments. The American Journal of Emergency Medicine. 2014;32(9):997–1004. doi: 10.1016/j.ajem.2014.05.038. [PubMed: 24993680]

15. Nirula R, Maier R, Moore E, Sperry J, Gentilello L. Scoop and run to the trauma center or stay and play at the local hospital: hospital transfer's effect on mortality. J Trauma. 2010;69(3):595–9; discussion 9–601. Epub 2010/09/15. doi: 10.1097/TA.0b013e3181ee6e32. [PubMed: 20838131]

16. Hsia RY, Wang E, Torres H, Saynina O, Wise PH. Disparities in trauma center access despite increasing utilization: data from California, 1999 to 2006. J Trauma. 2010;68(1):217–24. Epub 2009/11/11. doi: 10.1097/TA.0b013e3181a0e66d. [PubMed: 19901854]

17. Harrington DT, Connolly M, Biffl WL, Majercik SD, Cioffi WG. Transfer times to definitive care facilities are too long: a consequence of an immature trauma system. Ann Surg. 2005;241(6):961–6; discussion 6–8. Epub 2005/05/25. doi: 10.1097/01.sla.0000164178.62726.f1. [PubMed: 15912045]

18. Newgard CD, McConnell KJ, Hedges JR, Mullins RJ. The benefit of higher level of care transfer of injured patients from nontertiary hospital emergency departments. J Trauma. 2007;63(5):965–71. Epub 2007/11/13. doi: 10.1097/TA.0b013e31803c5665. [PubMed: 17993937]

19. Della Valle JM, Newton C, Kline RA, Spain DA, Pirrotta E, Wang NE. Rapid Retriage of Critically Injured Trauma Patients. JAMA Surg. 2017;152(10):981–3. doi: 10.1001/jamasurg.2017.2178. [PubMed: 28678987]
20. Garwe T, Cowan LD, Neas B, Cathey T, Danford BC, Greenawalt P. Survival benefit of transfer to tertiary trauma centers for major trauma patients initially presenting to nontertiary trauma centers. Acad Emerg Med. 2010;17(11):1223–32. Epub 2010/12/24. doi: 10.1111/j.1553-2712.2010.00918.x. [PubMed: 21175521]
21. American College of Surgeons Committee on Trauma. Resources for Optimal Care of the Injured Patient. 6th ed. Chicago: American College of Surgeons; 2014.
22. Sasser SM, Hunt RC, Faul M, Sugerman D, Pearson WS, Dulski T, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep. 2012;61(Rr-1):1–20. Epub 2012/01/13.
23. Gomez D, Haas B, Doumouras AG, Zagorski B, Ray J, Rubenfeld G, et al. A population-based analysis of the discrepancy between potential and realized access to trauma center care. Ann Surg. 2013;257(1):160–5. doi: 10.1097/SLA.0b013e31827b9649. [PubMed: 23235398]
24. HCUP State Emergency Department Databases (SEDD) Availability of Data Elements - 2016: Agency for Healthcare Research and Quality; 2020 [cited 2021 Dec 1]. Available from: https://www.hcup-us.ahrq.gov/db/state/sedddist/sedddistvarnote2016.jsp.
25. HCUP State Emergency Department Databases (SEDD) Availability of Data Elements - 2017: Agency for Healthcare Research and Quality; 2020 [cited 2021 Dec 1]. Available from: https://www.hcup-us.ahrq.gov/db/state/sedddist/sedddistvarnote2017.jsp.
26. HCUP State Inpatient Databases (SID) Availability of Data Elements - 2016: Agency for Healthcare Research and Quality; 2020 [cited 2021 Dec 1]. Available from: https://www.hcup-us.ahrq.gov/db/state/siddist/siddistvarnote2016.jsp.
27. HCUP State Inpatient Databases (SID) Availability of Data Elements - 2017: Agency for Healthcare Research and Quality; 2020 [cited 2021 Dec 1]. Available from: https://www.hcup-us.ahrq.gov/db/state/siddist/siddistvarnote2017.jsp.
28. United States Census Bureau. Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2019.
29. AHAID - AHA hospital identifier: Agency for Healthcare Research and Quality; 2008 [cited 2021 Dec 1]. Available from: https://www.hcup-us.ahrq.gov/db/vars/ahaid/nisnote.jsp.
30. User Guide: HCUP Supplemental Variables for Revisit Analyses. 2021.
31. Clark DE, Black AW, Skavdahl DH, Hallagan LD. Open-access programs for injury categorization using ICD-9 or ICD-10. Inj Epidemiol. 2018;5(1):11. Epub 2018/04/10. doi: 10.1186/s40621-018-0149-8. [PubMed: 29629480]
32. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care. 1998;36(1):8–27. Epub 1998/02/07. doi: 10.1097/00005650-199801000-00004. [PubMed: 9431328]
33. Stagg V. ELIXHAUSER: Stata module to calculate Elixhauser index of comorbidity. Statistical Software Components S458077: Boston College Department of Economics; 2015.
34. Moore BJ, White S, Washington R, Coenen N, Elixhauser A. Identifying Increased Risk of Readmission and In-hospital Mortality Using Hospital Administrative Data: The AHRQ Elixhauser Comorbidity Index. Med Care. 2017;55(7):698–705. Epub 2017/05/13. doi: 10.1097/mlr.0000000000000735. [PubMed: 28498196]
35. Bukur M, Teurel C, Catino J, Kurek S. The Price of Always Saying Yes: A Cost Analysis of Secondary Overtriage to an Urban Level I Trauma Center. Am Surg. 2018;84(8):1368–75. [PubMed: 30185318]
36. Newgard CD, Hsia RY, Mann NC, Schmidt T, Sahni R, Bulger EM, et al. The trade-offs in field trauma triage: a multiregion assessment of accuracy metrics and volume shifts associated with different triage strategies. J Trauma Acute Care Surg. 2013;74(5):1298–306; discussion 306. doi: 10.1097/TA.0b013e31828b7848. [PubMed: 23609282]
37. Lehmann R, Brounts L, Lesperance K, Eckert M, Casey L, Beekley A, et al. A Simplified Set of Trauma Triage Criteria to Safely Reduce Overtriage: A Prospective Study. Archives of Surgery. 2009;144(9):853–8. doi: 10.1001/archsurg.2009.153. [PubMed: 19797111]

38. Mann NC, Mackenzie E, Teitelbaum SD, Wright D, Anderson C. Trauma system structure and viability in the current healthcare environment: a state-by-state assessment. J Trauma. 2005;58(1):136–47. Epub 2005/01/28. doi: 10.1097/01.ta.0000151181.44658.0a. [PubMed: 15674164]
39. National Highway Traffic Safety Administration. Trauma System Agenda for the Future. 2002.
40. Institute of Medicine. Hospital-Based Emergency Care: At the Breaking Point. Washington, DC: National Academies Press; 2007. 424 p.
41. Choi J, Carlos G, Nassar AK, Knowlton LM, Spain DA. The Impact of Trauma Systems on Patient Outcomes. Curr Probl Surg. 2021;58(1):100849-. Epub 2020/06/10. doi: 10.1016/j.cpsurg.2020.100849. [PubMed: 33431134]
42. State of Alabama Department of Public Health. Chapter 420–2-2: Alabama Statewide Trauma System. 2009.
43. American College of Surgeons Committee on Trauma, Trauma Systems Evaluation and Planning Committee. Trauma System Consultation Report, State of Florida. 2013.
44. California Emergency Medical Services Authority, State Trauma Advisory Committee. California Statewide Trauma System Planning: Recommendations of the State Trauma Advisory Committee. 2017.
45. Bureau of EMS, Trauma and Preparedness, Michigan Department of Health and Human Services. Michigan Trauma System: Strategic Plan 2018–2023. 2019.
46. Lin S, Johnson C, Opelka F, Liepert A. Trauma system funding: implications for the surgeon health policy advocate. Trauma Surg Acute Care Open. 2020;5(1):e000615. Epub 2020/12/12. doi: 10.1136/tsaco-2020-000615. [PubMed: 33305009]
47. Furmanchuk A, Rydland KJ, Hsia RY, Mackersie RC, Shi M, Hauser MW, et al. Geographic Disparities in Re-triage Destinations Among Seriously Injured Californians. Annals of Surgery Open. In Press.
48. Romano PS, Mark DH. Bias in the coding of hospital discharge data and its implications for quality assessment. Med Care. 1994;32(1):81–90. [PubMed: 8277803]
49. Web-Based Injury Statistics Query and Reporting System (WISQARS) [Internet]. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. 2019. Available from: https://www.cdc.gov/injury/wisqars/index.html.
50. Kwon AM, Garbett NC, Kloecker GH. Pooled preventable death rates in trauma patients : Meta analysis and systematic review since 1990. Eur J Trauma Emerg Surg. 2014;40(3):279–85. Epub 2014/06/01. doi: 10.1007/s00068-013-0364-5. [PubMed: 26816061]
51. Broderick CT, Slocum JD, Visenio M, David Jelke D, Albanese J, Voights MB, et al. Characterizing Re-Triage Guidelines: A Scoping Review of States' Rules and Regulations. In Submission.

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HIGHLIGHTS

- Severely injured patients in states with trauma funding are more broadly distributed across the trauma system and more frequently re-triaged.
- Patients in states with trauma funding had 0.71 lower adjusted odds of in-hospital mortality.
- Patients who were optimally re-triaged in states with trauma funding had 0.67 lower adjusted odds of in-hospital mortality.
- Re-triage amplified the association between state trauma funding and in-hospital mortality.

Table 1:

Frequencies of Patient and Hospital Covariates by Trauma Funding Status

	Trauma Funding Status[a]		
	Without Trauma Funding (N=99071)	**With Trauma Funding (N=142685)**	**p-value**
Age (yrs)			0.0570[d]
<18	12019 (12.1%)	15561 (10.9%)	
18–36	22689 (22.9%)	34014 (23.8%)	
37–57	22054 (22.3%)	32025 (22.4%)	
58–75	20010 (20.2%)	29796 (20.9%)	
>75	22299 (22.5%)	31289 (21.9%)	
Sex			0.6976[d]
Male	56283 (56.8%)	81174 (56.9%)	
Female	42788 (43.2%)	61511 (43.1%)	
Race			<0.0001[e]
White	61096 (61.7%)	93819 (65.8%)	
Black	13438 (13.6%)	26668 (18.7%)	
Hispanic	11541 (11.7%)	16223 (11.4%)	
Asian or Pacific Islander	3270 (3.3%)	1361 (1.0%)	
Native American	244 (0.3%)	599 (0.4%)	
Other	9028 (9.1%)	2551 (1.8%)	
Missing	454 (0.5%)	1464 (1.0%)	
Primary Payer			<0.0001[e]
Medicare	32604 (32.9%)	48706 (34.1%)	
Medicaid	23165 (23.4%)	26615 (18.7%)	
Private Insurance	30753 (31.0%)	41385 (29.0%)	
Self-pay	5851 (5.9%)	15257 (10.7%)	
No Charge	180 (0.2%)	1501 (1.1%)	
Other	6466 (6.5%)	9135 (6.4%)	
Missing	52 (0.1%)	86 (0.1%)	
Injury Severity Score			<0.0001[d]
16–20	61934 (62.5%)	87176 (61.1%)	
21–25	23233 (23.5%)	32094 (22.5%)	
>25	13904 (14.0%)	23415 (16.4%)	
Elixhauser Comorbidity Index			<0.0001[f]
Mean (SD)	1.3 (1.81)	1.5 (1.91)	
Trauma Center Level Designation [b]			<0.0001[d]
Level I	41350 (41.7%)	28567 (20.0%)	
Level II	13741 (13.9%)	29667 (20.8%)	
Level III, IV, Non-Trauma Center[c]	40670 (41.1%)	77049 (54.0%)	

	Trauma Funding Status[a]		
	Without Trauma Funding (N=99071)	**With Trauma Funding (N=142685)**	**p-value**
Missing	3310 (3.3%)	7402 (5.2%)	
Bed Size (beds) [b]			<0.0001[d]
<100	6793 (6.9%)	16285 (11.4%)	
100–199	13146 (13.3%)	22468 (15.8%)	
200–299	14361 (14.5%)	24434 (17.1%)	
300–399	10227 (10.3%)	23302 (16.3%)	
400–499	9845 (9.9%)	13517 (9.5%)	
≥500	44512 (44.9%)	40520 (28.4%)	
Missing	187 (0.2%)	2159 (1.5%)	
Medical School Affiliationb			<0.0001[d]
Yes	73105 (73.8%)	72450 (50.8%)	
No	25779 (26.0%)	68076 (47.7%)	
Missing	187 (0.2%)	2159 (1.5%)	

[a.] Trauma Funding Status was determined by the absence ($0.00) or presence (>$0.00) of per capita state trauma funding in the state that the patient was hospitalized in.

[b.] Defined by the first hospital at which patients received care.

[c.] These levels were grouped together due to state variations in characterization of Trauma Center Level Designation (FL reports Level I, II, and Non-Trauma designations; MA, MD, and NY report Level I, II, III, and Non-Trauma designations; WI reports Level I, II, III, IV, and Non-Trauma designations).

[d.] P-value obtained using a chi-square test for linear trend employing the chi-square correlation statistic. Missing values were excluded when applying this test.

[e.] P-value obtained using a Pearson’s chi-square test. Missing values were excluded when applying this test.

[f.] P-value obtained using a two-sample t-test assuming unequal variances using Satterthwaite degrees of freedom.

Table 2.

Frequencies of Re-triage Status by Trauma Funding Status

	Trauma Funding Status[a]		
	Without Trauma Funding (N=99071)	**With Trauma Funding (N=142685)**	**p-value**
Re-Triage Status			
Field Triage	**94010 (94.9%)**	**129570 (90.8%)**	**<0.0001** [f]
Appropriate Triage[b]	54694 (58.2%)	57698 (44.5%)	
Under-Triage[c]	39316 (41.8%)	71872 (55.5%)	
Re-Triage	**1806 (1.8%)**	**5301 (3.7%)**	**<0.0001** [f]
Optimal[d]	1666 (92.3%)	4055 (76.5%)	
Sub-optimal[e]	140 (7.8%)	1246 (23.5%)	
Other	**3255 (3.3%)**	**7814 (5.5%)**	

[a.] Trauma Funding Status was determined by the absence ($0.00) or presence (>$0.00) of per capita state trauma funding in the state that the patient was hospitalized in.

[b.] Patients presenting to an emergency department at or directly admitted to a Level I or II trauma center, with no subsequent transfer, were defined as Appropriate Triage on the field.

[c.] Patients presenting to an emergency department at or directly admitted to a Level III, IV, or non-trauma center, with no subsequent transfer, were defined as Under-Triage on the field.

[d.] Patients emergently transferred from any emergency department to a Level I or II trauma center were defined as Optimal Re-Triage.

[e.] Patients emergently transferred from any emergency department to a Level III, IV, or non-trauma center were defined as Sub-optimal Re-Triage.

[f.] P-value obtained using a Pearson’s chi-square test.

Table 3.

Unadjusted In-Hospital Mortality by Trauma Funding Status

	Trauma Funding Status[a]		
	Without Trauma Funding (N=99071)	**With Trauma Funding (N=142685)**	**p-value**
All Patients	3293 (3.3%)	4820 (3.4%)	0.4806[f]
Re-triage Status			<0.0001[f]
Field Triage			
Appropriate Triage[b]	2540 (4.6%)	2995 (5.2%)	
Under-Triage[c]	595 (1.5%)	1195 (1.7%)	
Re-Triage			
Optimal[d]	105 (6.3%)	189 (4.7%)	
Sub-optimal[e]	13 (9.3%)	60 (4.8%)	
Other	40 (1.2%)	381 (4.9%)	
Homogeneity of ORs Across Trauma Funding Status Groups			0.0009[g]

a. Trauma Funding Status was determined by the absence ($0.00) or presence (>$0.00) of per capita state trauma funding in the state that the patient was hospitalized in.

b. Patients presenting to an emergency department at or directly admitted to a Level I or II trauma center, with no subsequent transfer, were defined as Appropriate Triage on the field.

c. Patients presenting to an emergency department at or directly admitted to a Level III, IV, or non-trauma center, with no subsequent transfer, were defined as Under-Triage on the field.

d. Patients emergently transferred from any emergency department to a Level I or II trauma center were defined as Optimal Re-Triage.

e. Patients emergently transferred from any emergency department to a Level III, IV, or non-trauma center were defined as Sub-optimal Re-Triage.

f. P-value testing the association between total mortality and trauma funding status obtained using a Pearson's chi-square test.

g. P-value testing for the homogeneity of odds ratios between funding status groups via a test of a three-way interaction between trauma funding status, re-triage status, and mortality. The Other group was excluded when performing this test.

Table 4.

Adjusted Odds of In-Hospital Mortality

	Odds Ratio[a]	95% CI
Trauma Funding Status [b]		
Without Trauma Funding	Reference	
With Trauma Funding	0.73	0.60–0.89
Re-triage Status		
Field Triage; Appropriate[c]	Reference	
Field Triage; Under-Triage[d]	0.48	0.42–0.54
Optimal Re-Triage[e]	1.30	1.09–1.54
Sub-optimal Re-Triage[f]	1.90	1.33–2.70
Age (yrs)		
<18	0.64	0.55–0.75
18–36	Reference	
37–57	0.94	0.86–1.02
58–75	1.48	1.35–1.61
>75	2.75	2.49–3.04
Sex		
Female	0.61	0.58–0.64
Race		
White	Reference	
Black	1.21	1.12–130
Hispanic	0.81	0.73–0.90
Asian or Pacific Islander	0.99	0.83–1.19
Native American	1.06	0.66–1.71
Other	1.32	1.18–1.48
Primary Payer		
Private Insurance	Reference	
Medicaid	1.04	0.95–1.13
Medicare	1.18	1.09–1.27
Self-pay	2.05	1.86–2.27
No Charge	0.85	0.59–1.23
Other	0.86	0.75–0.98
Injury Severity Score (ISS)		
16–20	Reference	
21–25	3.19	3.00–3.40
>25	5.24	4.93–5.57
Elixhauser Comorbidity Index		
For each +1 comorbidity	1.25	1.24–1.27
Bed Size [g]		
<100 beds	Reference	

	Odds Ratio[a]	95% CI
100–199 beds	1.20	0.99–1.46
200–299 beds	1.52	1.25–1.84
300–399 beds	1.59	1.28–1.97
400–499 beds	1.70	1.33–2.18
≥500 beds	1.72	1.36–2.17
Medical School Affiliation [g]		
Yes	0.88	0.77–1.01

[a.] Values were obtained from a hierarchical logistic regression model with in-hospital mortality as the outcome. Age, sex, race, primary payer, Injury Severity Score, Elixhauser Comorbidity Index, hospital bed size, hospital medical school affiliation, trauma funding status, re-triage status, and a re-triage status by funding status interaction term are included as fixed effects. An intercept defined by hospital ID was used as the sole random effect. .

[b.] Trauma Funding Status was determined by the absence ($0.00) or presence (>$0.00) of per capita state trauma funding in the state that the patient was hospitalized in.

[c.] Patients presenting to an emergency department at or directly admitted to a Level I or II trauma center, with no subsequent transfer, were defined as Appropriate Triage on the field.

[d.] Patients presenting to an emergency department at or directly admitted to a Level III, IV, or non-trauma center, with no subsequent transfer, were defined as Under-Triage on the field.

[e.] Patients emergently transferred from any emergency department to a Level I or II trauma center were defined as Optimal Re-Triage.

[f.] Patients emergently transferred from any emergency department to a Level III, IV, or non-trauma center were defined as Sub-optimal Re-Triage.

[g.] Defined by the first hospital at which patients received care.

Table 5.

Adjusted Odds of In-Hospital Mortality with Trauma Funding Status and Re-triage status Interaction

	Re-triage status					Re-triage status × Trauma Funding Status Interaction Term p-value
	Field Triage; Appropriate[a]	Field Triage; Under-Triage[b]	Optimal Re-triage[c]	Sub-optimal Re-triage[d]	All Patients	
	Odds Ratio (CI)[e]	Odds Ratio (CI)[e]	Odds Ratio (CI)[e]	Odds Ratio (CI)[e]	Odds Ratio (CI)[e]	
Trauma Funding Status [f]						0.0374
Without Trauma Funding	Reference	Reference	Reference	Reference	Reference	
With Trauma Funding	0.98 (0.82–1.17)	0.90 (0.77–1.05)	0.70 (0.53–0.92)	0.46 (0.23–0.89)	0.73 (0.60–0.89)	

a. Patients presenting to an emergency department at or directly admitted to a Level I or II trauma center, with no subsequent transfer, were defined as Appropriate Triage on the field.

b. Patients presenting to an emergency department at or directly admitted to a Level III, IV, or non-trauma center, with no subsequent transfer, were defined as Under-Triage on the field.

c. Patients emergently transferred from any emergency department to a Level I or II trauma center were defined as Optimal Re-Triage.

d. Patients emergently transferred from any emergency department to a Level III, IV, or non-trauma center were defined as Sub-optimal Re-Triage.

e. Values were obtained from a hierarchical logistic regression model with in-hospital mortality as the outcome. Age, sex, race, primary payer, Injury Severity Score, Elixhauser Comorbidity Index, hospital bed size, hospital medical school affiliation, trauma funding status, re-triage status, and a re-triage status by funding status interaction term are included as fixed effects. An intercept defined by hospital ID was used as the sole random effect.

f. Trauma Funding Status was determined by the absence ($0.00) or presence (>$0.00) of per capita state trauma funding in the state that the patient was hospitalized in.