HHS Public Access

Author manuscript

Ann Surg. Author manuscript; available in PMC 2023 February 01.

Published in final edited form as:

Ann Surg. 2022 February 01; 275(2): 406–413. doi:10.1097/SLA.0000000000005258.

Extending Trauma Quality Improvement Beyond Trauma Centers: Hospital Variation in Outcomes Among Non-Trauma Hospitals

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Abstract

Objective: The American College of Surgeons (ACS) conducts a robust quality improvement program for ACS-verified trauma centers, yet many injured patients receive care at non-accredited facilities. This study tested for variation in outcomes across non-trauma hospitals and characterized hospitals associated with increased mortality.

Summary Background Data: The study included state trauma registry data of 37,670 patients treated between January 1, 2013, and December 31, 2015. Clinical data were supplemented with data from the American Hospital Association and U.S. Department of Agriculture, allowing comparisons among 100 non-trauma hospitals.

Methods: Using Bayesian techniques, risk-adjusted and reliability-adjusted rates of mortality and interfacility transfer, as well as Emergency Departments length-of-stay (ED-LOS) among patients transferred from EDs were calculated for each hospital. Subgroup analyses were performed for patients ages >55 years and those with decreased Glasgow coma scores (GCS). Multiple imputation was used to address missing data.

Results: Mortality varied 3-fold (0.9% - 3.1%); interfacility transfer rates varied 46-fold (2.1% - 95.6%); and mean ED-LOS varied 3-fold (81 - 231 minutes). Hospitals that were high and low statistical outliers were identified for each outcome, and subgroup analyses demonstrated comparable hospital variation. Metropolitan hospitals were associated increased mortality (OR

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1.7, $P = 0.004$), decreased likelihood of interfacility transfer (OR 0.7, $P = <.001$), and increased ED-LOS (coef. 0.1, $P = <.001$) when compared with non-metropolitan hospitals and risk adjusted.

Conclusions: Wide variation in trauma outcomes exist across non-trauma hospitals. Efforts to improve trauma quality should include engagement of non-trauma hospitals to reduce variation in outcomes of injured patients treated at those facilities.

Mini-abstract

Wide variation exists in risk-adjusted and reliability-adjusted outcomes – including mortality, interfacility transfer rates, and ED length-of-stay –across non-trauma hospitals that treat injured patients with hospitals that are high and low statistical outliers. Efforts to advance trauma quality should include the engagement of non-trauma hospitals to reduce variation at these facilities.

INTRODUCTION

Traumatic injuries are a leading cause of death and disability.(1–3) In order to improve the quality of care and outcomes of injured patients, the American College of Surgeons Committee on Trauma (ACS-COT) developed the American College of Surgeons Trauma Quality Improvement Program (ACS TQIP).(4, 5) ACS TQIP collects data from all ACS-COT verified level I and level II trauma centers and provides risk-adjusted outcome reports, benchmarked against national averages.(6) The reports have been a fundamental component of the program, as ACS TQIP hospitals have used them to identify at-risk populations and guide their hospital-specific quality improvement initiatives.(7) These measures, particularly when implemented as part of a regional collaborative quality initiative infrastructure, have been associated with significant improvements in trauma patient outcomes compared with national benchmarks, yet the ACS TQIP includes only a fraction of U.S. hospitals that treat injured patients.(8)

Trauma center status has benefitted those patients treated at hospitals that have been verified as trauma centers by the ACS-COT.(9) However, a substantial number of trauma patients (including many who are severely injured) receive their care at hospitals that lack trauma center verification and/or designation, so-called “non-trauma hospitals.”(10–12) States with organized trauma systems and trauma designation programs have generally either adopted triage and transfer guidelines recommended by the Centers for Disease Control and Prevention (CDC) or developed their own.(13–16) These guidelines direct providers at non-trauma hospitals to identify patients with potentially life-threatening injuries and transfer them to trauma centers, yet no formal program exists to evaluate compliance with those guidelines, assess the outcomes of injured patients, and promote best practices at non-trauma hospitals. As with ACS TQIP, such a quality improvement program for non-trauma hospitals would rely on demonstrable variation in clinical outcomes between facilities to guide hospital-based quality improvement initiatives.

We postulate that significant variation in the outcomes of injured patients exists among non-trauma hospitals at which they are initially treated. To test this hypothesis and provide information critical to the development of a quality improvement program for those hospitals, we performed a statewide analysis of trauma mortality and interfacility transport

patterns to inform the efforts of non-trauma hospitals to rapidly identify critically injured patients and potentially triage them to more appropriate levels of care.

METHODS

Data Source and Study Population

We used trauma registry data of the Indiana State Department of Health (ISDH), 2013 through 2015. In Indiana, all hospitals that treat patients with diagnoses encoded as injury and poisoning are required to submit data in compliance with state rule 410 IAC 34 of the ISDH Trauma Care Committee.(17) The registry is inclusive, since the rule applies to both trauma centers and non-trauma hospitals, and it consists of all data fields of the National Trauma Data Standards set by the ACS COT.(17, 18) During the study period, all diagnoses were encoded using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, because ICD-10-CM codes were not included until 2016.(16) To maintain the trauma registry, hospital personnel collect detailed prehospital, emergency department, operative, intensive care, and hospital data for all patients with diagnoses encoded as injury and poisoning (800-999) using the ICD-9-CM. (16) ISDH provided these data in an encrypted fashion to ensure compliance with the Health Insurance Portability and Accountability Act.

We supplemented the data from the trauma registry with hospital-level data – number of hospital beds, teaching status, and profit status – obtained from the American Hospital Association (AHA) by linking the datasets using the name of each hospital identified in both datasets.(19) For hospitals that lacked AHA data, ISDH conducted a hospital survey to acquire that information directly.

To measure the influence of hospital location on patient outcomes, we coded each hospital with its county-level urban influence code (UIC).(20) The UIC was developed by the U.S. Department of Agriculture to characterize counties according to population density and “metro influence.” The score ranges from one to twelve, with lower scores signifying urban areas (described as “metropolitan”) and higher scores indicating suburban and rural areas. These data are publicly available and were last updated in 2013. Given that 75% of study cohort was treated in metropolitan hospitals (UIC <3), we used the UIC to create a dichotomous variable (metropolitan/non-metropolitan) and included it in the mortality model.

The study cohort consisted of all patients (age ≥16 years) treated at non-trauma hospitals. We excluded patients transferred from referring hospitals (N=1,233, 3.2%), so the study cohort only consisted of admissions directly to the ED following arrival from the scene of injury. Given that providers at non-trauma hospitals may not know the full extent of injuries when they determine whether or not to transfer a patient to a trauma center, we included all patients in the Indiana trauma registry in the study rather than selecting or excluding patients based on specific types of injury.

In Indiana, all trauma centers require ACS verification.(21) To account for changes in ACS trauma verification levels during the study period, we classified the trauma levels of

hospitals to which patients were admitted according to the dates when those changes in verification level occurred. This method of accounting for changes in trauma verification level is consistent with the state triage and transport rules which state that hospitals are classified as “trauma centers” on the dates when they begin to pursue trauma center verification or become “in-process.”(17) We also excluded patients who presented to emergency departments without signs of life, defined as an initial systolic blood pressure of 0 mmHg, heart rate of 0 beats/min, and Glasgow Coma Scale motor score of 1.(22) A summary of the cohort selection following STROBE criteria is shown in eFigure 1 in the Supplement.

Primary Outcomes

We examined hospital variation in three outcomes: in-hospital mortality (primary), interfacility transfer, and emergency department length-of-stay (ED-LOS). We defined mortality as patients who had either a hospital or ED discharge disposition of “Deceased/Expired” or were discharged to hospice care.(23, 24) We examined the two secondary outcomes, transfer and ED-LOS, because ISDH has identified the rapid transfer of critically injured patients (defined by state triage and transfer criteria) to trauma centers as a priority for the statewide trauma system.(9, 25, 26) We excluded patients who died from analyses of interfacility transfer, and we limited our analyses of ED-LOS to those patients who underwent transfer directly from EDs to assess how quickly the transfer processes at those hospitals occurred. Thus, we sought to avoid confounding introduced by patients who were admitted to non-trauma hospitals and transferred afterwards, so ICU-to-ICU transfers, for example, were excluded.

Analysis

The main purpose of this study was to determine whether significant variation in clinical outcomes existed among hospitals. Our primary exposure variable was risk-adjusted and reliability-adjusted mortality, assessed at the hospital level. To model mortality, we used a standardized risk-adjustment model for trauma, which has been well described and validated previously.(6) Specifically, we included the following patient-level covariates to perform risk-adjustment: Injury Severity Score (ISS), Glasgow coma scale (GCS), age, gender, race, initial systolic blood pressure (SBP) and pulse rate in the emergency department, mechanism of injury, payer type, and the Elixhauser comorbidity index (ECI). Additionally, we included the following hospital-level covariates: number of general hospital beds, teaching status, metropolitan status (defined by the UIC), profit status, and annual trauma volume. ACS TQIP uses similar variables, except the ECI, annual trauma volume, metropolitan status, to perform risk-adjustment when assessing mortality at trauma centers.(6) We elected to use the ECI rather than including comorbidities as separate variables in order to maintain statistical parsimony, given the low number of trauma admissions in non-trauma hospitals relative to trauma centers.

To address missing values, we performed multiple imputation using chained equation algorithm (20 iterations) to reduce bias and preserve study power.(27) We evaluated the results of imputation by examining trace plots of the imputed values (means and standard deviations) and found no evidence of violation of convergence. A summary of missing

variables is available in eTable 1 in the Supplement. Our final model included 15 variables, with a C statistic for mortality of 0.87 using multivariable logistic regression.

Since the trauma volume at each hospital varied and may have contributed to random "noise" in the observed rates of mortality, we also applied a Bayes technique for reliability adjustment. This approach has been previously described and applied in comparing hospital outcomes.(28–32) Briefly, the approach uses mixed effects, hierarchical modeling to "shrink" lower-volume hospitals toward the overall hospital mean in proportion to the strength of the hospitals' statistical signal (i.e., trauma volume). Thus, the final mortality rates used to rank hospitals were based on risk-adjusted and reliability-adjusted outcomes, making the ranking a conservative estimate of variation across the centers.

Using the model described above, we examined hospital rates of interfacility transfer and ED-LOS among the subset of patients transferred from the ED. Continuous data for ED-LOS exhibited a right- skewed distribution, so we performed natural log transformation of that data, then performed multivariable linear regression. We excluded 2% (N=788) of the study cohort from the ED-LOS analysis, either because they lacked data for ED-LOS (N=731); it was entered as a negative value (N=29); or the values were statistical outliers (N=28), which likely represented a data entry error. Upon completion of the analysis of ED-LOS, we exponentiated the log transformed values to determine the adjusted mean ED-LOS of each hospital and the overall cohort mean.

We generated caterpillar-style plots to compare hospital outcomes. These figures show ranked, adjusted rates for each hospital. We used significance levels of 95%, and confidence intervals (CIs) for hospital-level outcomes that did not overlap the overall collaborative average indicated statistically significant differences, whereas CIs that overlapped provided insufficient statistical evidence of a difference.

We performed subgroup analyses of two cohorts, patients who were age >55 years and patients with trauma brain injuries, evidenced by an initial Glasgow coma scale (GCS) <14. We selected those cohorts, because ISDH prioritizes their transfer to designated trauma centers in the Indiana Trauma Transfer Guidelines based on CDC recommendations. (13, 26) Furthermore, existing literature suggests that patients with a decreased GCS are particularly likely to experience a survival benefit, once transferred to a trauma center. (33) We performed the analyses detailed above with each subgroup for all three clinical outcomes. Finally, we tabulated the hospital discharge disposition of the overall cohort to quantify the number of patients who are discharged with on-going medical needs such as inpatient rehabilitation services.

All two-sided hypotheses were tested at 0.05 level of significance. Statistical analyses were completed with Stata software, version 15 (StataCorp), and the study was approved by the Indiana University Institutional Review Board.

RESULTS

The study included 37,670 trauma patients, and they were predominantly white, female, and had blunt injuries (e.g., falls and motor vehicle collisions) (Table 1). Of those patients,

66% were age >55 years, and 4% presented with an initial GCS <14. The majority of patients were treated at metropolitan, non-profit, teaching hospitals. Analyses of mortality and interfacility transfer among the overall cohort included 100 facilities, the majority of which were small (<50 general hospital beds), metropolitan, non-teaching, and non-profit (Table 2). The analysis of ED-LOS in that cohort included 10,065 patients transferred from 93 facilities. Subgroup analyses of patients age >55 years included patients treated at 98 hospitals, and the analysis of ED-LOS of included 92 facilities. Mortality and interfacility transfer analyses of patients with an initial GCS <14 included 81 hospitals, and the ED-LOS analysis included 74 hospitals.

Regarding study outcomes, overall in-hospital mortality was 2.3%, 31% of patients underwent interfacility transfer, and the median ED-LOS of patients transferred from the ED was 175 min. (IQR 115-246). When evaluating patients age >55 years, their mortality (2.9%) was greater than that of younger patients (1.0%) (OR 3.3, P=<.001); they had lower transfer rates (23.9% v. 45.2%) (OR 0.7, P = <.001); and if they were transferred to another facility, they had a greater median ED-LOS (196 min. v. 153 min.) (coef. 0.05, P = <.001). The mortality of patients with an initial GCS <14 was greater than that of patients with an initial GCS ≥14 (14.6% v. 1.6%) (OR 5.4, P = <.001); they were more likely to undergo transfer (48.3% v. 28.4%) (OR 1.1, P = 0.02); and if they transferred, their median ED-LOS was significantly lower (111 min. v. 178 min.) (coef. −0.36, P = .001).

We found wide variation among hospitals for all risk-adjusted and reliability-adjusted outcomes in the overall cohort, with statistically significant high and low outliers (Table 3). Mortality varied 3-fold across hospitals, ranging from 0.9% to 3.1% (Figure 1). Interfacility transfer rates ranged from 2.1% to 95.6%, a 46-fold difference (Figure 2), and ED-LOS varied 3-fold, with mean ED-LOSs ranging from 81 min. to 232 min. (Figure 3). Similarly, when examining the outcomes of the two high-risk cohorts, we found considerable hospital variation (Table 3). For patients age >55 years, mortality ranged from 1.3% to 4.1%, a 3-fold difference; transfer rates ranged from 1.2% to 92.4%; and mean ED-LOS varied from 117 min. to 229 min., a 2-fold difference. The hospital mortality of patients with an initial GCS <14 varied 5-fold, ranging from 5.5% to 24.8%. Transfer rates ranged from 19.3% to 81.0%, a 4-fold variation, and mean ED-LOS varied from 65 min. to 169 min., a 3-fold difference.

We identified multiple hospital characteristics associated with variation in outcomes. Notably, hospitals located in metropolitan areas had significantly increased mortality (OR 1.7, P = <.001), decreased likelihood of transfer (OR 0.7, P = <.001), and greater ED-LOSs (coef. 0.1, P = <.001) compared with non-metropolitan hospitals. Similarly, teaching hospitals were associated with increased mortality (OR 1.43, P = 0.001) and decreased likelihood of transfer (OR 0.85, P = <.001) than non-teaching hospitals. Larger hospitals (measured by number of general hospital beds) were associated with decreased transfers (OR 0.997, P = <.001) and increased ED-LOSs of transfer patients (Coef. 0.001, P = <.001). Increases in annual trauma volume were associated with increased mortality (OR 1.001, P = 0.02) and decreased transfer rates (OR 0.996, P <.001). The association between hospital characteristics and outcomes is summarized in eTables 2–4 of the Supplement for the overall study cohort as well as both high-risk subgroups.

We also identified several patient-level characteristics associated with the study outcomes. As one may expect, increases in ISS and initial heart rate and decreases in initial systolic blood pressure and GCS were all associated with increased mortality (P = <.001) and increased likelihood of transfer (P = <.05). However, of those variables, only GCS was associated with changes in ED-LOS among transfer patients; specifically, increases in GCS were associated with increases in ED-LOS (Coef. 0.044, P = <.001). Increases in both patient age and burden of comorbidities were associated with increased mortality (P = <.001) and increased ED-LOS among transfer patients (P = <0.05). Notably, when compared with males, females had decreased mortality (OR 0.67, P = <.001) despite a decreased likelihood of transfer (OR 0.73, P = <.05) and increased ED-LOS (Coef. 0.099, P = <.001). Also, of note, no significant differences in mortality and ED-LOS were noted between white and black patients, but black patients were less likely to undergo transfer (OR 0.78, P = <.001). The association between patient characteristics and outcomes is summarized in eTables 2–4 of the Supplement for the overall study cohort as well as both high-risk subgroups.

A total of 37,581 patients had documented hospital discharge dispositions, whereas the remaining patients only had ED discharge dispositions. Of the patients with hospital discharge dispositions, a substantial number had ongoing medical needs after discharge; 6.5% were discharged to inpatient rehabilitation or a long-term facility and 4.2% were discharge home with home health services. A summary of hospital discharge dispositions is provided in eTable 5 of the Supplement.

DISCUSSION

Our study presents four principle findings that advance our understanding of the processes and safety of trauma care at hospitals that lack a trauma center designation. First, there was widespread variation in risk-adjusted and reliability-adjusted mortality among non-trauma hospitals – up to 3-fold between top and bottom performers – across the studied facilities. Second, we found dramatic variation in hospital rates of interfacility transfer (46-fold), a routine practice essential to ensuring that the needs of injured patients are matched by the resources and capabilities of the institutions at which they receive their care. Third, among patients who underwent interfacility transfer from the ED, ED-LOS varied 3-fold, a finding that has clear implications for the timeliness of those patients to receive definitive care. Fourth, we identified two high-risk patient populations treated at non-trauma hospitals, patients age >55 years and those with an initial GCS <14, and we identified similar variations across hospitals in outcomes of those cohorts. Most notably, among patients with an initial GCS <14, hospital mortality varied 5-fold, ranging from 5.5% to 24.8%.

Non-trauma hospitals are ubiquitous, and they are integral to current US trauma systems. Yet a paucity of evidence exists regarding their clinical outcomes. Trauma mortality at these hospitals is generally thought to be low, which our study confirmed (1.7%), because providers presumably identify patients whose needs exceed local resources and rapidly transfer those patients to a higher level of care. However, we found that non-trauma hospitals are not uniformly meeting the needs of at-risk, injured patients. Some of the variation in transfer rates may be attributable to differences in the resources across hospitals, such as

availability of blood products, staffing, training, and expertise; but the variations in mortality and the ED-LOS of transfer patients suggest that gaps may also exist in the quality of care.

To examine hospital compliance with Indiana Trauma and Triage Guidelines, which are based on CDC guidelines, we performed analyses of two subgroups presumed to be high-risk (patients ages > 55 years and patients with an initial GCS <14) and should be considered for transfer to a designated trauma center, according to those guidelines. We verified that they, indeed, had significantly increased mortality relative to patients ages ≤55 years and patients with an initial GCS ≥ 14, respectively (P=<.05). Yet we found that inter-facility transfer of those patients occurred infrequently (Table 3). For example, only 48% of patients with an initial GCS < 14 (often indicative of a traumatic brain injury) transferred to a trauma center, and their mortality at non-trauma hospitals was 13%. These findings suggest that a large proportion of those high-risk patients did not receive treatment at facilities with dedicated neurosurgical capabilities, since exceedingly few non-trauma hospitals have those resources. For those patients, hospital mortality varied 5-fold; transfer rates varied 4-fold; and timeliness of transfer (ED-LOS) varied 3-fold. Those levels of variation are highly indicative of the presence of substantial opportunities to improve the clinical care of those at-risk patients.

Prior studies have examined geographic proximity to trauma centers, which are generally located in metropolitan centers, as a potential barrier to access to trauma care.(34–37) However, this study found that patients treated at metropolitan hospitals had lower rates of interfacility transfer; were transferred less rapidly; and had increased mortality when compared with those treated at non-metropolitan (i.e., rural and suburban) facilities. These findings add to existing literature that suggests that geographic distance alone does not explain access to care at trauma centers or necessarily result in improved outcomes.(38) Moreover, we found that increased annual trauma volume was associate increased mortality and decreased transfer rates. Further research is needed to identify potential institutional and culture barriers to optimal care within an organized trauma system.

This study has substantial implications for both practice and policy to improve the safety of trauma care at non-trauma hospitals. The ability to provide risk-adjusted hospitals performance measures is an essential component of a learning health care system, as defined by the Institute of Medicine.(39) ACS TQIP, for example, has employed such performance measures to great effect, however, no formal program currently exists to advance trauma quality at non-trauma hospitals. The National Academies of Science, Engineering, and Medicine identify the use of existing data resources across the spectrum of trauma care (which includes non-trauma hospitals) as a national priority, and the effective use of such resources is critical to the reduction of preventable deaths secondary to traumatic injuries.(40, 41) Through this study, we demonstrate that the resources and infrastructure currently exist, at least at the state-level, to generate risk-adjusted performance measures of trauma outcomes at non-trauma hospitals.

Using similar hospital performance reports, other regionalized CQI programs have achieved improved patient outcomes and reduced healthcare costs by working to close gaps in quality of care.(8, 42) Although the cohort of hospitals represented in this study may differ from

those that typically engage in CQI, such as accredited trauma centers and bariatric centers of excellence, the inclusion of non-trauma hospitals in CQI would represent a meaningful expansion of the current trauma system.

Clearly, the challenges to trauma care and the needs of non-trauma hospitals differ from those of accredited trauma centers, so the design of a CQI program for non-trauma hospitals may differ in structure from programs such as ACS TQIP. Further study is needed to define "quality of trauma care" from the perspective of stakeholders at non-trauma hospitals to ensure that a CQI program for those hospitals provides meaningful feedback to address their needs. Outcomes at non-trauma centers are likely to reflect the complexity of trauma care as it exists in the community. For example, the increased ED-LOS of transfer patients may be attributable to delays that occur within a hospital, a lack of transport availability, or some combination of both factors. Through the use of risk-adjusted hospital performance reports, we have the opportunity to address these complex challenges by engaging with stakeholders at non-trauma hospitals to examine the structures and practices of hospitals identified as low and high outliers.

In addition to assisting with the planning and design of CQI, representatives of non-trauma hospitals are needed to participate in establishing standards for outcomes such as interfacility transfer and ED-LOS. Given the diversity of resources and capabilities among non-trauma hospitals, it is unclear what an ideal transfer rate should be for any particular hospital. The evidence of widespread hospital variation presented in this study represents an opportunity for policymakers and hospitals stakeholders to collaborate to critically evaluate outcomes and establish evidence-based standards of practice. When evaluating the practice of inter-facility transfer, in particular, those standards should incorporate existing data regarding which patients benefit from transfer, once they arrive at a given trauma center.(33) Conversely, further research is needed to identify which patients are at low risk of adverse outcomes and could be managed safely at non-trauma facilities.

Despite the potential promises of CQI at non-trauma hospitals, multiple barriers exist to development of such a program. While non-trauma centers experience variation in outcomes, such variation also exists at trauma centers. Given that healthcare resources are limited, further study is needed to compare variation among trauma and non-trauma centers. Such work could guide future investment decisions by identifying where the greatest opportunities reside to reduce preventable deaths secondary to traumatic injuries. Another potential challenge is that clinical practices at non-trauma hospitals, such as interfacility transfer, are not currently subject to external regulation. In the absence of such regulation, willingness to participate in CQI at non-trauma hospitals is unclear. The institutional and cultural readiness to undertake such work as well as the availability of alternative incentives to participate in CQI (through insurance providers, for example) warrant further investigation.

The findings of this study should be interpreted in the context of its multiple limitations. First, the examination of mortality is limited to that which occurred among patients admitted to non-trauma hospitals. We did not track outcomes of patients after being transferred other hospitals, and as a result, the study likely underestimated the mortality of patients initially

treated at non-trauma hospitals. Further study of outcomes after undergoing inter-facility transfer is warranted by linking data from trauma and non-trauma centers. Second, the study does not account for patient preference when evaluating hospital transfer patterns; the Indiana trauma registry does not capture these data currently. Further research regarding the influence of patient preference on trauma outcomes at non-trauma hospitals is needed. Third, we used the ISS to evaluate risk-adjusted outcomes at non-trauma centers. While the ISS is a widely accepted measure of patient acuity, the score is calculated retrospectively, based on information available at the hospitals where the patients were treated. Patients who were transferred to other facilities may have received incomplete evaluations of their injuries, so the ISS of those patients may not accurately reflect their acuity. Further study of the validity of this measure when calculated at non-trauma hospitals is warranted. Fourth, this study is limited to a single state, so the results may not be generalizable elsewhere. Unfortunately, a comprehensive national trauma registry data including non-trauma hospitals is not currently available in the United States.

In conclusion, this study found widespread variation in risk-adjusted outcomes among non-trauma hospitals that treat injured patients, with hospitals that were statistically high and low outliers. As stakeholders in trauma care look to improve the outcomes of injured patients, focus should be aimed at reducing mortality where it is greatest. Given that the majority of injured patients who presented to non-trauma hospitals were treated at metropolitan facilities, where both mortality and proximity to trauma centers was greatest, the establishment of quality improvement initiatives and the selective referral of high-risk patients at those hospitals should be considered.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

The Indiana State Department of Health, Division of Trauma and Injury Prevention generously provided access to data in support of this study.

Research reported in this publication was supported by the National Center for Advancing Translational Sciences of the National Institutes of Health under Award Number UL1TR002529 and the Indiana State Department of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the Indiana State Department of Health.

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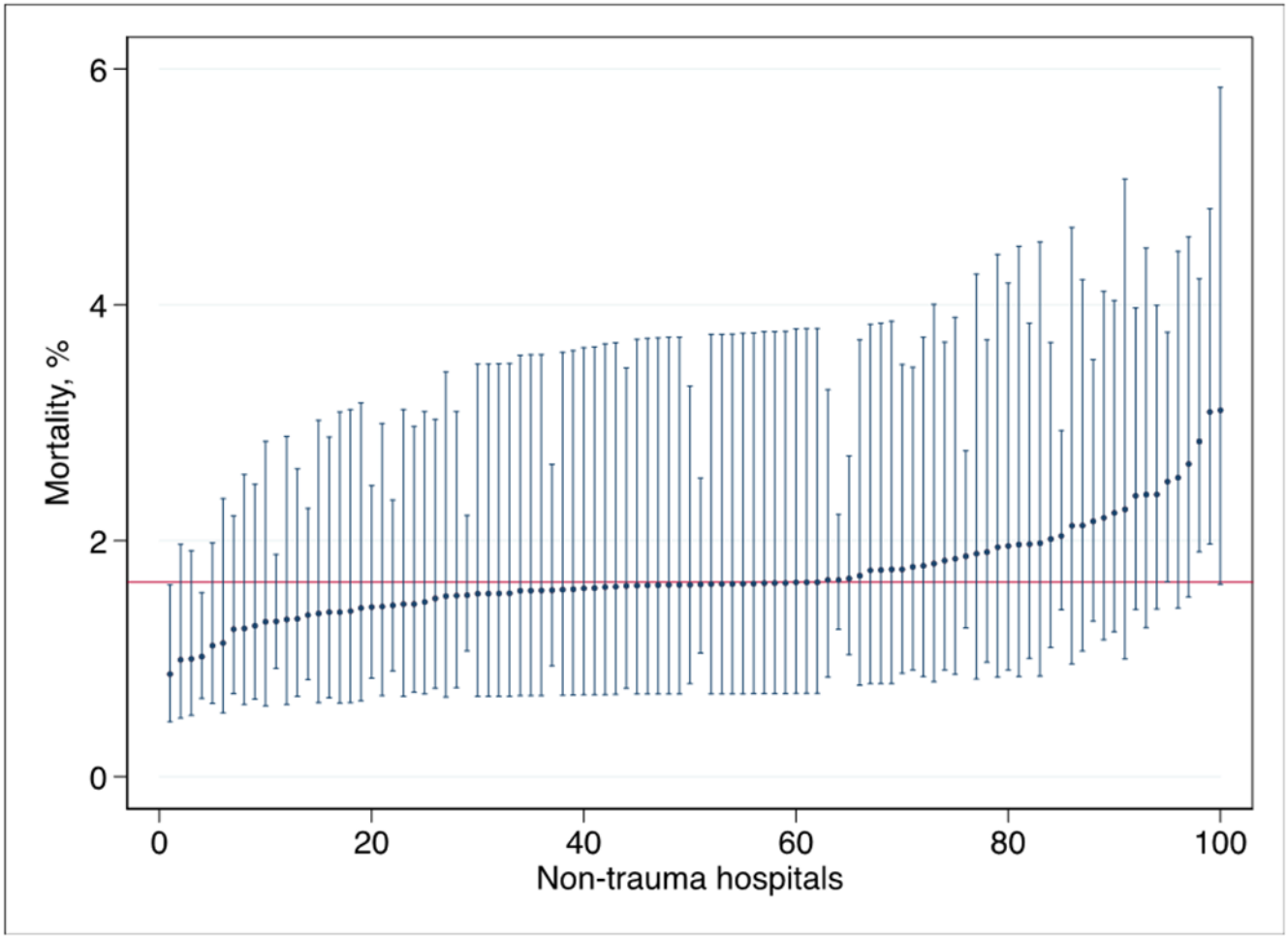

Figure 1.

Ranked variation in risk-adjusted and reliability-adjusted mortality of injured patients treated at non-trauma hospitals with 95% CIs and cohort mean (N=100)

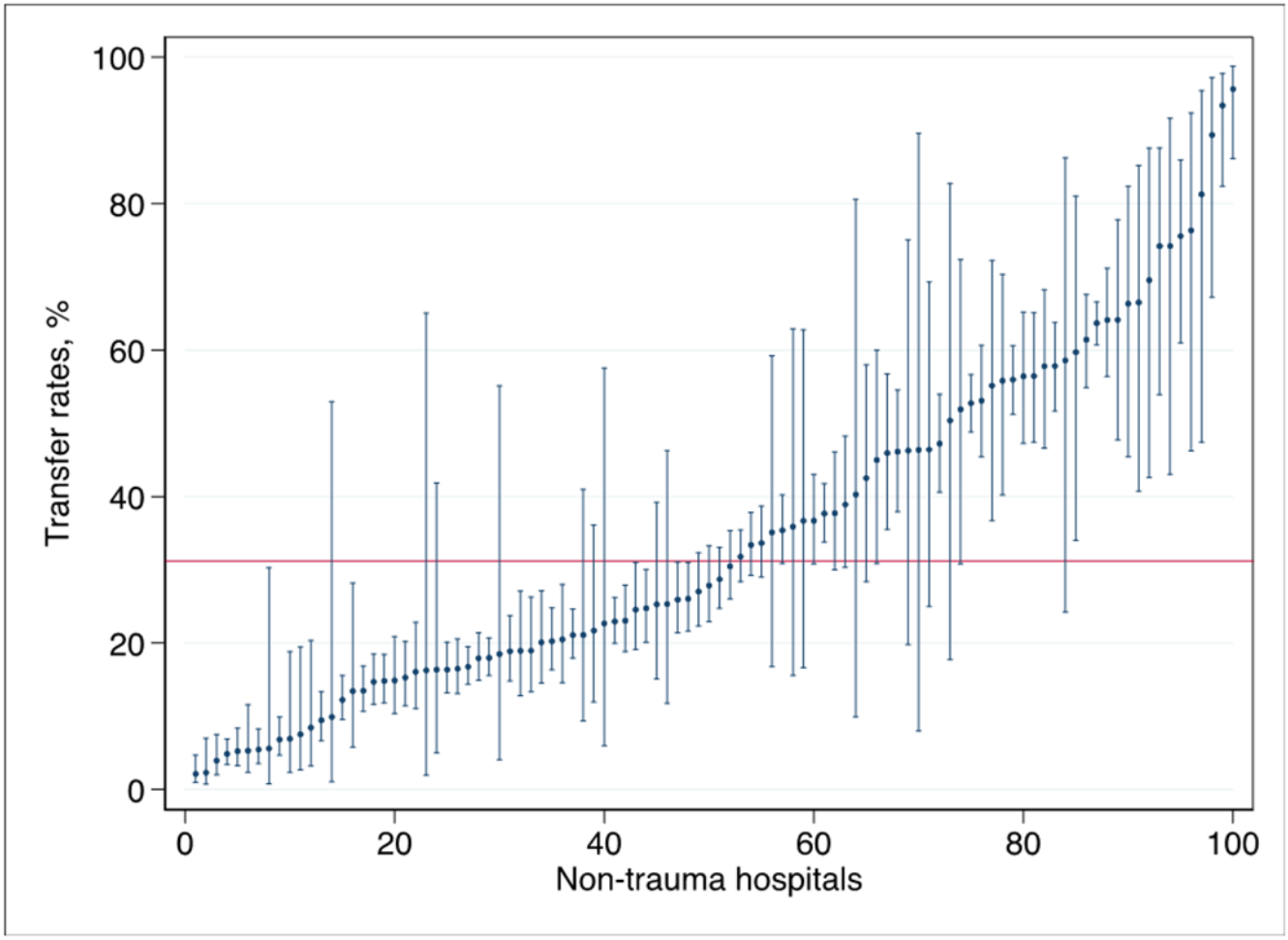

Figure 2.

Ranked variation in risk-adjusted and reliability-adjusted transfer rates of injured patients treated at non-trauma hospitals with 95% CIs and cohort mean (N=100)

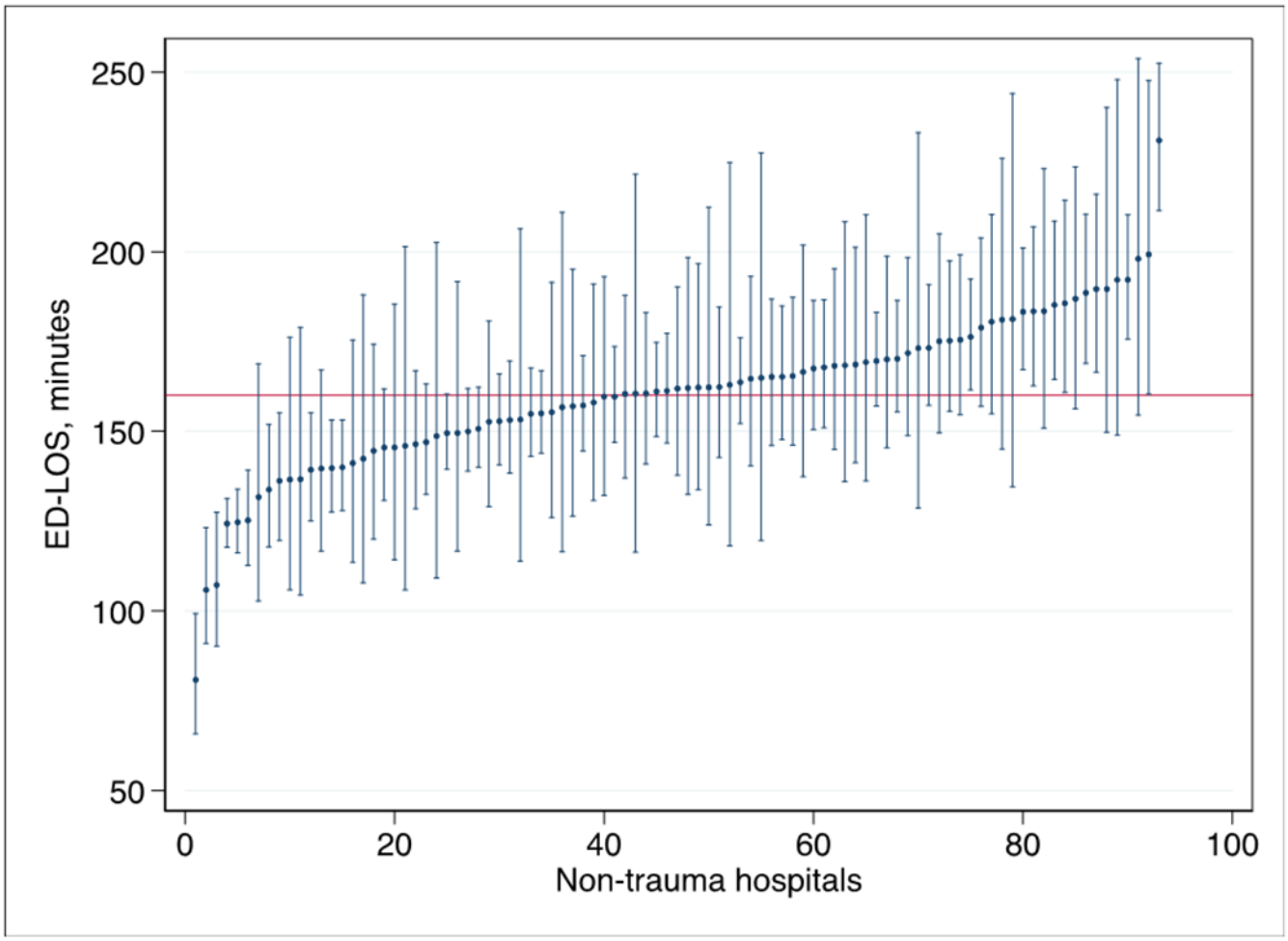

Figure 3.

Ranked variation in risk-adjusted and reliability-adjusted Emergency Department length-of-stay (ED-LOS) of injured patients transferred from the ED at non-trauma hospitals with 95% CIs and cohort mean (N=93)

Table 1.

Patient characteristics of total cohort, patients age >55 years, and patients with an initial Glasgow coma scale (GCS) <14.

	All patients n = 37,670	**Age >55 years N = 24,991**	**GCS <14 N = 1,560**
Age in years, median (IQR)	68 (47-83)	79 (68-86)	62 (38-82)
Elixhauser Comorbidity Index, median (IQR)	1 (0-1)	1 (0-2)	0 (0-1)
Race (%)			
White	85.1	88.4	81.6
Black	5.5	2.8	8.6
Other	1.8	1.0	2.8
NA/not known	7.0	7.2	6.6
Female (%)	53.3	64.1	43.1
Payer type (%)			
Medicare	49.1	70.8	44.7
Private/commercial	20.6	13.5	18.5
Medicaid	5.9	2.6	7.7
Other	16.1	5.6	22.7
NA/not known	8.1	7.4	6.3
Mechanism (%)			
Adverse reaction/overdose/ poisoning	1.1	0.5	1.5
Assault	3.7	0.6	5.6
Burn/electrocution/explosion	1.7	0.6	2.1
Cut/pierce	1.9	0.6	1.0
Fall	60.9	78.2	51.3
Firearm	0.8	0.2	3.0
Hanging/ asphyxiation/ drowning	0.1	0.03	1.0
Machinery	1.1	0.6	0.1
Motor vehicle accident	14.0	6.2	19.4
Natural	0.03	0.02	0.6
Other/not known	4.3	3.5	5.3
Overexertion	0.4	0.3	0.1
Pedestrian/pedestrian cyclist/ pedestrian struck	1.9	1.0	3.7
Struck by/against	2.6	1.2	1.5
Transport	0.6	0.3	0.3
Injury Severity Score, median (IQR)	5 (4-9)	8 (4-9)	9 (4-10)
Initial Systolic Blood Pressure, mean (SD)	144.2 (28)	148.5 (29)	141.3 (35)
Initial Heart Rate, mean (SD)	84.3 (18)	81.3 (17)	89.9 (25)
Glasgow coma scale, mean (SD)	14.6 (2)	14.6 (2)	8.4 (4)
General hospital beds, mean (SD)	125 (87)	125 (84)	138 (94)

	All patients n = 37,670	**Age >55 years N = 24,991**	**GCS <14 N = 1,560**
Teaching hospital (%)	55.8	54.8	64.0
Non-profit hospital (%)	92.1	92.0	92.5
Metropolitan (%)	74.5	75.0	79.4

*No. = number; IQR = interquartile range; SD = standard deviation

Table 2.

Hospital characteristics

Characteristic	Data
All hospitals, No.	100
Teaching status, No.	37
Non-profit status, No.	91
Metropolitan, No.	63
General hospital beds, No.	
<50	49
50-100	25
101-150	9
151-200	7
>200	10
Annual trauma volume, median (IQR)	102 (31-230)

* No. = number; IQR = Interquartile range

Table 3.

Summary of adjusted hospital outcomes and number of hospital outliers by patient cohort

Mortality			
	Mean (range), %	**Low Outliers, N**	**High Outliers, N**
All patients (Hospital No.= 100)	1.6 (0.9-3.1)	2	3
Age >55 years (Hospital No.= 98)	2.0 (1.3-4.1)	0	1
GCS <14 (Hospital No.= 81)	12.9 (5.5-24.8)	2	0
Transfer rate			
	Mean (range), %	**Low Outliers, N**	**High Outliers, N**
All patients (Hospital No.= 100)	31.2 (2.1-95.6)	39	29
Age >55 years (Hospital No.= 98)	23.9 (1.2-92.4)	35	29
GCS <14 (Hospital No.= 81)	48.3 (19.3-81.0)	3	2
Emergency Department Length-of-Stay			
	Mean (range), min.	**Low Outliers, N**	**High Outliers, N**
All patients (Hospital No.= 93)	160 (81-231)	11	10
Age >55 years (Hospital No.= 92)	185 (117-229)	9	2
GCS <14 (Hospital No.= 74)	107 (65-169)	5	2

*GCS = Glascow Coma Scale