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The impact of level of the American College of Surgeons Committee on Trauma verification and state designation status on trauma center outcomes

Adel Elkbuli, MD, MPH[a,*], Brianna Dowd[a], Rudy Flores, BSPH, CSTR, CAISS, RHIT[c], Dessy Boneva, MD, FACS[a,b], Mark McKenney, MD, MBA, FACS[a,b]

Abstract

The American College of Surgeons (ACS) Committee on Trauma (COT) verification and State designation of trauma centers (TCs) into Level 1 or 2 establishes a distinction based on resources, trauma volume, and educational commitment. The ACS COT and individual states each verify TCs to differentiate performance levels. We aim to determine the relationship between ACS and State Level 1 versus 2, and injury-adjusted, all-cause mortality in a national sampling.

TCs were identified by review of the National Sample Program (NSP) from the National Trauma Data Bank (NTDB)—the largest validated trauma database in the nation—of the year 2013. TCs were categorized by ACS or State Level 1 or 2 status, all others were excluded. Adjusted mortality was determined using observed/expected mortality (O/E) ratios, derived by trauma and injury severity score (TRISS) methodology. Chi-squared and *t* test analyses were used for categorical variables, with a statistical significance defined as *P*-value $<.05$.

Of the 94 TCs in the NSP, 67 had ACS and 80 had State designations. There were 38 ACS Level 1 TCs and 29 ACS Level 2. For State designations, there were 45 as State Level 1 and 35 State Level 2. ACS Level 1 TCs had a similar O/E compared with ACS Level 2 verified centers (0.73 vs 0.75, chi-square, $P=.36$). Level 1 TCs designated by their state, had a similar O/E compared with State Level 2 centers (0.70 vs 0.74, chi-square, $P=.08$).

Both ACS and State Level 1 and 2 trauma centers performed similarly on injury adjusted, all-cause mortality.

Abbreviations: ACS = American College of Surgeons, ACS-COT = American College of Surgeons Committee on Trauma, ARDS = acute respiratory distress syndrome, ISS = injury severity score, NSP = National Sample Program, NTDB = National Trauma Data Bank, O/E Mortality = observed/expected mortality, PI = performance improvement, RTS = revised trauma score, SE = standard error, TCs = trauma centers, TCV = trauma center volume, TRISS = trauma and injury severity score.

Keywords: American College of Surgeons Committee on Trauma verification, National Trauma Data Bank, observed/expected (o/e) mortality, state designation, trauma center volume, trauma quality measures

1. Introduction

The designation of trauma centers (TCs) into various levels establishes a distinction based on resources, trauma volume, and educational commitment. It may be expected that there is a performance distinction between the Level 1 and 2 TCs. This is especially crucial in the face of the current prevalence and severity of traumatic injury. Each year over 200,000 people die in the United States from trauma injury—that is one person every 3 minutes.[1] This does not include the millions of people who survive and are faced with life-long mental, physical, and financial problems.[2] Trauma, in fact, is the leading cause of death and disability in the United States.[3] The demonstrated severity of trauma establishes a demand for an evaluation of the factors that contribute to mortality in TCs—namely TC designation level.

The American College of Surgeons (ACS) and individual state agencies can each verify or designate TCs into different levels, including Level 1 and Level 2. These designations require a process of review of the TC and typically evaluate resources, volume, and educational commitment. According to the ACS, Level 1 TCs have a major responsibility for providing leadership in medical education programs, clinical research, and prevention programs which is not expected of Level 2 TCs.[4] Although, they clarify that Level 1 and Level 2 TCs are expected to be clinically equivalent.[4] Most state verifications follow similar guidelines. Due to the distinction between Level 1 and 2, the outcome differences have been investigated and debated. Some studies support the distinction by demonstrating that outcomes of Level

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[a] *Department of Surgery, Kendall Regional Medical Center, Miami,* [b] *University of South Florida, Tampa, Florida,* [c] *Health Corporation of America - South Atlantic Division, Charleston, South Carolina.*

[*] *Correspondence: Adel Elkbuli, Kendall Regional Medical Center, 11750 Bird Road, Miami, FL 33175 (e-mail: Adel.Elkbuli@HCAHealthcare.com).*

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1 TCs are superior to that of Level 2s. For instance, a study which examined the difference in patient outcomes between Level 1 versus Level 2 TCs in Ohio, determined that Level 1 TCs had improved survival and better functional outcomes.[5] Similarly, another study which also assessed differences in outcomes between TC levels found that Level 1 TCs had significantly lower mortality in the subgroup, severely injured patients.[6] While the performance distinction between Level 1 and Level 2 is supported by some studies, many studies do not support such distinction. For example, a study which examined the impact of TC designation on outcomes found Level 1 centers to be statistically similar to Level 2 centers in outcomes and complication rates of severe head injures.[7] Likewise, a study which evaluated outcomes and resource use in Level 1 versus Level 2 TCs in North Carolina in patients with specific injuries (aorta, liver, pelvic fractures, or pulmonary contusions) also concluded fatality to be similar between the designations.[8] This evidence suggests Level 1 and Level 2 TCs are indistinguishable based on patient outcomes, including mortality rate.

To date there are no national studies looking at all-cause injury adjusted mortality for both ACS and State Level 1 versus Level 2 designation. Our present study aimed to determine the relationship between ACS and State TCs' Level designation on observed/expected (O/E) mortality. We hypothesize that ACS and State Level 1 TCs performance measured by O/E mortality is superior to ACS and State Level 2 TCs, respectively.

1.1. Study design and methods

A retrospective cohort review was done using the National Sample Program (NSP) from the National Trauma Data Bank (NTDB)—the largest validated trauma database in the nation—of the year 2013. This is the most current year of which all data were available at the inception of this study. Access to patient data was given by the American College of Surgeons (ACS) Committee on Trauma (COT). The NTDB is currently the largest registry of trauma patient data, containing voluntarily contributed data from over 900 TCs which undergoes enhanced data validation screening. All identifying information has been concealed to ensure confidentiality while including demographics, injury information, and outcomes to allow accurate analyses.

TCs involved in the NSP included community, university, and non-teaching hospitals with ACS Level verification and/or State designation. TCs were categorized based on ACS and State Level. TCs not categorized as ACS or State Level 1 or 2 were excluded. This study analyzed all centers available in the NTDB NSP that were Level 1 or 2. There were no centers excluded that were Level 1 or 2. Adjusted mortality was determined by TRISS methodology using O/E ratios, derived from the Injury Severity Score (ISS) and Revised Trauma Score (RTS). O/E ratios were calculated by dividing the number of actual (observed) deaths by the expected deaths. Data were analyzed using chi-squared and *t* test analyses with statistical significance defined as *P*-value $<.05$. Trauma Center Volume (TCV) is a reporting of the annual number of trauma admissions at a TC. Generally, high TCV centers admit greater than 1200 patients annually while low TCV centers admit less.[9] A Shapiro-Wilk test was used to test for normality/skewness in TCV and injury distribution among ACS and State Level 1 and 2 TCs. To adjust for skewness in ISS data distribution among ACS and State Level 1 and 2 TCs, we used adjusted all-cause mortality (O/E mortality) as our primary outcome. This study received an exempt determination from our Institutional Review Board.

2. Results

2.1. Sample characteristics

Overall, the 2013 NSP provided 94 TCs with 172,387 total trauma patients who had blunt and/or penetrating injuries. Sixty-seven TCs in the 2013 NSP were designated as ACS Level 1 or 2 (38 Level 1 and 29 Level 2) treating 123,103 patients. Of which 87,340 were treated at ACS Level 1 TCs and 35,763 were treated at ACS Level 2 TCs. Moreover, 80 TCs in the 2013 NSP were designated as State Level 1 or 2 (45 Level 1 and 35 Level 2) treating 149,930 patients. Of which 106,640 were treated at State Level 1 TCs and 43,290 were treated at State Level 2 TCs.

A Shapiro-Wilk test ($P>.05$) and a visual inspection of volume histograms, normal Q–Q plots, and box plots showed that the TCVs were approximately normally distributed for both ACS and State Level 1 and Level 2 TCs, with a skewness of 0.511 (standard error "SE" = 0.393) and a kurtosis of –0.493 (SE = 0.768) for the Level 1 TCs and a skewness of 0.699 (SE = 0.448) and a kurtosis of 0.037 (SE = 0.872) for the Level 2 TCs as shown in Fig. 1A and B.

A Shapiro-Wilk test ($P>.05$) and a visual inspection of ISS histograms, Q–Q plots and box plots showed that the ISS were positively skewed for both ACS and State Level 1 and Level 2 TCs simulating overall injury distribution in the NTDB 2013, with a skewness of 2.203 (SE = 0.008) and a kurtosis of 7.915(SE = 0.017) for the Level 1 TCs and a skewness of 2.232 (SE = 0.013) and a kurtosis of 9.326 (SE = 0.026) for the Level 2 TCs as shown in Fig. 2A–C.

The Level 1 TCs have on average significantly higher TCVs than Level 2 centers. Average TCV in ACS Level 1 TCs was significantly higher than ACS Level 2 TCs (2298 vs 1233, $P<.05$). Similarly, average TCV in State Level 1 TCs was significantly higher than State Level 2 (2370 vs 1237, $P<.05$).

Mean ISS was similar between ACS Level 1 versus Level 2 TCs (10.10 vs 9.30, $P>.05$) and between State Level 1 versus Level 2 TCs (9.60 vs 9.20, $P>.05$). Revised trauma scores (RTSs) were also similar between ACS Level 1 versus Level 2 TCs (7.50 vs 7.56, $P>.05$) and State Level 1 versus Level 2 TCs (7.49 vs 7.58, $P>.05$) as shown in Table 1.

ACS Level 2 TCs have a significantly lower crude death rate compared with ACS Level 1 TCs (2.77% vs 3.31%, $P<.005$). When adjusted by using O/E, ACS Level 1 TCs have a similar O/E compared with ACS Level 2 TCS (0.73 vs 0.75, $P=.36$) as shown in Table 2 and Fig. 1. Crude death rate in State Level 2 TCs were also significantly lower compared with State Level 1 TCs (2.75% vs 3.11%, $P=.0002$). However, when factoring in O/E, State Level 1 TCs have a similar O/E compared with State Level 2 TCs (0.70 vs 0.74, $P=.08$).

3. Discussion

Trauma is a prevalent, life-threatening and life-changing event. Of the various factors affecting trauma patient's outcome, in our study ACS Level 1 and 2 and State Level 1 and 2 TCs performed similarly on O/E mortality. While both ACS Level 1 and State Level 1 Centers both had significantly higher crude death rates compared with their respective Level 2 centers, when this was adjusted for injury the differences evaporated. Although ACS

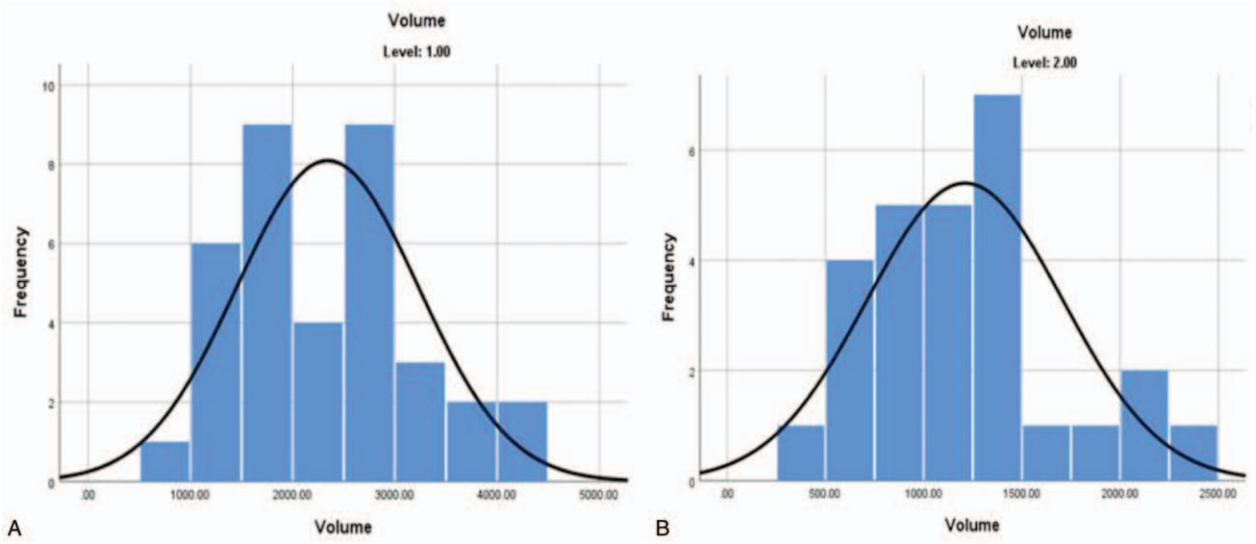

Figure 1. A: TCV distribution among ACS and State Level 1 TCs shows the volume histogram for Level 1 centers. This displays the frequency distribution of trauma center volume in ACS and State Level 1 trauma centers. The majority of Level 1 trauma centers have an annual volume around 2000 to 3000 patients. The TCV follows a normal distribution with a skewness of 0.511 (SE = 0.393) and a kurtosis of –0.493 (SE = 0.768). B: TCV distribution among ACS and State Level 2 TCs shows the volume histogram for Level 2 centers. This displays the frequency distribution of trauma center volume in ACS and State Level 2 trauma centers. The majority of Level 2 trauma centers have an annual volume around 1000 to 1500 patients. The TCV follows a normal distribution with a skewness of 0.699 (SE = 0.448) and a kurtosis of 0.037 (SE = 0.872). ACS = American College of Surgeons, SE = standard error, TCs = trauma centers, TCV = trauma center volume.

verified Level l and 2 centers' mortality difference is not statistically significant, the difference between State designated 1 and 2 centers nearly reaches statistical significance. The similarity in the O/E mortality between Level 1 and Level 2 TCs is likely due to the minimal differences in the designation of Level 1 and 2 regarding patient care. Most differences relate to research and training. As mentioned, the ACS has stated that Level 1 and Level 2 TCs are expected to be clinically equivalent. Therefore, a similar O/E mortality between Level 1 and 2 TCs should be expected.

When relating these findings to TCV, both ACS and State Level 1 TCs have a higher average annual TCV than ACS and State Level 2 TCs. The ACS-COT has long recognized the need for a certain minimum patient volume to maintain adequate experience and expertise for the delivery of effective trauma care.[10] ACS and State Level 1 TCs had similar average volume of about 2300 trauma patients per year. ACS and State Level 2 TCs, although less than their Level 1 counterparts, still had on average, over 1200 trauma patients per year. These volume numbers may explain the similarity of O/E mortality between Level 1 and Level 2 TCs because of the "threshold" effect, which signifies that TCV above a certain threshold correlated to improved mortality. Both ACS and State Level 1 and 2 TCs had on average volumes above 1200 admissions per year, which is well above the 650-admission threshold determined by Nathens et al[11] for significantly improved outcomes. A similar study by Elkbuli et al[9] investigated the relationship between TCVs and observed/expected (O/E) all-cause mortality and found that higher TC volumes are correlated with higher injury severity and lower O/E mortality. This may indicate that TCV above a certain threshold is beneficial to patient outcomes and that the "threshold" effect is confirmed. While other evidence suggests that TCV is not associated with patient outcomes. For example, London and Battistella[12] evaluated the relationship between patient volume and outcomes in California's TCs and found that hospital volume was not a good proxy for outcome and hospital volume was not a significant predictor of death; they were therefore unable to find a "threshold effect" where trauma volume is concerned. This finding is supported by another assessment, which examined the volume–mortality relation for patients with severe trauma in the National Trauma Databank (NTDB) and determined that no significant association was demonstrated between TCV and mortality.[13]

Further, average ISSs were similar between ACS and State Level 1 and 2 TCs, indicating the severity of injury among patients brought to each level TC were comparable.

Liberman et al[14] examined the association between various components that make up a trauma system and patient outcomes. From this examination, they determined that a performance improvement (PI) program was associated with improved outcomes.[14] To obtain ACS Level 1 and 2 verification, a robust PI program is a requirement and might explain why adjusted outcomes between ACS Levels 1 and 2 were similar. The fact that Level 1 and 2 TCs have similar adjusted outcomes also indicates that the system is working and good care can be achieved at both types of centers.

Interestingly Kim[15] performed a systematic review of the relationship of TC and ACS verification and concluded that achieving ACS verification is beneficial to outcomes. Additionally, they found disagreement in the literature on whether Level 1 or 2 can deliver similar care. Bukur et al[16] further evaluated the relationship between ACS center designation and outcomes after early thoracotomy for trauma. In their evaluation, they found no significant differences in adjusted mortality between the different levels of ACS designation.[16] DuBose et al[17] also sought to determine the relationship between ACS center designation and outcomes for trauma patients undergoing mechanical ventilation. They determined that ACS level had no effect on overall mortality.[17] These findings support our results which demonstrates ACS Level 1 and 2 TC perform similarly as do State Level

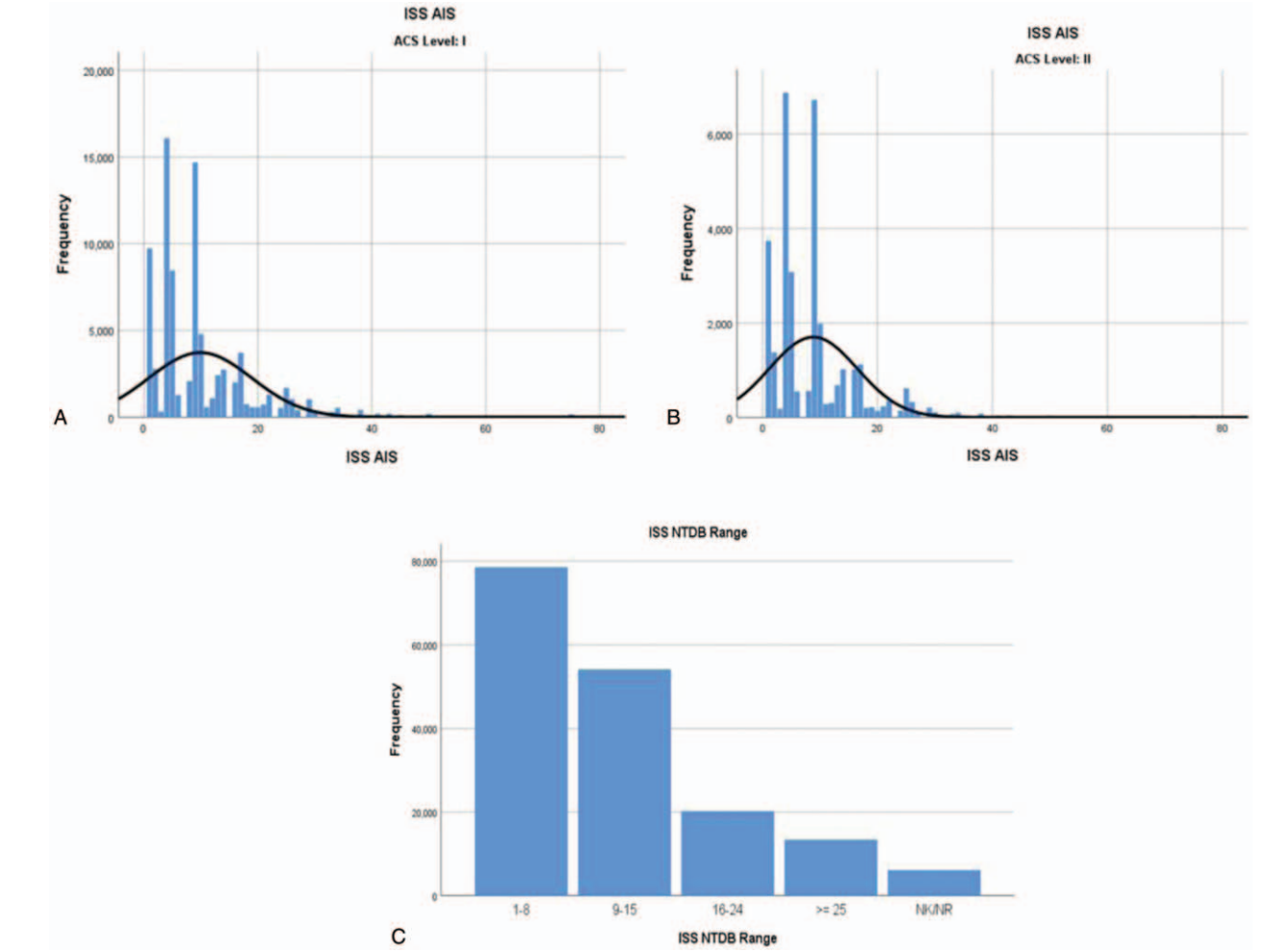

Figure 2. A: ISS distribution among ACS and State Level 1 TCs shows the injury severity score histogram for Level 1 centers. This displays the frequency distribution of injury severity scores in ACS and State Level 1 trauma centers. The majority of Level 1 trauma centers treat patients with an injury severity score between 0 and 20. The ISS were positively skewed with a skewness of 2.203 (SE = 0.008) and a kurtosis of 7.915 (SE = 0.017). B: ISS distribution among ACS and State Level 2 TCs shows the injury severity score histogram for Level 2 centers. This displays the frequency distribution of injury severity scores in ACS and State Level 2 trauma centers. The majority of Level 2 trauma centers treat patients with an injury severity score between 0 and 20. The ISS were positively skewed with a skewness of 2.232 (SE = 0.013) and a kurtosis of 9.326 (SE = 0.026). C: ISS distribution in the NTDB 2013 shows the percent of each injury severity score category in the NTDB for 2013. This displays the frequency distribution of ISS for all trauma centers reported to the NTDB for 2013. The overall ISS is positively skewed. ACS = American College of Surgeons, ISS = injury severity score, SE = standard error, TCs = trauma centers, TCV = trauma center volume.

1 and 2 TCs. Alternatively, Smith et al[18] compared overall survival and survival after Acute Respiratory Distress Syndrome (ARDS) in patients admitted to ACS verified versus state designated Level 1 TCs. After adjusting for injury severity and facility size, it was found that admission to an ACS Level 1 TC was associated with significantly greater survival after ARDS compared with a state Level 1. They concluded that Level 1 verification does not necessarily imply similar outcomes in all subgroups.[18]

By and large, the ACS and state designation and verification systems effectively categorize TCs based on resources, volume, and scientific and educational commitment. The verifications of each TC help to establish and enforce uniformity which benefits the center's outcomes and therefore the patients.

Table 1

Revised trauma scores (RTSs).

	ACS Level 1 TCs (n = 87,340)	ACS Level 2 TCs (n = 35,763)	*P*	State Level 1 TCs (n = 106,640)	State Level 2 TCs (n = 43,290)	*P*
Mean SBP, mmHg	136	138	>.05	136	138	>.05
Mean RR	18.3	18.4		18.4	18.5	
Mean GCS	14.01	14.13		13.99	14.2	
RTS	7.50	7.56		7.49	7.58	

ACS = American College of Surgeons, GCS = Glasgow Coma Score, RR = respiratory rate, RTS = revised trauma score, SBP = systolic blood pressure.

Table 2

Observed/expected mortality.

	O/E mortality	P
ACS Level 1 TCs	0.73	.36
ACS Level 2 TCs	0.75	
State Level 1 TCs	0.70	.08
State Level 2 TCs	0.74	

ACS = American College of Surgeons, O/E Mortality = observed/expected mortality, TCs = trauma centers.

In the present study, there were limitations. This is an analysis of retrospective data from the NTDB, the largest collection of trauma registry data. With this comes the same limitations as the use of any large dataset, which include possible misclassification of injuries, lack of consistency, unrepresentativeness, and wide variability. This study included only 1 year of NTDB data, the NSP from 2013 is a relatively small sample size which may affect the generalization of the results. Another limitation in this research is that there are variations in the state designation systems. Some states have designation systems that include more or less requirements than other states, yielding the State Level 1 or Level 2 designation unequal amongst different states. The use of Trauma and Injury Severity Score (TRISS) adjustment methodology is a limitation, although widely used there are other methods available. Furthermore, there is some overlap in the ACS and State TCs. Some State designated centers were also ACS verified, and some ACS verified centers were not State designated. This makes the ACS and State cohorts indistinguishable; however, this does not affect the comparison of Level 1 with Level 2 TCs. Also, there is a limitation with the RDS as not all demographic characteristics and variables may be available. Future studies should aim to account for these variations in the state designation systems. Future studies should also evaluate the impact of verified versus non-verified TCs on outcome performance and injury adjusted mortality.

Future research efforts should further investigate the relationship between ACS/State Level verification and trauma outcomes particularly complication rates to fully evaluate its impact on trauma outcomes. Additionally, future studies should assess the relationship between ACS/State Level verification and teaching status and its effects on TC performance. Future research could also focus on high volume Level 1, 2, and 3 TCs to better understand what the necessary components to exceptional care are.

4. Conclusion

Both ACS and State Level 1 and 2 trauma centers perform similarly on all-cause injury adjusted mortality. Future studies should focus on the additional components of high performing trauma centers to evaluate their unique managing techniques to achieve better outcomes and lower mortality.

Author contributions

Conceptualization: Adel Elkbuli, Dessy Boneva, Mark McKenney.
Data curation: Adel Elkbuli, Rudy Flores, Mark McKenney.
Formal analysis: Adel Elkbuli, Rudy Flores, Mark McKenney.
Investigation: Adel Elkbuli, Brianna Dowd, Rudy Flores, Dessy Boneva, Mark McKenney.
Methodology: Adel Elkbuli, Brianna Dowd, Rudy Flores, Mark McKenney.
Project administration: Adel Elkbuli, Brianna Dowd, Dessy Boneva, Mark McKenney.
Resources: Adel Elkbuli, Mark McKenney.
Supervision: Adel Elkbuli, Dessy Boneva.
Writing – original draft: Adel Elkbuli, Brianna Dowd, Rudy Flores, Dessy Boneva, Mark McKenney.
Writing – review & editing: Adel Elkbuli, Brianna Dowd, Rudy Flores, Dessy Boneva, Mark McKenney.
Adel Elkbuli orcid: 0000-0001-7730-617X.

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