Published in final edited form as:
Ann Surg. 2013 July ; 258(1): 178–183. doi:10.1097/SLA.0b013e31828226b6.

Comparative Effectiveness of In-Hospital Trauma Resuscitation at a French Trauma Center and Matched Patients Treated in the United States

Adil H. Haider, MD, MPH, FACS[1], **Jean-Stephane David, MD, PhD**[2], **Syed Nabeel Zafar, MBBS, MPH**[1], **Pierre-Yves Gueugniaud, MD, PhD**[3], **David T. Efron, MD**[1], **Bernard Floccard, MD**[4], **Ellen J. MacKenzie, PhD**[5], and **Eric Voiglio, MD, PhD, FACS, FRCS**[6]

[1]Center for Surgery Trials and Outcomes Research, Department of Surgery, The Johns Hopkins School of Medicine, Baltimore MD, USA

[2]Department of Anesthesiology and Critical Care Medicine, Lyon Sud Hospital, Hospices Civils de Lyon (HCL), F-69495 Pierre Benite, France and Charles Merieux Lyon-Sud School of Medicine, University Lyon 1, Oullins, France

[3]Department of Emergency and Emergency Medical Service, Edouard Herriot Hospital (HCL), F-69437 Lyon, France and Charles Merieux School of Medicine, University Lyon 1, Oullins, France

[4]Department of Anesthesiology and Critical Care Medicine, Edouard Herriot Hospital (HCL), F-69437 Lyon, France

[5]Department of Health Policy and Management, Bloomberg School of Public Health, Johns Hopkins University, Baltimore MD, USA

[6]Department of Surgery, Trauma & Emergency Surgery Unit, Lyon Sud Hospital (HCL), F-69495 Pierre Benite, France and Lyon-Est School of Medicine, University Lyon 1, Lyon, France

Abstract

Objective—The objective of this paper is to compare mortality outcomes between patients treated at a trauma center in France and matched patients in the United States.

Author for correspondence, Adil H. Haider, MD, MPH, Center for Surgery Trials and Outcomes Research, Department of Surgery, The Johns Hopkins School of Medicine, 600 N. Wolfe St., Halsted 610, Baltimore, MD 21212, ahaider1@jhmi.edu.

Conflicts of Interest

None of the authors has any conflicts of interest.

Contributions: Dr. Adil H. Haider contributed to the literature search, development of figures, data analysis and interpretation, as well as the writing of the manuscript. Dr. Jean-Stephane David contributed to the study design, data collection and interpretation, and the writing of the manuscript. Dr. Syed Nabeel Zafar contributed to the literature search, development of figures, data analysis and interpretation, and the writing of the manuscript. Dr. Pierre-Yves Gueugniaud contributed to the study design, data collection and interpretation, and writing of the manuscript. Dr. David T. Efron contributed to the study design, data interpretation, and writing of the manuscript. Dr. Bernard Floccard contributed to the study design, data interpretation, and writing of the manuscript. Dr. Ellen J. Mackenzie contributed to the study design, data interpretation, and writing of the manuscript. Dr. Eric Voiglio contributed to the literature review, study design, data collection and interpretation, and writing of the manuscript.

Summary Background Data—Although trauma systems in France and the U.S. differ significantly in pre-hospital and in-hospital management, previous comparisons have been challenged by lack of comparable data.

Methods—Coarsened exact matching identified matching patients between a single center trauma database from Lyon, France and the National Trauma Data Bank (NTDB) of the U.S. Moderate to severely injured (ISS >8) adult patients (age ≥16) presenting alive to level-1 trauma centers from 2002–2005 with blunt or penetrating injuries were included. After matching patients, multivariate regression analyses were performed to determine difference in mortality between patients in Lyon and the NTDB.

Results—A total of 1,043 significantly injured patients presented to the Lyon center. Matching eligible patients with complete records were sought from 219,985 patients in the NTDB. The unadjusted odds of mortality at the Lyon center was 2.5 times higher than that of the NTDB (95% CI =2.18, 2.98). However, the Lyon center received patients with higher ISS, lower GCS and lower SBP (all p<0.001). After 1:1 matching 858 patient pairs were produced, and the odds of mortality became equivalent (OR= 1.3, 95% CI =0.91, 1.73). Similar results were found on multiple subset analyses.

Conclusions—Trauma patients admitted to a single French trauma center had an equal chance of survival compared to similarly injured patients treated at U.S. trauma centers.

Introduction

Trauma remains the leading cause of death and disability among young people in both the United States (U.S.) and France.[1] In the U.S., over 50 million people are injured per year, resulting in about 169,000 deaths and a lifetime cost of $406 billion.[1,2] In France, approximately 47,000 deaths per year are attributable to injuries.[1] Preventive interventions such as seatbelts and the development of trauma systems have been credited with reducing the burden of trauma in both countries.[3,4] Further enhancements to existing trauma systems and early trauma management hold promise as a way to improve outcomes after severe injury.

The French and U.S. trauma systems have independently evolved over the past several decades and have a number of important differences.[3,5] The most commonly discussed differences have to do with pre-hospital care; in France, this is performed by a physician-led team who initiate resuscitation at the injury scene and continue this during transport. In the U.S., non-physician first responders constitute the emergency response. Fewer interventions are performed, with first responders aiming to transfer the patient to definitive care immediately. Significant national differences in the organization of in-hospital care and initial trauma resuscitation exist as well. In the U.S., emergency physicians and trauma surgeons provide the initial care for the severely injured, with the surgeon typically directing the team and assuming responsibility of the patient. In France, an anesthetist-intensivist leads the trauma team, receives the patient in the trauma bay, and assumes responsibility of resuscitation, deciding with a trauma and emergency surgeon the best diagnostic and therapeutic strategy.

Comparing outcomes between these different systems may allow us to understand their relative strengths and weaknesses and help improve trauma care paradigms at an international level. However, previous attempts at doing so have proved to be challenging. Nathens *et al.* attempted to compare trauma outcomes between France and the U.S. using available evidence and scientific literature.[3] The authors concluded that the lack of data available to compare outcomes between countries is a "significant impediment to the identification and implementation of components of a trauma system that are effective and the discarding of those that offer little benefit."[3]

The objective of this paper is to compare mortality outcomes between severely injured trauma patients at a representative trauma center in France with matched patients in the United States, using current state of the art statistical methodologies.

Methods

Data source

We compared in-hospital mortality between patients treated at a single academic tertiary medical center in Lyon, France and matched cases from the United States National Trauma Data Bank (NTDB) for patients injured between January 1, 2002 and December 31, 2005. This study was approved by the institutional review board of the primary author's academic institution in the U.S. Because patient care was not altered in any way, neither informed consent nor ethics committee approval for the study was required under French law.[6]

The academic medical center in Lyon is a regional referral center and serves a population of approximately 1.6 million in southeastern France. In addition to the trauma center at the study institution, Lyon has one other teaching hospital with a trauma center. Together both hospitals provide care for almost all severely injured trauma patients in the region. Patients are brought to one of these centers if they are known or suspected to have severe injuries by the pre-hospital physician care provider. Patients who were ill enough to be triaged to the Trauma Resuscitation unit of the study institution were included in this analysis.

The NTDB is maintained by the American College of Surgeons and is the largest repository of trauma patients ever created. [7] Data is reported voluntarily from over 900 trauma centers across the United States. Demographic, injury-related, clinical and facility level information is available for over two million trauma incidents. To achieve a similar sample base we selected all adult patients (age 16 and above) with Injury Severity Scores greater than 8 who were treated at level 1 trauma centers in the years 2002–2005 with either blunt or penetrating injuries. Patients deemed 'dead on arrival' were excluded from both datasets.

Statistical Analysis

Coarsened Exact Matching (CEM) was used to match patients in the Lyon database with patients in the NTDB in a 1:1 ratio. CEM is a relatively new method for matched adjustment that reduces the imbalance in covariates between two groups.[8] It involves temporarily coarsening the data, exact matching of variables and then running analysis on the uncoarsened, matched data. CEM has the advantage of meeting the congruence principle, being invariant to measurement error, using monotonic imbalance bounding (reducing the balance in one factor has no effect on others), balancing nonlinearities and is thought to be computationally efficient. It eliminates the need for iterations in balance checking and rematching or using a separate procedure for estimation. Since CEM is from the family of monotonic imbalance bounding methods the matching is exact on coarsened variables and further adjustment on the same variables becomes redundant. After CEM we determined the difference in mortality between using bivariate conditional logistic regression analyses. This accounts for the loss of independence between variables as a result of the matching process which accounts for dependent observations.

We also report the degree of imbalance between the two datasets before and after before after matching by measuring the multivariate L1 distance. [8] The L1 distance provides a multivariable measure.[8,9] An L1 of 0 indicates perfect global balance and larger values correspond to larger imbalance between the groups. The maximum imbalance is denoted by an L1 of 1.

Patients were matched on co-variants known to impact trauma outcomes including age, gender[10], year of admission, Injury Severity Score (ISS), Glasgow Coma Score (GCS), systolic blood pressure (SBP) [11], type of injury (blunt/penetrating) [12] and mechanism of injury. [13] Vital signs such as SBP and GCS for both datasets were measured at patient presentation to a physician, i.e. before extensive resuscitation or other procedures were carried out. This was the initial vitals in ED for the NTDB and in the field for the Lyon dataset during the initial medical evaluation. The combination of GCS and SBP provides an equally effective assessment of physiologic injury as the Revised Trauma Score (RTS), with the added advantage of having less missing data.[11] All variables were categorized, and coarsening was performed by the same cut-offs. Cut-offs were decided with the aim to find pairs that would be as closely matched as possible. Age was categorized as 16–25, 26–35, 36–45….76–85, and above 85 years; ISS as 9–15, 16–24, 25–39 and 40–75; GCS as 3, 4–5, 6–8, 9–11 and 12–15; SBP as 0, 1–49, 50–75, 76–89, and 90 and above mmHg; mechanism of injury as falls, motor vehicle crashes, pedestrian injury, stab or gunshot, and ‘other injuries.’

Crude estimates of mortality differences between the two datasets (in the form of odds ratios with 95% confidence intervals) were calculated using univariate logistic regression analysis. The primary outcome measure was in-hospital mortality (‘dead’ yes/no). Differences between length of stays were calculated by the Wilcoxon rank sum test (Mann-Whitney U test) for crude data and by the Wilcoxon signed rank test for matched data. In the multivariate regression model age, gender, ISS, mechanism of injury, GCS and SBP were included as covariates with the primary predictor ‘dataset’ (NTDB vs Lyon Dataset). The regression models were adjusted for clustering by facility. Analyses were performed on all patients and on subsets delineated by ISS (ISS >8), injury type (blunt and penetrating) and GCS (3–8 and 9–15). Sensitivity analysis was performed using a 1: many matching strategy.

Financial support for this work was provided by: National Institutes of Health/ NIGMS K23GM093112-01; American College of Surgeons C. James Carrico Fellowship for the study of Trauma and Critical Care and Hopkins Center for Health Disparities Solutions (Dr Haider) The funding sources had no role in the study design, collection, analysis and

interpretation of data, writing of the report or decision to submit the manuscript for publication.

Results

There were a total of 1,044 severely injured patients at the Lyon center during the time period of the study, of which complete records were found for 1,043 patients (Figure 1). The NTDB contained information on 1,861,779 patients, out of which 219,985 were complete records for severely injured (ISS >8) adult (age ≥16 years) patients presenting alive to level 1 trauma centers between 2002–2005 with blunt or penetrating trauma (Figure 1).

The center in Lyon received a higher proportion of male patients (76% vs 69%) (Table 1). The mean age for patients in Lyon was 39 (±18) years, while for those in the NTDB it was 42 (±21) years. Patients in Lyon had a higher ISS, lower GCS and lower SBP when compared to patients in the NTDB (p <0.001). Motor Vehicle Crash (MVC) accounted for the majority of the injury in both groups; 46% for Lyon and 55% for NTDB. However, the Lyon center received a higher proportion of pedestrian injuries (12%) than centers in the U.S. (5%). At this particular trauma center in Lyon the crude mortality was 19%. The unadjusted odds of mortality at the Lyon center was 2.5 times higher than that of the NTDB (95% CI =2.18, 2.98). Upon crude analysis, patients at the Lyon center had significantly longer hospital and ICU length of stays than patients in NTDB (p <0.001) (Table 1). A 1:1 match on age, gender, year of admission, ISS, SBP, GCS, injury type and mechanism of injury resulted in a total of 858 pairs. The multivariate L1 distance, a measure of global imbalance, prior to matching was 0.878 on un-coarsened variables and was 0.447 after coarsening. After CEM the L1 distance was 0.308 on the un-coarsened variables and 0.0 on the coarsened variables denoting a perfect match.

There were 185 patients from the Lyon center that remained unmatched. These patients had a mean age of 40 (±19) years, 78% were males and were equally distributed with regards to year of admission. Sixty nine (37%) of them suffered from fall injuries, while 24 (13%) had a motor vehicle crash and 20 (11%) suffered from stab or gunshot wounds. The mean presenting ISS was 37 (±18), GCS score was 8 (±3) and 70% were hypotensive (SBP<90 mmHg) on arrival. The median length of hospital stay was 13 (2–32) days and 78 (42.2%) of patients died within the hospital.

Weighted analysis revealed a mortality of 13.6% at the Lyon center and 12.5% in the NTDB (Figure 2). Multivariate logistic regression analysis revealed no difference in mortality (OR= 1.24, 95% CI =0.82, 1.85). However, even after matching, the difference in hospital and ICU length of stays remained significant (p<0.001). Median hospital stay was almost twice as long at the Lyon trauma center than the NTDB (Figure 3).

Similar results were achieved with subset analyses and when multiple matches were sought from the NTDB for each patient in the Lyon database (Tables 2 and 3).

Discussion

This paper demonstrates that there is no difference in in-hospital mortality for significantly injured patients at a single French trauma center when compared to matched patients treated at U.S. level 1 trauma centers during the same time period. These results suggest that, despite their different compositions, trauma teams in France and the U.S. that provide initial in-hospital resuscitation and subsequent hospital care may be equally effective. This study, however, does not provide a comparison of pre-hospital care and thus, these results cannot be used to comment on which pre-hospital emergency response system is superior.

Numerous similarities and differences exist between the systems of care in these two countries. In the United States, the trauma patient is triaged and brought to the trauma center by emergency medical services (EMS). EMS teams can provide a variety of emergent care ranging from intravenous fluid administration to intubation. However, the focus is on transport of the patient and, apart from establishing IV lines, only immediately life-saving interventions are performed – hence, the common ‘scoop and run’ description. In some instances, a trauma patient may be brought to a smaller community hospital where the goal is rapid assessment, stabilization and transfer to a trauma center.[11] A trauma surgeon leads the trauma team and directs diagnostic evaluation, therapeutic interventions and the treatment plan, including specialty consultations and disposition to the operating room, intensive care unit, ward or discharge home. The trauma surgeon remains primarily responsible for the patient until discharge.

In contrast, the *modus operandi* of the French system takes the ‘hospital to the patient.’ The pre-hospital team, called the *Service Mobile d’Urgence et de Réanimation* (Emergency Medical Assistance Service) (SMUR), consists of an emergency physician (or an anesthetist-intensivist) and a nurse.[14] Their goal is to stabilize vital ventilatory, circulatory and neurological functions and transport the patient in the best possible condition with the minimum use of time (Run and Play strategy).[14] In Lyon and other advanced pre-hospital systems in France, SAMU units have the possibility carry 4–6 units of O –ve blood . Once stabilized the severely injured trauma patient is transported to the ‘resuscitation unit,’ which has necessary equipment and personnel and is in proximity to imaging units and operating rooms. Here the team is led by an anesthetist-intensivist who continues the resuscitation initiated by the field intensivist and, along with a trauma and emergency surgeon, makes diagnostic and therapeutic decisions. Once life-threatening hemorrhagic injuries have been cleared, the anesthesiologist is responsible for coordinating with surgeons of the appropriate organ system and other physicians. In France ‘Trauma Center’ designation is not as comprehensive as it is in the US. To qualify as a ‘trauma center’ the center must be located in a university hospital that regularly receives severe trauma patients annually and it must have the ability to provide surgery to patients of all ages with all kinds of injuries. Designation of the level of trauma center (1,2 or 3) is being planned with implementation of more a more organized trauma system.

The comparable effectiveness of in-hospital resuscitation for either system may in part be explained by the fact that both systems take a multidisciplinary approach to manage the patient. Also, a designated trauma team provides initial care of the patient in both systems, which is considered to be an essential component of contemporary trauma care.[15] Studies have shown that the institution of trauma teams has halved resuscitation time and decreased delayed injury diagnosis by ten fold.[16,17] It has been shown to result in a 1.9% to 8.3% reduction in the risk of death depending on injury severity.[18] A designated team leader enhances the functioning of the trauma team.[19], [20] Some argue that the team should be led by a surgeon,[19,20] while others believe anyone trained in trauma management can provide adequate care, and the team leader should rotate between various specialists.[21,22,23] Interestingly, we find that even though the team leader differs in the French and U.S. systems, mortality remained the same. This has implications for optimal allocation of resources, especially in areas where surgeon availability is low. Credentialing alternative physicians trained in trauma management to take on the team leader role may be a viable option and needs to be prospectively explored further.

Patients included in the Lyon database, on average were more severely injured (higher ISS, lower GCS, lower SBP) than patients in the NTDB. A possible reason for this could be due to physician assisted pre-hospital triage in France. Many patients without severe injuries that have been triaged in the field by physicians are directly sent to the emergency department rather than to the Trauma Resuscitation Unit, which forms our study cohort. [24]

The lack of difference in mortality is perhaps not surprising as primary and secondary surveys are in effect, very similar. In France, the hospital trauma team, in essence, initiates with a secondary survey, as the primary survey has already been conducted by the SMUR team (Emergency Medical Assistance Service). In the U.S., the primary survey is the first process performed by the trauma team immediately followed by the secondary survey. It may be possible that patients end up receiving the same diagnostic and therapeutic interventions in a comparable amount of time. We were unable to collect detailed data and thus are unable to comment on this. However, this is an important aspect and should be studied further.

The significant difference in hospital and ICU length of stays between the Lyon trauma center and the NTDB may be due to differences in national insurance coverage models. In France, universal health care exists via compulsory health insurance, largely provided by government-run national health insurance. French patients pay small co-payments, but no deductibles, and critical surgeries are fully reimbursed. In stark contrast, a high proportion of American trauma patients are uninsured. In Haider et al.'s study of the effects of race and insurance on trauma mortality, performed on more than 400,000 NTDB patients, 47% of patients were uninsured.[25] The ability to pay is linked to hospital length of stay, with uninsured patients experiencing decreased length of stay.[26], [27] Given the guaranteed insurance coverage of all French trauma patients, French physicians may feel less pressured than American physicians to minimize patient length of stay. Challenges in transferring patients out of the surgery ward or out of the hospital may also play a role in France.

The retrospective nature of the analysis limited our ability to control for all potential confounders. Even though it is possible that some unmeasured confounders do exist, we believe the effect of these, if any, will be minimal. Also, we were unable to look at outcomes other than mortality. It would have been interesting to look at differences in the cost of care

NIH-PA Author Manuscript

NIH-PA Author Manuscript

or in incidence of major complications. Another limitation is that of generalizability. The Lyon data set was from one trauma center of the country, and caution should be used in generalizing results to the whole country. The NTDB is also not a representative sample, with trauma centers voluntarily participating in the NTDB. Another potential source of bias can be due to coarsening the variables before matching. Coarsening provides for more matched pairs at the expense less exact matching. However our analysis may not be as susceptible to this problem. Categorical variables such as gender, mechanism of injury, injury type and year of admission are not affected by this and the issue arises only for our continuous variables namely; Age, SBP, GCS and ISS. When measuring the imbalance between the two groups, after CEM we find a L1 distance of 0 as expected. On the uncoarsened continuous variables the degree of imbalance is 0.308. However, all of these continuous variables were categorized in to as many clinically relevant categories as possible (instead of dichotomizing or trichotimizing them). Age was categorized in deciles, SBP was categorized as 0, 1–49, 50–75, 76–89 and >90 mm Hg, GCS as 3, 4–5, 6–8, 9–11, 12–15 and ISS as 9–15, 16–24, 25–39, and 40–75. The differences in patients within these categories are thought of minimal clinical importance compared to the differences between the categories.

In addition to this we were unable to match 185 patients from the Lyon trauma center to patients in the NTDB which could potentially produce some selection bias. A certain degree of un-matching is expected while attempting to match groups with numerous variable permutations. It is not surprising that many of the unmatched patients represent patients which were present in very low frequencies in either dataset, such as a severely injured female penetrating trauma patient. However, since we were able to achieve matches in greater than 80% of cases, including those with very severe injury we believe that we were able to achieve our objective to compare outcomes between closely matched patients in two different trauma systems.

In conclusion, we found no difference in mortality between trauma patients brought alive to a single French trauma center when compared to matched patients treated at a U.S. level 1 trauma center. The significant differences in pre-hospital and in-hospital management of these patients suggests the potential for learning further strengths from each of these systems to improve universal trauma care.

Acknowledgments

Dr. Adil H. Haider had full access to all data in the study and had final responsibility for the decision to submit for publication.

Source of Funding:

Sources of funding include: National Institutes of Health/ NIGMS K23GM093112-01; American College of Surgeons C. James Carrico Fellowship for the study of Trauma and Critical Care and Hopkins Center for Health Disparities Solutions (Dr. Haider)

References

1. World Health Organization. Disease and injury country estimates. 2004. [updated 2004; cited 2011 June 26]; Available from: http://apps.who.int/ghodata/

2. Corso P, Finkelstein E, Miller T, Fiebelkorn I, Zaloshnja E. Incidence and lifetime costs of injuries in the United States. Inj Prev. 2006 Aug; 12(4):212–218. [PubMed: 16887941]
3. Nathens AB, Brunet FP, Maier RV. Development of trauma systems and effect on outcomes after injury. Lancet. 2004 May 29; 363(9423):1794–1801. [PubMed: 15172780]
4. Abbas AK, Hefny AF, Abu-Zidan FM. Seatbelts and road traffic collision injuries. World J Emerg Surg. 2011 May; 28(1):6–18.
5. Dick WF. Anglo-American vs. Franco-German emergency medical services system. Prehosp Disaster Med. 2003 Jan-Mar;18(1):29–35. discussion-7. [PubMed: 14694898]
6. Lapostolle F, Gere C MD, Borron SW MD, Pétrovic T, Dallemagne F, Beruben A, et al. Prognostic factors in victims of falls from height. Crit Care Med. 2005 Jun.33:1239–1242. [PubMed: 15942337]
7. Haider AH, Saleem T, Leow J, Villegas CV, Kisat MT, Schneider ER, Haut ER, Stevens KA, Cornwell EE III, Efron DT. Influence of the National Trauma Data Bank on the Study of Trauma Outcomes: Is it Time to Set Research Best Practices to Further Enhance Its Impact? J Am Coll Surg. 2012 May; 214(5):756–768. Epub 2012 Feb 7. [PubMed: 22321521]
8. Iacus SM, King G, Porro G. Causal Inference Without Balance Checking: Coarsened Exact Matching. Political Analysis. 2011
9. Blackwell M, Iacus S, King G, Porro G. cem: Coarsened Exact Matching in Stata. The STATA Journal. 2010 Feb; 9(4):524–546.
10. Haider AH, Crompton JG, Oyetunji TA, Efron DT, Chang DC, Stevens KA, Cornwell EE 3rd, Haut ER. Females have fewer complications and lower mortality following trauma than similarly injured males: a risk adjusted analysis of adults in the National Trauma Data Bank. Surgery. 2009 Aug; 146(2):308–315. [PubMed: 19628090]
11. Oyetunji T, Crompton JG, Efron DT, Haut ER, Chang DC, Cornwell EE 3rd, et al. Simplifying physiologic injury severity measurement for predicting trauma outcomes. J Surg Res. 2010 Apr; 159(2):627–632. [PubMed: 20036392]
12. Greene WR, Oyetunji TA, Bowers U, Haider AH, Mellman TA, Cornwell EE, Siram SM, Chang DC. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. Am J Surg. 2010 Apr; 199(4):554–557. [PubMed: 20359573]
13. Haider AH, Chang DC, Haut ER, Cornwell EE 3rd, Efron DT. Mechanism of injury predicts patient mortality and impairment after blunt trauma. J Surg Res. 2009 May 1; 153(1):138–4210. [PubMed: 18805554]
14. Blackwell T, Kellam JF, Thomason M. Trauma care systems in the United States. Injury. 2003 Sep; 34(9):735–739. [PubMed: 12951302]
15. Masmejean EH, Faye A, Alnot JY, Mignon AF. Trauma care systems in France. Injury. 2003 Sep; 34(9):669–673. [PubMed: 12951291]
16. Georgiou A, Lockey DJ. The performance and assessment of hospital trauma teams. Scand J Trauma Resusc Emerg Med. 2010; 18:66. [PubMed: 21144035]
17. Driscoll PA, Vincent CA. Organizing an efficient trauma team. Injury. 1992; 23(2):107–110. [PubMed: 1572704]
18. Perno JF, Schunk JE, Hansen KW, Furnival RA. Significant reduction in delayed diagnosis of injury with implementation of a pediatric trauma service. Pediatr Emerg Care. 2005 Jun; 21(6): 367–371. [PubMed: 15942513]
19. Gerardo CJ, Glickman SW, Vaslef SN, Chandra A, Pietrobon R, Cairns CB. The rapid impact on mortality rates of a dedicated care team including trauma and emergency physicians at an academic medical center. JEM. 2009 May; 40(5):586–591.
20. American College of Surgeons. Resources for optimal care of the injured patient. Chicago: 2006.
21. Phillips JA, Buchman TG. Optimizing prehospital triage criteria for trauma team alerts. J Trauma. 1993 Jan; 34(1):127–132. [PubMed: 8437179]
22. Sakellariou A, McDonald PJ, Lane RH. The trauma team concept and its implementation in a district general hospital. Ann R Coll Surg Engl. 1995 Jan; 77(1):45–52. [PubMed: 7717645]
23. Sugrue M, Seger M, Kerridge R, Sloane D, Deane S. A prospective study of the performance of the trauma team leader. J Trauma. 1995 Jan; 38(1):79–82. [PubMed: 7745665]

24. David JS, Gueugniaud PY, Riou B, Pham E, Dubien PY, Goldstein P, Freysz M, Petit P. Does the prognosis of cardiac arrest differ in trauma patients? Crit Care Med. 2007 Oct; 35(10):2251–2255. [PubMed: 17944013]
25. Haider AH, Chang DC, Efron DT, Haut ER, Crandall M, Cornwell EE 3rd. Race and insurance status as risk factors for trauma mortality. Arch Surg. 2008 Oct; 143(10):945–949. [PubMed: 18936372]
26. Weissman J, Epstein AM. Case mix and resource utilization by uninsured hospital patients in the Boston metropolitan area. JAMA. 1989; 261(24):3572–3576. [PubMed: 2498539]
27. Englum BR, Villegas C, Bolorunduro O, Haut ER, Cornwell EE 3rd, Efron DT, Haider AH. Racial, ethnic, and insurance status disparities in use of posthospitalization care after trauma. J Am Coll Surg. 2011 Dec; 213(6):699–708. Epub 2011 Sep 29. [PubMed: 21958511]

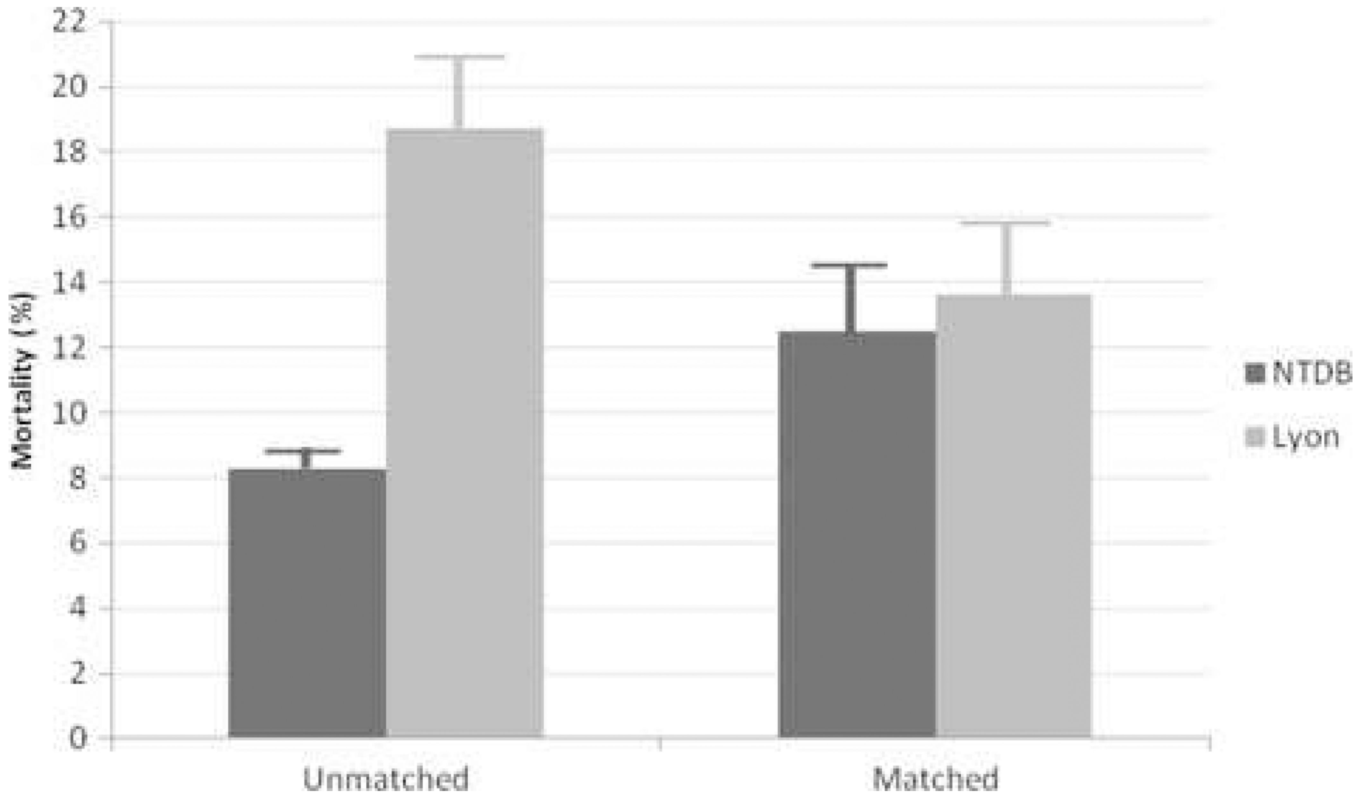

FIGURE 1.
Comparison of mortality proportions between the Lyon dataset and the NTDB, before and after matching.

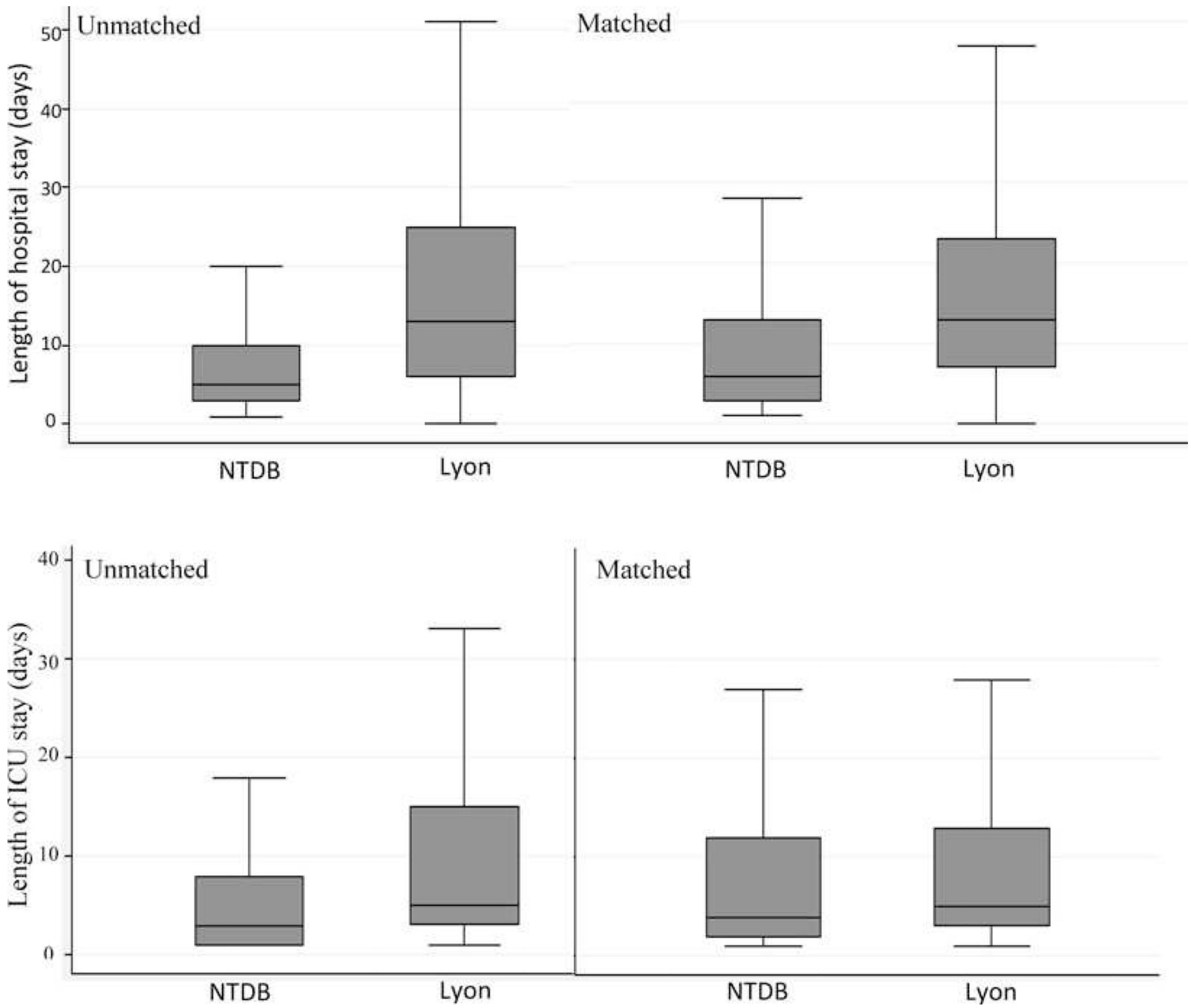

FIGURE 2.
Comparison of hospital and ICU length of stays between the Lyon dataset and the NTDB, before and after matching.

Table 1

Characteristics of patients in the Lyon Dataset and the National Trauma Database (NTDB).

Variable	Category	Lyon n= 1,043	NTDB n= 219,985	P value
Age (years)	16–25	295 (28.3)	55,827 (25.4)	<0.001
	26–35	228 (21.9)	36,817 (16.8)	
	36–45	187 (17.9)	37,262 (16.9)	
	46–55	137 (13.1)	30,789 (14.0)	
	56–65	76 (7.3)	19,027 (8.7)	
	66–75	62 (5.9)	14,709 (6.7)	
	76–85	47 (4.5)	16,866 (7.7)	
	Above 85	11 (1.1)	8,688 (4.0)	
Gender	Male	792 (75.9)	151,490 (68.9)	<0.001
	Female	251 (24.1)	68,495 (31.1)	
ISS	9–15	303 (29.1)	120,273 (54.7)	<0.001
	16–24	260 (24.9)	55,734 (25.3)	
	25–39	298 (28.6)	35,904 (16.3)	
	40–75	182 (17.5)	8,074 (3.7)	
Mechanism	Fall	262 (25.2)	53,375 (24.3)	<0.001
	MVC	477 (45.7)	120,584 (54.8)	
	Other	87 (8.3)	7,584 (3.5)	
	Pedestrian	128 (12.3)	11,978 (5.4)	
	SGSW	89 (8.5)	26,464 (12.0)	
Year	2002	291 (27.9)	49,587 (22.5)	0.103
	2003	263 (25.2)	52,872 (24.0)	
	2004	244 (23.4)	54,028 (24.6)	
	2005	245 (23.5)	63, 498 (28.9)	
GCS	3	133 (12.8)	24,620 (11.2)	<0.001
	4–5	53 (5.1)	2,318 (1.1)	
	6–8	104 (10.0)	6,019 (2.7)	
	9–11	84 (8.1)	5,581 (2.5)	
	12–15	669(64.1)	181,447 (82.5)	
SBP (mmHg)	0	43 (4.1)	2,859 (1.3)	<0.001
	1–49	41 (3.9)	558 (0.3)	
	50–75	61 (5.9)	3,380 (1.5)	
	76–89	109 (10.5)	5,471 (2.5)	
	>90	789 (75.7)	207,717 (94.4)	
Injury type	Blunt	938 (89.9)	192,900 (87.7)	<0.001
	Penetrating	105 (10.1)	27,085 (12.3)	
Mortality	Dead	195 (18.7)	18,219 (8.3)	<0.001
	Alive	848 (81.3)	201,766 (91.7)	
Hospital length of Stay (days)		13 (6–25)	5 (3–10)	<0.001*

Variable	Category	Lyon	NTDB	P value
		n= 1,043	n= 219,985	
ICU length of stay (days)		5 (3–15)	3 (1–8)	<0.001[*]

Values are median (Interquartile Range) or n (%).

[*]Wilcoxon rank sum test SGSW = Stab or Gunshot Wound.

Table 2

Subset analyses: crude and matched mortality rates with odds ratios and 95% confidence intervals

	Mortality rate		OR	95% CI
	Lyon	**NTDB**		
Blunt injury				
Crude	19.4%	7.4%	3.0*	2.55–3.53
Matched	14.4%	13.3%	1.2	0.81–1.85
Penetrating injury				
Crude	12.4%	14.3%	0.8	0.47–1.51
Matched	5.3%	4.0%	2.0	0.18–22.06
GCS 3–8				
Crude	51.4%	37.5%	1.8*	1.40–2.22
Matched	47.4%	42.7%	1.5	0.82–2.58
GCS 9–15				
Crude	6.1%	3.1%	2.0*	1.49–2.72
Matched	3.9%	3.8%	1.0	0.59–1.86

*Significant at $p<0.05$

Table 3

Sensitivity analysis of mortality rates using a 1: many matching scheme

	Mortality rate		OR	95% CI
	Lyon	NTDB		
All	13.7%	13.5%	1.0	0.77–1.39
Blunt injury	14.5%	14.4%	1.0	0.75–1.37
Penetrating injury	5.3%	4.2%	1.9	0.41–8.59
GCS 3–8	47.4%	43.8%	1.4	0.91–2.07
GCS 9–15	3.9%	4.8%	0.7	0.47–1.19