Disparities in trauma care and outcomes in the United States: A systematic review and meta-analysis

Adil H. Haider, MD, MPH, Paul Logan Weygandt, MPH, Jessica M. Bentley, BS, Maria Francesca Monn, MPH, Karim Abdur Rehman, Benjamin L. Zarzaur, MD, MPH, Marie L. Crandall, MD, MPH, Edward E. Cornwell, MD, MPH, *and* **Lisa A. Cooper, MD, MPH,** *Baltimore, Maryland*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this Journal-based CME activity for a maximum of *1 AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Credits can only be claimed online at this point.

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care* Surgery, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of *J Trauma Acute Care Surg* articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a 'commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12 months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff:

Ernest E. Moore, Editor: PI, research grant, Haemonetics. Associate editors: David Hoyt, Ronald Maier, and Steven Shackford have nothing to disclose. Editorial staff: Jennifer Crebs, Jo Fields, and Angela Sauaia have nothing to disclose.

Author Disclosures:

All authors have nothing to disclose.

Reviewer Disclosure:

The reviewers have nothing to disclose.

Cost

For AAST members and *Journal of Trauma and Acute Care Surgery* subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $25.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

Submitted: September 24, 2012, Revised: January 30 2013, Accepted: January 30 2013.

From the Center for Surgical Trials and Outcomes Research, Department of Surgery (A.H.H., P.L.W., J.M.B., M.F.M., K.A.R.), and Department of Medicine and Center to Eliminate Cardiovascular Health Disparities (L.A.C.), Johns Hopkins School of Medicine, Baltimore, Maryland; Department of Surgery (B.L.Z.), University of Tennessee Health Sciences Center, Memphis, Tennessee; Department of Surgery (M.L.C.), Northwestern University, Feinberg School of Medicine, Chicago, Illinois; and Department of Surgery (E.E.C.), Howard University College of Medicine, Washington, DC.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.jtrauma.com).

Address for reprints: Adil H. Haider, MD, MPH, Center for Surgical Trials and Outcomes Research, Johns Hopkins School of Medicine, 1800 Orleans St, Zayed Tower, 6107, Baltimore, Maryland 21287; email: ahaider1@jhmi.edu.

DOI: 10.1097/TA.0b013e31828c331d

Disparities in health outcomes have been uncovered for many conditions. Data indicate that black patients currently have higher mortality than white patients for 9 of the leading 15 causes of death. The life expectancy gap between black patients and white patients persists, although it has gradually improved from 7.1 years in 1989 to less than 5.0 years in 2009.[1]

Recent research suggests that patients from minority groups have higher mortality than white patients following trauma. This was surprising to some because trauma was thought to be immune to disparities given its emergent nature and apparent universal access to care for it. Therefore, an in-depth review of currently published literature on this topic is warranted. Studies have also shown that disparities in trauma are associated with insurance coverage and socioeconomic status (SES). Understanding the relationship between disparities based on race, insurance status, and SES may help to elucidate the mechanisms leading to these disparities. Moreover, by assessing the literature regarding disparities in the context of the continuum of care, a better understanding of possible interventions addressing these mechanisms can be obtained.

OBJECTIVES

The objectives of this review were to critically assess and summarize trauma outcome disparities by race, insurance, and SES and to determine if racial disparities are independent of insurance and SES. The objective of the meta-analysis was to determine whether mortality among trauma patients in the United States is associated with differences in patients' race and/or insurance coverage.

METHODS

Search Strategy

Using the Cochrane Handbook, the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) statement and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement as guides, we created a study protocol (see Supplement A, Supplemental Digital Content 1, http://links.lww.com/TA/A257). Accordingly, we searched PubMed and EMBASE for articles published between April 1990 and October 2011. Our search strategy is detailed in our study protocol, and the search process and study selection are detailed in Figure 1.

Analyses

We performed double data extraction and risk-of-bias assessment for all studies included in the meta-analysis. Articles were evaluated for variables tested, data quality, and statistical compatibility. Meta-analyses were performed only on those studies that provided information on race or insurance. Studies with the same-effect measure can be combined; therefore, only studies providing odds ratios (ORs) and confidence intervals (CIs) or standard errors (SEs) were included. In cases where study

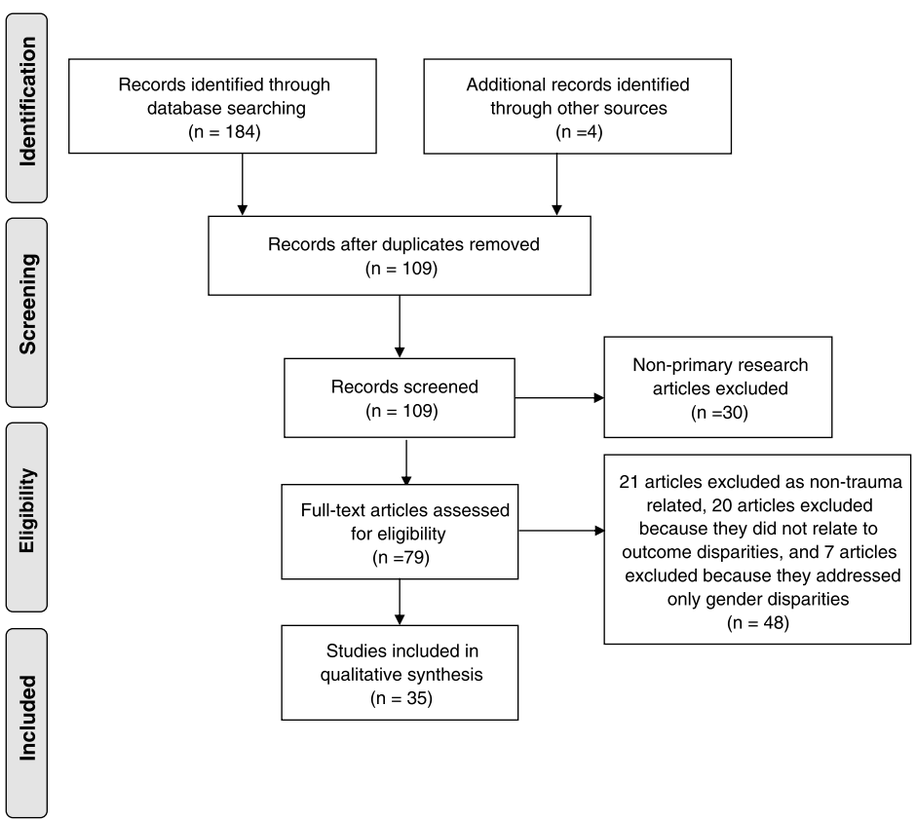

Figure 1. Flow diagram of search process and study selection as suggested by the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA).[5]

populations were likely to be overlapping, larger or higher-quality studies were selected for inclusion in meta-analysis. Studies were evaluated using a random-effects model to account for heterogeneity between the studies, which was evaluated using I^2. Forest plots were generated to evaluate relevant subgroups and sensitivity analyses. A p value of <0.05 was chosen a priori as indication of statistical significance. Statistical analysis was performed using Stata 12.1 (Statacorp, College Station, TX)

RESULTS

We identified 35 articles that qualified for inclusion in the systematic review (see Appendix I for characteristics). Ten studies were eliminated from the meta-analysis owing to insufficient mortality data.[2–11] We also eliminated eight studies for statistical incompatibility.[12–19]

Disparities by Insurance Status

Of 14 studies that assessed the impact of insurance status on trauma outcomes, 12[12,14,15,20–29] conclude that uninsured trauma patients have higher mortality rates than insured patients, while 1[8] found they had worse long-term functional outcomes, and one concludes that lack of private insurance is associated with higher mortality.[15] Increased mortality among uninsured patients was consistent among studies of the National Trauma Data Bank (NTDB), in regional studies and in single-institution studies.[20–22,28,29] The finding also held across studies of both adults and pediatric patients,[23,29] independent of injury type.[28] Vettukattil et al.[19] suggest that patients treated at safety-net hospitals do not experience an increased burden of mortality, despite the fact that they treat a higher burden of uninsured patients. While the definition of insurance differed among studies, consistency in conclusions suggests that this variation is unlikely to affect overall results.

For the meta-analysis, only those studies that were statistically compatible and which provided mortality data were eligible.[20–29] These studies categorized insurance in various ways; however, the majority of comparisons analyzed insured versus uninsured patients and private versus uninsured patients. There were insufficient nonoverlapping studies to allow for meta-analysis comparing insured and uninsured patients. Of the 10 eligible studies, 2[20,22] did not compare privately insured patients with uninsured patients, 4[24–26,28] overlapped with larger studies.[27,29] Our meta-analysis demonstrates that uninsured patients were more likely than privately insured patients to die after trauma (OR, 2.17; 95% CI, 1.51–3.11) (Fig. 2).

Differences in interventions may be related to disparities in trauma outcomes. In a statewide study in Massachusetts, uninsured trauma patients were less likely than the privately insured to undergo an operative procedure (OR, 0.68; 95% CI, 0.63–0.74) or physical therapy (OR, 0.61; 95% CI, 0.57–0.67).[21] Wood et al.[17] showed that uninsured more likely than the insured patients to receive skeletal surveys to uncover suspected child abuse; however, child abuse or positive skeletal surveys were more common among whites in this study.

Disparities by SES

Two studies[15,23] assess outcome disparities by SES, both of which conclude that median income of the patient's home address is a predictor of higher trauma mortality rates. In a small study on infant mortality following nonaccidental trauma by Rangel et al.,[15] median income was divided into quartiles and compared with the highest earning quartile (Q4). Each of the lower three quartiles were found to have significantly higher odds of mortality (Q1: OR, 6.75; $p = 0.0008$) (Q2: OR, 5.58; $p = 0.003$) (Q3: OR, 5.64; $p = 0.007$). Similarly, a large retrospective study of adults hospitalized after injury by Arthur et al.[23]

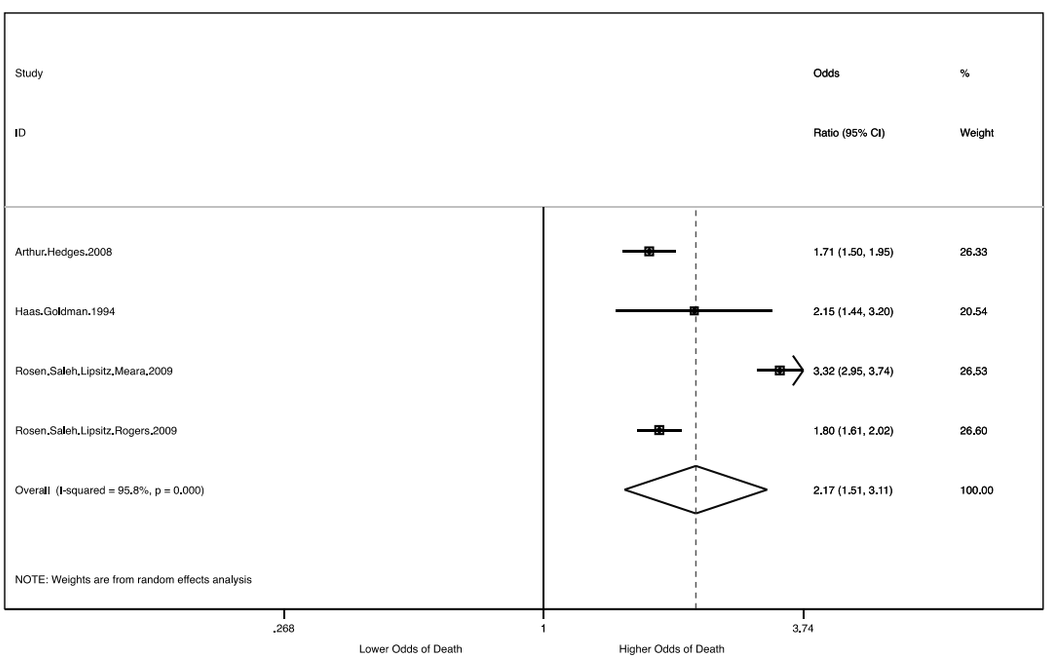

Figure 2. Random-effects meta-analysis of mortality for uninsured and privately insured patients. Pooled OR 2.17 (95% CI, 1.51–3.11) for uninsured patients compared with privately insured patients.

showed that a median income of patient's home zip code less than $45,000 was a predictor of higher mortality rates. This was highest for a median income less than $25,000, the lowest income bracket (OR, 1.32; 95% CI, 1.14–1.53).

Disparities by Race

Overall, data show that minority patients have worse trauma outcomes than white patients. Twenty-four studies[2,3,8,9,12,14–16,20,22–36] assess outcome disparities between racial groups; the majority focus on mortality as the outcome, and five focus on posttrauma functional outcomes. Of those, four[2,3,9,30] show that minority patients have worse functional outcomes, and one[8] found no significant difference by race. Another study went beyond comparing outcomes between racial groups and found that patients treated in hospitals with higher percentages of minority patients had significantly increased odds of mortality compared with hospitals treating primarily white patients.[13]

Similar to our qualitative review, our meta-analysis demonstrates that black patients have worse trauma mortality rates than white patients. Of the 24 studies in the qualitative analysis, 14 were eligible for meta-analysis,[20,22–25,27–32,34–36] and 1 study was eliminated from the analysis because it did not provide data for specific races.[31] Another study was eliminated because it did not provide ORs comparing minority races to the reference group.[22] Five studies[24,25,28,32,36] were eliminated because they overlapped with larger studies.[27,29] Our meta-analysis showed that black patients have worse trauma mortality rates than white patients (OR, 1.19; 95% CI, 1.09–1.31) (Fig. 3).

Findings vary when all nonwhite patients are combined into a single group. Of those, Downing et al.[12] and Gannon et al.[31] found that nonwhite race was a significant predictor of mortality, while three other studies[15,16,22] found no significant difference. However, there were insufficient nonoverlapping studies to perform a meta-analysis of nonwhite patients compared with white patients.

These conflicting results become clearer when considering each nonwhite cohort independently. Ten studies[14,23–27,32–35] found that black patients have significantly higher posttrauma mortality than white patients, while only three studies[22,24,30] found no significant difference between groups. In a retrospective cross-sectional analysis of the NTDB, Rosen et al.[27] found that black trauma patients had higher odds of death than white trauma patients after controlling for severity and patient characteristics including insurance status (OR, 1.18; 95% CI, 1.07–1.29). Oyetunji et al.[14] obtained similar results (OR, 1.31; 95% CI, 1.20–1.44). However, a retrospective single-institution study of 29,829 trauma patients controlled for similar factors and found that no single race or ethnicity was a significant predictor of mortality.[22]

Outcome disparities for black patients held across several types of trauma as well. Most prominent are well-documented racial disparities in pediatric traumatic brain injury (TBI) patients.[34,35] In a retrospective study comparing 3,111 pediatric head injury patients from the trauma database of Cincinnati Children's Hospital Medical Center to 13,363 patients in the NTDB, Falcone et al.[33] found that, even after controlling for insurance, injury severity, and other factors, African-American children had a mortality OR 3.1 times higher than that of white children (95% CI, 1.2–7.8). In moderately and severely injured pediatric trauma patients in the NTDB, blacks had higher mortality rates than whites (OR, 1.37; 95% CI, 1.22–1.52), even after controlling for insurance status, injury severity, and other

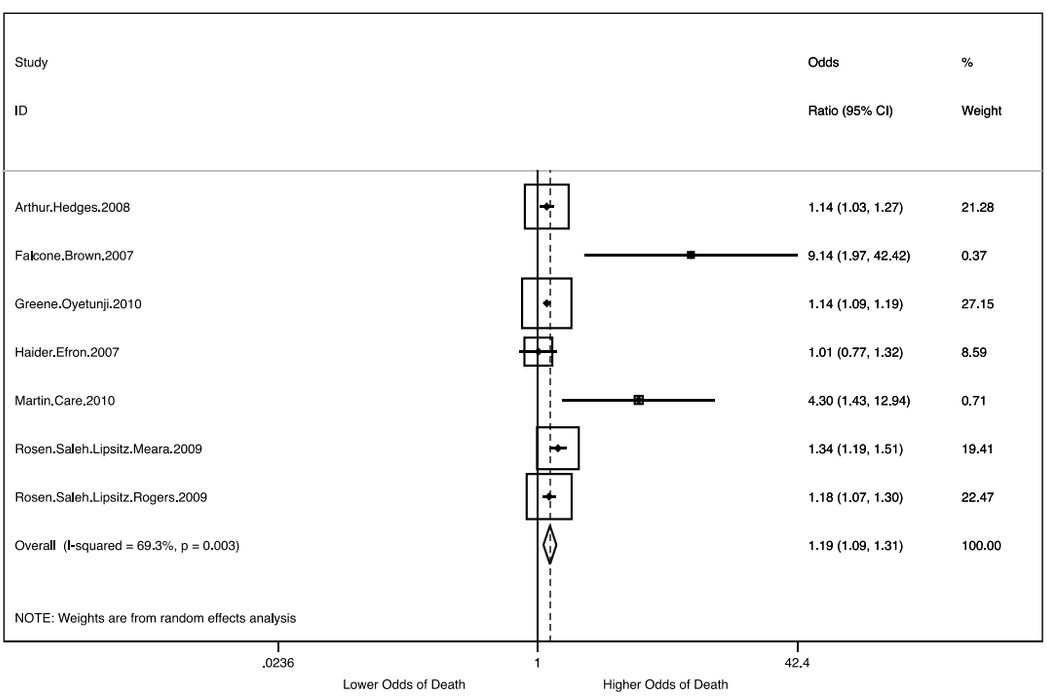

Figure 3. Random-effects meta-analysis of mortality for black and white patients. Pooled OR 1.19 (95% CI, 1.09–1.31) for black patients compared with white patients.

factors.[26] While one study found no significant difference for in-hospital mortality, black pediatric TBI patients had significantly worse functional outcomes at discharge than white patients.[30]

In both of the studies that assessed Asian trauma outcomes, mortality rates were higher than whites. In a 2008 study of adults hospitalized after injury, using data from the Healthcare Cost and Utilization Project, odds of death were higher for Asian patients (OR, 1.39; 95% CI, 1.06–1.83) and black patients (OR, 1.14; 95% CI, 1.03–1.27) compared with whites.[23] Among patients with moderate-to-severe TBI, blacks and Asians each had higher odds of mortality than whites with ORs of 1.19 (95% CI, 1.02–1.39) and 1.41 (95% CI, 1.11–1.79), respectively. In addition to controlling for patient characteristics and injury severity, this study also used the two following proxies to control for SES: insurance status and median income by patient zip code.[24]

In the seven studies comparing Hispanic and white post-trauma mortality outcomes, the results are less clear. Three studies found that Hispanic patients have worse post-trauma mortality outcomes than whites,[25,26,28] one found worse outcomes only associated with blunt mechanism,[36] and three found no significant difference between groups.[22,24,27] Using the NTDB, Rosen et al.[27] found no significant mortality difference between Hispanic and white trauma patients after controlling for severity and patient characteristics such as insurance status. By contrast, an analysis of 429,751 patients in the NTDB showed that Hispanic patients had higher adjusted odds of mortality than white patients (OR, 1.47; 95% CI, 1.39–1.57).[28] Millham and Jain[36] found that Hispanic drivers in motor vehicle crashes experienced higher mortality than white patients (OR, 1.72; 95% CI, 1.36–2.19) even after controlling for patient characteristics, presence of shock, and treatment facility characteristics. Two additional studies showed that Hispanic patients fare worse as pedestrians in motor vehicle accidents as well as in moderately and severely injured pediatric trauma.[25,26] Our meta-analysis, however, only demonstrated a trend toward a difference in mortality between Hispanic and white patients (OR, 1.08; 95% CI, 0.99–1.18).

An additional concern considered by this review was initial treatment upon presentation to the emergency department. Some might suggest that differential initial assessment and management of minority patients might lead to the aforementioned disparities, yet Shafi and Gentilello[10] found that these factors do not differ between racial groups.

Independence of Race Outcome Disparities

Because race and SES are correlated, it is important to decipher whether racial disparities are independent of socioeconomic disparities. The overwhelming majority of data show that black race is a predictor of higher trauma mortality independent of SES. Of the eight studies that compared black and white trauma patients while controlling for insurance status, seven[14,25–27,32–34] showed that black race is an independent predictor of mortality, while one study[5] found no significant difference. Arthur et al.[23] conclude that black patients have higher mortality rates independent of both proxies for SES (insurance status and median income of patient zip code).

For Hispanic trauma outcomes, controlling for SES does not significantly add to the mixed results presented previously. Of the studies that control for insurance status, two[25,26] found that Hispanic patients had worse outcomes, while two[22,27] found no difference. Likewise, only one[23] of the two studies[24] assessing Asian trauma outcomes controlled for SES. While Asian race was an independent predictor of higher mortality rates using both proxies, further studies are needed to validate this finding. Although black race seems to be an independent predictor of mortality and results regarding other racial disparities are not clear, one study showed that insurance has a stronger predictive value on mortality than race,[28] a finding echoed by two other recent studies.[14,26]

Disparities in Post–Acute Trauma Care and Rehabilitation

Disparities in post–acute care have also been well demonstrated.[4,6,11,18] Millham and Jain[36] found that black and Hispanic patients surviving gunshot wounds and motor vehicle accidents had a shorter length of stay than white patients ($p < 0.001$). The study controlled for insurance, injury severity, and other patient and hospital characteristics. A large study of the NTDB found that black and Hispanic patients were less likely to be discharged to a rehabilitation center than white patients following moderate or severe TBI with relative odds of 0.68 (95% CI, 0.55–0.83) and 0.67 (95% CI, 0.52–0.86).[24] Despite some conflicting evidence,[8] these results are confirmed by a comparable

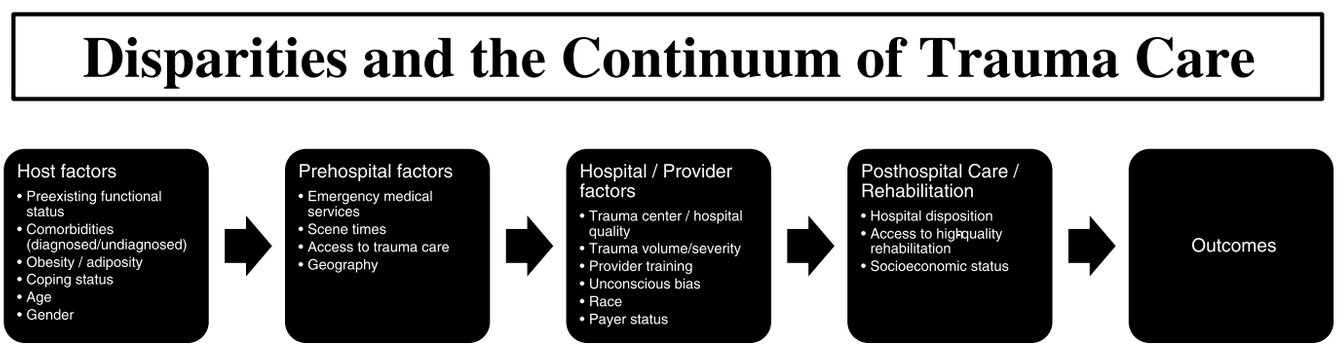

Figure 4. The continuum of trauma care. Factors identified in literature that are thought to impact outcome and lead to disparities in trauma outcomes.

study of TBI patients in the NTDB by Shafi et al.[7] and a study by Nirula et al.,[5] which showed evidence that race and insurance status are independent negative predictors in the likelihood of being transferred to a rehabilitation facility upon discharge. Englum et al.[18] found that black patients were much less likely to be discharged to rehabilitation centers (RRR 0.61; 95% CI 0.56–0.66) as were Hispanic patients (RRR 044; 95% CI 0.40–.049).

DISCUSSION

Trauma is considered an important frontier in disparities research because of apparent universal access and well-validated means of severity adjustment that allow for reasonable comparisons between groups.[36] Despite these advantages, refining study variables and developing comparison groups that uncover existing disparities are still a work in progress. This review demonstrates the progress that has been made in refining the measurement of SES and addressing the heterogeneity of minority populations. Both of the studies that assessed SES outcome disparities using median income of the patient's home address found clear evidence that SES is a predictor of higher trauma mortality rates. The apparent significance of this variable should encourage health disparities researchers to incorporate additional SES indicators. At the same time, researchers should continually push for more accurate and sensitive data, such as income, wealth, and education data at the census tract level and occupation data on the individual patient level. Overall, studies that combine all minority patients into one cohort did not find evidence of inequalities. Departing from this binary approach, evidence of disparities becomes immediately evident for black and Asian trauma patients. While outcome disparities were less clear for Hispanic patients, the large heterogeneity in length of years in the United States and English proficiency of the US Hispanic population may mask inequalities experienced by segments of this population. Disparities in Hispanic patient outcomes may be ambiguous at a national level but should be able to be unmasked through additional regional and subgroup studies.

Mechanisms of Disparities and Opportunities for Intervention

While trauma may provide universal access to some level of care, clear outcome disparities based on race, SES, and insurance status suggest that these inequalities are likely to have a systemic component. By assessing mechanisms of disparities within the context of the continuum of care (Fig. 4), we can begin to understand the interplay of factors that contribute to disparate health outcomes. See Supplement B (Supplemental Digital Content 2, http://links.lww.com/TA/A258) for an in-depth discussion of mechanisms of disparities within the continuum of trauma care as well as interventions we believe to be most prudent for reducing or eliminating those disparities. Firm elucidation of mechanisms underlying disparities is timely, as policy makers have begun to seek and support interventions.

Limitations

This study is limited by the observational nature of the included articles and the inherent risks of selection bias and confounding associated with such studies. Many of the included articles assessed mortality following trauma, although it has been suggested that adjusted mortality may not be the best indicator of quality of trauma care.[37] Future studies should assess quality of care using quality indicators, such as those proposed by the American College of Surgeons' Committee on Trauma (ACSCOT), which have been shown to correlate with outcomes.[38] Moreover, it has been suggested that when assessing outcomes, it is important to determine subtler measures of quality not currently included in the ACSCOT quality indicators by assessing metrics such as failure to rescue, cost-effectiveness, and functional outcomes in lieu of "blunt," measures such as mortality.[39] Databases such as the NTDB represent convenience samples, leading to a risk of selection bias. However, the vast majority of trauma centers are now reporting to the NTDB, and this database is thus becoming more representative of the general US population. Administrative databases are also limited in that they lack patient-level information necessary to use ACSCOT audit filters or other metrics of quality.[38] To address confounding, we performed an assessment of risk of bias and included effect measures from the most adjusted models in the meta-analysis. Even still, not all studies adjusted for the same variables, which likely led to increased interstudy heterogeneity. One limitation of the meta-analysis is that studies reported outcomes by different groups, thus limiting the numbers of comparisons we could make. Moreover, many of the studies were published using the NTDB, and because study populations overlapped, we were forced to eliminate many studies from the meta-analysis, thus reducing our sample size. Future systematic reviews and meta-analysis should take care to assess risk of bias in included studies, attempt to reduce sources of bias and confounding, and avoid analyzing studies that investigate overlapping populations.

CONCLUSION

This study finds consistent evidence that disparities in trauma care and outcomes exist between privately insured patients and uninsured patients, with the bulk of the literature showing uninsured patients have worse outcomes regardless of the reference group. This study also finds significant disparities in outcomes between black and white patients, but we identified inconsistent evidence that these disparities in trauma care and outcomes also exist for Hispanic and Asian patients. Finally, we suggest that interventions should focus on injury prevention, increasing access to care, encouraging growth in number of trauma centers serving vulnerable populations, and improvements in resident training.

AUTHORSHIP

A.H.H. contributed in the study design, data analysis, data interpretation, and writing of the article. J.M.B. contributed in the study design, data interpretation, and writing of the article. P.L.W. contributed in the study design, data analysis, data interpretation, and writing of the article. M.F.M. contributed in the study design, data analysis, data interpretation, and critical review. K.A.R. contributed in the study design, data interpretation, and writing of the article. B.L.Z. contributed in the study design, data interpretation, and critical review. M.L.C. contributed in the study design, data interpretation, and critical review. A.E.C. contributed in the study design, data interpretation, and critical review. L.A.C. contributed in the study design, data interpretation, and critical review.

ACKNOWLEDGMENT

We thank Ariel Bowman for providing important input regarding issues of access in trauma care.

DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Kochanek KD, Xu J, Murphy SL, Minino AM, Kung HC. Deaths: final data for 2009. National vital statistics reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System. 2011;60:1–166.
2. Arango-Lasprilla JC, Rosenthal M, Deluca J, Cifu DX, Hanks R, Komaroff E. Functional outcomes from inpatient rehabilitation after traumatic brain injury: how do Hispanics fare? *Arch Phys Med Rehabil*. 2007;88:11–18.
3. Arango-Lasprilla JC, Rosenthal M, Deluca J, et al. Traumatic brain injury and functional outcomes: does minority status matter? *Brain Inj*. 2007;21: 701–708.
4. Krause JS, Broderick LE, Saladin LK, Broyles J. Racial disparities in health outcomes after spinal cord injury: mediating effects of education and income. *J Spinal Cord Med*. 2006;29:17–25.
5. Nirula R, Nirula G, Gentilello LM. Inequity of rehabilitation services after traumatic injury. *J Trauma*. 2009;66:255–259.
6. Sacks GD, Hill C, Rogers SO Jr. Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care. *J Trauma*. 2011;71:1011–1015.
7. Shafi S, de la Plata CM, Diaz-Arrastia R, et al. Ethnic disparities exist in trauma care. *J Trauma*. 2007;63:1138–1142.
8. Shafi S, Marquez de la Plata C, Diaz-Arrastia R, et al. Racial disparities in long-term functional outcome after traumatic brain injury. *J Trauma*. 2007;63:1263–1268; discussion 1268–1270.
9. Staudenmayer KL, Diaz-Arrastia R, de Oliveira A, Gentilello LM, Shafi S. Ethnic disparities in long-term functional outcomes after traumatic brain injury. *J Trauma*. 2007;63:1364–1369.
10. Shafi S, Gentilello LM. Ethnic disparities in initial management of trauma patients in a nationwide sample of emergency department visits. *Arch Surg*. 2008;143:1057–1061; discussion 1061.
11. Leukhardt WH, Golob JF, McCoy AM, Fadlalla AM, Malangoni MA, Claridge JA. Follow-up disparities after trauma: a real problem for outcomes research. *Am J Surg*. 2010;199:348–352; discussion 353.
12. Downing SR, Oyetunji TA, Greene WR, et al. The impact of insurance status on actuarial survival in hospitalized trauma patients: when do they die? *J Trauma*. 2011;70:130–134; discussion 134–135.
13. Haider AH, Ong'uti S, Efron DT, et al. Association between hospitals caring for a disproportionately high percentage of minority trauma patients and increased mortality: a nationwide analysis of 434 hospitals. *Arch Surg*. 2012;147:63–70.
14. Oyetunji TA, Crompton JG, Ehanire ID, et al. Multiple imputation in trauma disparity research. *J Surg Res*. 2011;165:e37–e41.
15. Rangel EL, Burd RS, Falcone RA Jr. Socioeconomic disparities in infant mortality after nonaccidental trauma: a multicenter study. *J Trauma*. 2010; 69:20–25.
16. Tepas JJ 3rd, Pracht EE, Orban BL, Flint LM. Insurance status, not race, is a determinant of outcomes from vehicular injury. *J Am Coll Surg*. 2011; 212:722–727; discussion 727–729.
17. Wood JN, Hall M, Schilling S, Keren R, Mitra N, Rubin DM. Disparities in the evaluation and diagnosis of abuse among infants with traumatic brain injury. *Pediatrics*. 2010;126:408–414.
18. Englum BR, Villegas C, Bolorunduro O, et al. Racial, ethnic, and insurance status disparities in use of posthospitalization care after trauma. *J Am Coll Surg*. 2011;213:699–708.
19. Vettukattil AS, Haider AH, Haut ER, et al. Do trauma safety-net hospitals deliver truly safe trauma care? A multilevel analysis of the national trauma data bank. *J Trauma*. 2011;70:978–984.
20. Greene WR, Oyetunji TA, Bowers U, et al. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. *Am J Surg*. 2010;199:554–557.
21. Haas JS, Goldman L. Acutely injured patients with trauma in Massachusetts: differences in care and mortality, by insurance status. *Am J Public Health*. 1994;84:1605–1608.
22. Salim A, Ottochian M, DuBose J, et al. Does insurance status matter at a public, Level I trauma center? *J Trauma*. 2010;68:211–216.
23. Arthur M, Hedges JR, Newgard CD, Diggs BS, Mullins RJ. Racial disparities in mortality among adults hospitalized after injury. *Med Care*. 2008;46:192–199.
24. Bowman SM, Martin DP, Sharar SR, Zimmerman FJ. Racial disparities in outcomes of persons with moderate to severe traumatic brain injury. *Med Care*. 2007;45:686–690.
25. Maybury RS, Bolorunduro OB, Villegas C, et al. Pedestrians struck by motor vehicles further worsen race- and insurance-based disparities in trauma outcomes: the case for inner-city pedestrian injury prevention programs. *Surgery*. 2010;148:202–208.
26. Hakmeh W, Barker J, Szpunar SM, Fox JM, Irvin CB. Effect of race and insurance on outcome of pediatric trauma. *Acad Emerg Med*. 2010;17: 809–812.
27. Rosen H, Saleh F, Lipsitz S, Rogers SO Jr., Gawande AA. Downwardly mobile: the accidental cost of being uninsured. *Arch Surg*. 2009;144: 1006–1011.
28. 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;143:945–949.
29. Rosen H, Saleh F, Lipsitz SR, Meara JG, Rogers SO Jr. Lack of insurance negatively affects trauma mortality in US children. *J Pediatr Surg*. 2009;44:1952–1957.
30. Haider AH, Efron DT, Haut ER, DiRusso SM, Sullivan T, Cornwell EE 3rd. Black children experience worse clinical and functional outcomes after traumatic brain injury: an analysis of the National Pediatric Trauma Registry. *J Trauma*. 2007;62:1259–1262; discussion 1262–1253.
31. Gannon CJ, Napolitano LM, Pasquale M, Tracy JK, McCarter RJ. A statewide population-based study of gender differences in trauma: validation of a prior single-institution study. *J Am Coll Surg*. 2002;195:11–18.
32. Crompton JG, Pollack KM, Oyetunji T, et al. Racial disparities in motorcycle-related mortality: an analysis of the National Trauma Data Bank. *Am J Surg*. 2010;200:191–196.
33. Falcone RA Jr, Martin C, Brown RL, Garcia VF. Despite overall low pediatric head injury mortality, disparities exist between races. *J Pediatr Surg*. 2008;43:1858–1864.
34. Falcone RA Jr, Brown RL, Garcia VF. Disparities in child abuse mortality are not explained by injury severity. *J Pediatr Surg*. 2007;42:1031–1036; discussion 1036–1037.
35. Martin CA, Care M, Rangel EL, Brown RL, Garcia VF, Falcone RA Jr. Severity of head computed tomography scan findings fail to explain racial differences in mortality following child abuse. *Am J Surg*. 2010;199: 210–215.
36. Millham F, Jain NB. Are there racial disparities in trauma care? *World J Surg*. 2009;33:23–33.
37. Stelfox HT, Bobranska-Artiuch B, Nathens A, Straus SE. Quality indicators for evaluating trauma care: a scoping review. *Arch Surg*. 2010;145:286–295.
38. Glance LG, Dick AW, Mukamel DB, Osler TM. Association between trauma quality indicators and outcomes for injured patients. *Arch Surg*. 2012;147:308–315.
39. Mabry CD. Time to turn the page: moving on to write new chapters for trauma care. *Arch Surg*. 2012;147:315–316.

APPENDIX I. Annotated Bibliography of Trauma Outcome Disparity Research

Author	Title	Study Design	Study Characteristics
Arango-Lasprilla et al.[3]	Traumatic brain injury and functional outcomes: does minority status matter?	Retrospective cross-sectional	Outcome of interest: rehabilitation characteristics and functional outcomes. Years: 1989–2004 Data source: TBI Model Systems database Age requirements: none. Adjusted variables: ethnicity, age, level of education, injury severity, functional status at rehabilitation admission, functional status 1 y later, community integration, and Extended Glasgow Outcomes Score
Arango-Lasprilla et al.[2]	Functional outcomes from inpatient rehabilitation after traumatic brain injury: how do Hispanics fare?	Retrospective cross-sectional	Outcome of interest: rehabilitation placement Years: 1989–2003 Data source: TBI Model Systems database Age requirements: >16 Adjusted variables: ethnicity, age, length of posttraumatic amnesia, injury severity, functional outcome scores, and preinjury education
Arthur et al.[23]	Racial disparities in mortality among adults hospitalized after injury	Retrospective cross-sectional	Outcome of interest: in-hospital mortality Years: 1998–2002 Data source: Healthcare Cost and Utilization Project Age requirements: 18–64 Adjusted variables: age, race, sex, comorbid conditions, injury severity, primary payer, median income of zip code of residence, hospital type
Bowman et al.[24]	Racial disparities in outcomes of persons with moderate to severe traumatic brain injury	Retrospective cross-sectional	Outcome of interest: TBI mortality Years: 2000–2003 Data source: NTDB Age requirements: none Adjusted variables: payer type, spinal cord injury, hypotension, comorbidities, age, sex, GCS, injury type, injury intent, injury severity, hospital volume of TBI, trauma designation
Crompton et al.[32]	Racial disparities in motorcycle-related mortality: an analysis of the National Trauma Data Bank	Retrospective cross-sectional	Outcome of interest: motorcycle crash in-hospital mortality Years: 2002–2006 Data source: NTDB Age requirements: >18 Adjusted variables: age, sex, insurance status, year, helmet use, injury severity characteristics
Downing et al.[12]	The impact of insurance status on actuarial survival in hospitalized trauma patients: when do they die?	Retrospective cross-sectional	Outcome of interest: mortality Years: 2002–2006 Data source: NTDB Age requirements: 19–30 Adjusted variables: age, ethnicity, sex, history of substance abuse, mechanism of injury, injury severity, shock, complications, teaching status of hospital
Englum et al.[18]	Racial, ethnic, and insurance status disparities in use of posthospitalization care after trauma	Retrospective cross-sectional	Outcome of interest: discharge to posthospitalization facilities by race and insurance status Years: 2007 Data source: NTDB Age requirements: 18–64 Adjusted variables: age, sex, ISS, presence of shock, GCS-motor, mechanism of injury, type of injury, intention of injury, presence of severe head/extremity injury, trauma level designation, and length of hospital stay.
Falcone et al.[34]	Disparities in child abuse mortality are not explained by injury severity	Retrospective cross-sectional	Outcome of interest: child abuse mortality Years: 1995–2004 Data source: Cincinnati Children's Hospital Database Age requirements: <16 Adjusted variables: race, age, GCS, injury severity, pulse, blood pressure, respiratory rate, insurance

Falcone et al.[33]	Despite overall low pediatric head injury mortality, disparities exist between races	Retrospective cross-sectional	Outcome of interest: mortality Years: 2000–2004 Data source: NTDB and Cincinnati Children's Hospital Database Age requirements: <16 Adjusted variables: sex, ethnicity, ISS, pulse, blood pressure, respiratory rate, GCS, number of injuries, insurance status, disposition, LOS
Gannon et al.[31]	A statewide population-based study of gender differences in trauma: validation of a prior single-institution study	Prospective cohort	Outcome of interest: hospital mortality Years: 1996–1997 Data source: Pennsylvania trauma centers database Age requirements: 18–64 Adjusted variables: sex, ethnicity, respiratory rate, blood pressure, Revised Trauma Score (RTS), injury type, history of cardiac disease, cancer, immune diseases, or diabetes mellitus
Greene et al.[20]	Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma	Retrospective cross-sectional	Outcome of interest: blunt trauma mortality Years: 2002–2006 Data source: NTDB Age requirements: <65 Adjusted variables: insurance status, mechanism of injury, age, race, sex, injury severity, shock head injury, extremity injury, hospital teaching status, year
Haas and Goldman[21]	Acutely injured patients with trauma in Massachusetts: differences in care and mortality, by insurance status	Retrospective cross-sectional	Outcome of interest: resource use and mortality Years: 1990 Data source: institutional data results Age requirements: 15–64 Adjusted variables: age, sex, race, injury severity, comorbidity
Haider et al.[13]	Association between hospitals caring for a disproportionately high percentage of minority trauma patients and increased mortality	Retrospective cohort	Outcome of interest: mortality Years: 2007–2008 Data source: NTDB Age requirements: 18–64 Adjusted variables: age, sex, insurance status, injury severity score, presence of hypotension, presence of severe head and/or extremity injury, mechanism of injury.
Haider et al.[28]	Race and insurance status as risk factors for trauma mortality	Retrospective cross-sectional	Outcome of interest: in-hospital mortality Years: 2001–2005 Data source: NTDB Age requirements: 18–64 Adjusted variables: age, sex, injury severity, RTS, severe extremity injury, type of injury, mechanism of injury
Haider et al.[30]	Black children experience worse clinical and functional outcomes after traumatic brain injury: an analysis of the National Pediatric Trauma Registry	Retrospective cross-sectional	Outcome of interest: TBI mortality Years: 1996–2001 Data source: NTDB Age requirements: 2–16 Adjusted variables: severity of head injury, anatomic injury, and physiologic injury, intent of injury, type of injury, mechanism of injury, age, sex, comorbidities, severe extremity injury
Hakmeh et al.[26]	Effect of race and insurance on outcome of pediatric trauma	Retrospective cross-sectional	Outcome of interest: moderate-to-severe injury mortality Years: 2000–2005 Data source: NTDB Age requirements: ≤17 Adjusted variables: race, insurance status, injury type, injury severity
Krause et al.[4]	Racial disparities in health outcomes after spinal cord injury: mediating effects of education and income	Retrospective cross-sectional	Outcome of interest: spinal cord injury outcomes disparities Years: not stated Data source: hospital records Age requirements: >18 Adjusted variables: race, sex, quality of life variables, use of services

(Continued on next page)

APPENDIX I. *(Continued)*

Author	Title	Study Design	Study Characteristics
Leukhardt et al.[11]	Follow-up disparities after trauma: a real problem for outcomes research	Retrospective cross-sectional	Outcome of interest: follow-up after trauma Years: 2000–2005 Data source: institutional records, trauma registry, national death index, census Age requirements: none Adjusted variables: age, sex, race, disposition, discharge zip code, length of stay, penetrating trauma, ISS, spinal cord injury, head ISS > 3, death after discharge.
Martin et al.[35]	Severity of head computed tomography scan findings fail to explain racial differences in mortality following child abuse	Retrospective cross-sectional	Outcome of interest: non-accidental trauma mortality Years: 1994–2004 Data source: institutional database Age requirements: ≤16 Adjusted variables: race, injury severity, others not specified.
Maybury et al.[25]	Pedestrians struck by motor vehicles further worsen race- and insurance-based disparities in trauma outcomes: the case for inner-city pedestrian injury prevention programs	Retrospective cross-sectional	Outcome of interest: pedestrian accident mortality Years: 2002–2006 Data source: NTDB Age requirements: 16–64 Adjusted variables: sex, age, injury severity, shock, severe head injury, severe extremity injury, hospital teaching status, year of admission
Millham et al.[36]	Are there racial disparities in trauma care?	Retrospective cross-sectional	Outcome of interest: gunshot wound, MVC mortality Years: 2001–2005 Data source: NTDB Age requirements: >14 Adjusted variables: age, sex, ISS, blood pressure, geographic region, hospital teaching status, trauma center status
Nirula et al.[5]	Inequity of rehabilitation services after trauma injury	Retrospective cohort	Outcome of interest: discharge to rehabilitation facility Years: 2000–2004 Data source: NTDB Age requirements: none (subgroup analysis for <65) Adjusted variables: age, sex, race, payer, comorbidities, drug or alcohol use, ISS, systolic blood pressure, GCS, AIS
Oyetunji et al.[14]	Multiple imputation in trauma disparity research	Retrospective cross-sectional	Outcome of interest: multiple imputation analysis in trauma Years: 2002–2006 Data source: NTDB Age requirements: age ≥18 Adjusted variables: age, sex, anatomic and physiologic injury severity, severe head and extremity injury
Rangel et al.[15]	Socioeconomic disparities in infant mortality after nonaccidental trauma: a multicenter study	Retrospective cross-sectional	Outcome of interest: nonaccidental trauma mortality Years: 2000–2004 Data source: multiple institutional databases Age requirements: <1 Adjusted variables: race, insurance status, injury severity, head injury severity
Rosen et al.[27]	Downwardly mobile: the accidental cost of being uninsured	Retrospective cross-sectional	Outcome of interest: mortality Years: 2002–2006 Data source: NTDB Age requirements: ≥18 Adjusted variables: sex, race, age, injury severity, RTS, trauma center level, mechanism of injury
Rosen et al.[29]	Lack of insurance negatively affects trauma mortality in US children	Retrospective cross-sectional	Outcome of interest: mortality Years: 2002–2006 Data source: NTDB Age requirements: ≤16 Adjusted variables: race, injury severity, sex, injury type
Sacks et al.[6]	Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care	Retrospective cohort	Outcome of interest: disposition to a specialized post–acute care facility Years: 2002–2006 Data source: NTDB Age requirements:≥18 Adjusted variables: age, sex, ISS, race/ethnicity, mechanism of injury.
Salim et al.[22]	Does insurance status matter at a public, level I trauma center?	Retrospective cross-sectional	Outcome of interest: trauma mortality Years: 1998–2005 Data source: institutional database Age requirements: ≥18 Adjusted variables: sex, age, injury type, blood pressure, GCS, toxicology, injury severity, AIS
Shafi et al.[7]	Ethnic disparities exist in trauma care	Retrospective cross-sectional	Outcome of interest: TBI mortality Years: 2004 Data source: NTDB Age requirements: none Adjusted variables: age, sex, injury severity, AIS, GCS, associate injuries, insurance status

Shafi and Gentilello[10]	Ethnic disparities in initial management of trauma patients in a nationwide sample of emergency department visits	Retrospective cross-sectional	Outcome of interest: intensity of ED assessment and management and discharge disposition Years: 2003 Data source: National Hospital Ambulatory Medical Care Survey Age requirements: ≥15 Adjusted variables: not explicitly stated
Shafi et al.[8]	Racial disparities in long-term functional outcome after traumatic brain injury	Retrospective cross-sectional	Outcome of interest: functional outcomes among TBI patients Years: 1998–2005 Data source: institutional data Age requirements: ≥14 Adjusted variables: age, sex, injury severity, AIS, GCS, disposition, insurance status
Staudenmayer et al.[9]	Ethnic disparities in long-term functional outcomes after traumatic brain injury	Prospective cohort	Outcome of interest: functional outcomes among TBI patients Years: 1998–2005 Data source: institutional data Age requirements: ≥14 Adjusted variables: age, sex, GCS, AIS, injury severity
Tepas et al.[16]	Insurance status, not race, is a determinant of outcomes from vehicular injury	Retrospective cross-sectional	Outcome of interest: MVC victim mortality Years: 2008–2009 Data source: Florida Healthcare Administration Database Age requirements: none Adjusted variables: age, sex, ethnicity, insurance status, ICISS, comorbidities, severity, TBI, spinal cord injury, torso injury, vascular injury
Vettukattil et al.[19]	Do trauma safety-net hospitals deliver truly safe trauma care? A multilevel analysis of the national trauma data bank	Retrospective cross-sectional	Outcome of interest: mortality Years: 2001–2005 Data source: NTDB Age requirements: 18–64 Adjusted variables: age, sex, insurance, injury severity, shock, type and mechanism of injury
Wood et al.[17]	Disparities in the evaluation and diagnosis of abuse among infants with traumatic brain injury	Retrospective cross-sectional	Outcome of interest: diagnosis of abuse in TBI infants Years: 2004–2008 Data source: pediatric Health Information System Age requirements: <1 Adjusted variables: unclear