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Journal
Annals of Surgery, 263(2)

ISSN
0003-4932

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Publication Date
2016-02-01

DOI
10.1097/sla.0000000000001047

Peer reviewed

Published in final edited form as:
Ann Surg. 2016 February ; 263(2): 406–412. doi:10.1097/SLA.0000000000001047.

Geographic Variation in Outcome Benefits of Helicopter Transport for Trauma in the United States:

A Retrospective Cohort Study

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Abstract

Objective—Evaluate the effect of US geographic region on outcomes of helicopter transport (HT) for trauma.

Background—HT is an integral component of trauma systems. Evidence suggests that HT is associated with improved outcomes; however, no studies examine the impact of geographic variation on outcomes for HT.

Methods—Retrospective cohort study of patients undergoing scene HT or ground transport in the National Trauma Databank (2009–2012). Subjects were divided by US census region. HT and ground transport subjects were propensity-score matched based on prehospital physiology and injury severity. Conditional logistic regression was used to evaluate the effect of HT on survival and discharge to home in each region. Region-level characteristics were assessed as potential explanatory factors.

Results—A total of 193,629 pairs were matched. HT was associated with increased odds of survival and discharge to home; however, the magnitude of these effects varied significantly across regions ($P < 0.01$). The South had the greatest survival benefit (odds ratio: 1.44; 95% confidence interval: 1.39–1.49, $P < 0.01$) and the Northeast had the greatest discharge to home benefit (odds ratio: 1.29; 95% confidence interval: 1.18–1.41, $P < 0.01$). A subset of region-level characteristics influenced the effect of HT on each outcome, including helicopter utilization, injury severity, trauma center and helicopter distribution, trauma center access, traffic congestion, and urbanicity ($P < 0.05$).

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Disclosure: The other authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.annalsofsurgery.com).

Conclusions—Geographic region impacts the benefits of HT in trauma. Variations in resource allocation partially account for outcome differences. Policy makers should consider regional factors to better assess and allocate resources within trauma systems to optimize the role of HT.

Keywords

geographic; helicopter; outcome; trauma; variation

Trauma remains one of the leading public health burdens in the United States.[1] Helicopter transport (HT) of injured patients has become an integral component of modern trauma systems. The availability of HT has substantially increased access to trauma center care.[2] Several studies have shown that HT compared with ground transport (GT) is associated with improved survival for the trauma patient.[3–10] Despite this, little evidence explores the impact of geographic variation on the role of HT in trauma systems. Some have reported significant regional variation in compliance of HT with triage guidelines, but the effect on outcomes was not reported.[11]

Regionalization of trauma systems has significantly improved trauma care[12–15]; however, significant variation in access, structure, and outcomes exists across trauma systems in the United States.[2,16–19] There is evidence that region-level factors may influence outcome after injury.[20–23] No studies have evaluated whether outcomes in trauma patients undergoing HT vary across region or the potential for region-level characteristics to influence these outcomes.

The objective of this study was to evaluate the effect of US geographic census region on outcomes in HT compared with GT, using a large national database. We hypothesized that the effect of HT compared with GT on mortality would vary across geographical regions, and region-level factors may play a role in these differences.

Methods

Data Sources and Study Population

Adult patients (aged ≥16 years) transported from the scene of injury by helicopter or ground ambulance from 2009 to 2012 in the National Trauma Databank (NTDB) were eligible for inclusion. The NTDB represents a national database containing more than 3 million injured patients from more than 900 hospitals in the United States.[24] Patients transferred from another hospital were excluded. Demographics, hospital characteristics, injury severity, vital signs, *International Classification of Diseases*, *Ninth Revision* diagnosis codes, intensive care unit admission, mechanical ventilation, emergency department disposition, and hospital disposition were collected for each subject. Hospital characteristics included US geographic census region in which the facility was located. US geographic census regions include the Northeast, Midwest, South, and West regions.[25] Subjects treated at a hospital with unknown US census region were excluded.

Several sources of data were utilized to examine region-level variables. Data were collected for each geographic census region or collected for each state and then combined into US census regions.[25] Data were collected for each year over the study period and combined to give an average region-level estimate.

Within the NTDB, the proportion of HT, median prehospital time, and median injury severity score (ISS) were calculated at the region level. Median prehospital time and median ISS were further separated into region-level median values for HT subjects and GT subjects. United States Census Bureau data were used to obtain population estimates and land area in square miles for each region.[26,27] The Atlas and Database of Air Medical Services was used to determine the number of medical helicopters and helicopter bases within each region.[28–31] The number of level I or level II trauma centers within each region was determined by the number of contributing facilities within the NTDB by region. These data were combined to calculate the number of level I or level II trauma centers, number of helicopter bases, and number of helicopters per 1 million people in each region. The number of level I or II trauma centers per 10,000 square miles was also calculated.

The proportion of the population with access to a level I or level II trauma center within 60 minutes by HT within each region was calculated from University of Pennsylvania Cartographic Modeling Laboratory data.[32] The ratio of HT:GT access within 60 minutes was calculated by dividing the proportion of population with access to a level I or level II trauma center within 60 minutes by HT by the proportion of population with the same access by GT. This gives a measure of how much HT increases trauma center access beyond access available by GT in each region. Geographic locations of level I and II trauma centers[32] were plotted using ArcMap software (Redlands, CA). Average nearest neighbor analysis was performed to obtain the mean distance to the closest neighboring trauma center for each hospital.

United States Department of Agriculture urban influence codes were combined as a measure of urbanicity for each region.[33] Urban influence codes range from 1 indicating a large metro area to 12 indicating a noncore micro area. This scale was recoded in reversed order, such that increasing urbanicity represents more urban areas.

Annual roadway congestion index and travel time index were obtained from the United States Department of Transportation as measures of traffic congestion in each region.[34,35] United States Census Bureau data regarding median household income for each region were obtained.[36] Finally, a previous study reported 5 triage criteria from the national field triage guidelines that are associated with a survival benefit in patients undergoing HT.[37,38] The proportion of HT subjects meeting each of these 5 triage criteria [age >55 years, penetrating injury, respiratory rate <10 or >29 breaths per minute, Glasgow Coma Scale (GCS) score <14, presence of any one physiologic triage criterion plus any one anatomic triage criterion (PHY + ANA)] at the region level was also determined. The presence of these triage criteria was determined from individual subject level data within each region, including age, prehospital vital signs, and *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis codes.

Missing Data

Multiple imputation was performed for variables to be used in the analysis if less than 25% of observations were missing. Imputed variables included sex, mechanism of injury, prehospital time, prehospital systolic blood pressure, prehospital heart rate, prehospital respiratory rate, prehospital GCS, ISS, and Trauma Mortality Prediction Model–predicted mortality. Multiple imputation using an iterative Markov chain Monte Carlo fully conditional specification model based on available demographics, vital signs, injury severity, intensive care unit admission, urgent operation, and survival was performed using 5 imputations. Imputations were pooled and analysis was performed on the complete data set. Missing data for imputed variables ranged from 0.2% (sex) to 20.8% (prehospital GCS score). Sensitivity analysis was performed using complete cases.

Propensity Score Matching

The use of propensity score matching has been shown to obtain more accurate treatment effect estimates for HT in a similar population,[6] thus propensity score matching was performed between HT and GT subjects. Propensity score matching is a method that reduces potential bias and known confounders by matching treated and control subjects on the basis of their likelihood of being exposed to the treatment taking into account known variables in the data set that would be expected to influence treatment assignment.[39] Propensity scores were estimated using generalized additive logit models that can reduce bias in treatment effect estimation when compared with logistic regression estimation of propensity scores.[40] Covariates in the propensity score model included hospital identification number, age, sex, mechanism of injury (blunt or penetrating), pre-hospital time, prehospital systolic blood pressure, prehospital heart rate, prehospital respiratory rate, prehospital GCS score, ISS, and Trauma Mortality Prediction Model–predicted mortality.[41] These covariates were selected for inclusion in the propensity score on the basis of information available during the prehospital period and markers of overall injury severity that prehospital providers would evaluate to reasonably guide the decision to assign a patient to either HT or GT at the scene of injury. HT subjects were considered treatment subjects whereas GT subjects were considered control subjects.

Matching was performed using a 1:1 ratio nearest neighbor algorithm. Subjects were matched in random order without replacement or caliper. Exact matching was specified for US census region, which restricts matching of any treatment and control subject pair to the same US census region. This allowed separate analysis of each US census region while maintaining the appropriate matched treatment and control pairs. Standardized differences were used to assess the balance of covariates after matching.[42] Standardized differences greater than 0.2 were considered to indicate large imbalance among covariates used in the propensity score for matching.

Statistical Analysis

The primary outcome was in-hospital survival. The secondary outcome was discharge disposition in survivors defined as home versus discharge to a rehabilitation or skilled nursing facility. Conditional logistic regression models were used to determine the association of HT compared with GT with the outcomes of interest while accounting for matched pairs. Model covariates were selected a priori for known prognostic significance to the outcomes of interest that were not accounted for in the propensity score matching procedure, which were then confirmed to be associated with the outcomes in univariate analysis or change the model coefficient for transport mode by 10% or more. Covariates for the primary outcome included trauma center level (level I or II vs other designation), urgent operation (defined as emergency department disposition to the operating room), mechanical ventilation, and admission year. Covariates for the secondary outcome included trauma center level, urgent operation, mechanical ventilation, development of a complication during admission, spinal cord injury, insurance status (commercial, Medicare/Medicaid, or none), and admission year. In addition, this model was used to test the interaction between transport mode and US census region to evaluate whether region modified the treatment effect of transport mode on the outcomes of interest. To evaluate the effect of transport mode on the outcomes of interest for each US census region, these models were repeated within subjects from each of the 4 regions separately. Geographic regional variation was considered significant if the interaction between transport mode and US census region was statistically significant, and the 95% confidence intervals (95% CIs) of the adjusted odds ratio (AOR) for the outcome of interest did not overlap for at least 2 individual regions.

Goodness-of-fit was graphically assessed by plotting the predicted survival from the primary outcome model versus observed survival. Predicted survival was divided into decile bins, and the average predicted survival within each decile bin was plotted against the proportion of actual surviving patients within the same decile bin. Collinearity was assessed using variance inflation factors, and any covariate with a value greater than 10 was removed from final models.

To evaluate whether region-level variables differed across US census regions, χ^2 tests were used to compare categorical variables and analysis of variance used to compare continuous variables between the 4 regions. To evaluate whether region-level variables also modified the treatment effect of transport mode on the outcomes of interest at the subject level, conditional logistic regression models adjusted for the covariates described previously for the primary and secondary outcomes were used to test the interaction between transport mode and each region-level variable. To account for multiple comparisons, false discovery rate (FDR) procedures were used and FDR-adjusted *P* values are reported.[43]

Based on NTDB data and prior work,[4,6] using a 2-sided α of 0.05, control group survival of 95.6%, and control:intervention allocation ratio of 7.7, the study requires a total sample size of 78,570 subjects to detect an odds ratio of 1.20 for survival in the intervention group with 90% power. The control group survival rate and the control:intervention allocation ratio for sample size were determined from data in the NTDB. The effect size was determined from prior studies utilizing the NTDB.[4,6] Numbers needed to treat were calculated from AORs and expressed as number of patients required to undergo HT to save 1 additional life or to result in 1 additional discharge to home.[44] For univariate comparisons of baseline subject-level characteristics, χ^2 tests were used to compare categorical variables and Wilcoxon rank sum tests were used to compare continuous variables. A *P* value of 0.05 or less was considered significant with 2-sided tests. This study was determined exempt by the

Institutional Board Review at the University of Pittsburgh. Data analysis was conducted using STATA version 13 (College Station, TX) and SPSS version 21 (Chicago, IL).

Results

There were 1,679,675 subjects included in the initial study population (Fig. 1). Table 1 illustrates subject characteristics in the HT and GT groups. HT subjects were younger, had longer prehospital times, and had a higher proportion of males, blunt injury, and admission to a level I or II trauma center. HT subjects had more severe injury, evidenced by lower systolic blood pressure and GCS, higher heart rate, ISS, and Trauma Mortality Prediction Model mortality probability. HT subjects also had a higher proportion of urgent operation and mechanical ventilation. Unadjusted survival was lower in the HT group.

During propensity score matching, 193,629 pairs were matched, leaving a study sample of 387,258 subjects for analysis. After matching, no variable included in the calculation of the propensity score remained unbalanced, with a standardized difference of greater than 0.2, and overall standardized difference was reduced by 93.1% (Fig. 2). After matching, unadjusted in-hospital survival was 92.3% versus 91% and discharge to home was 73% versus 76% in the HT and GT groups respectively.

HT was associated with an increased odds of in-hospital survival (AOR: 1.48, 95% CI: 1.44–1.52, $P < 0.001$; numbers needed to treat 27, 95% CI: 25–29). The interaction term of transport mode and region was significant ($P < 0.001$). HT was associated with an increased odds of survival across all regions in matched subjects. The magnitude of the treatment effect varied significantly across regions in matched patients, with the South region having the greatest increase in odds of survival (AOR: 1.44; 95% CI: 1.39–1.49, $P < 0.001$) and the Northeast region having the smallest increase in odds of survival (AOR: 1.27; 95% CI: 1.17–1.37, $P < 0.001$) with no overlap of the 95% CI between the South and Northeast regions (Table 2).

HT was associated with an increased odds of discharge to home (AOR: 1.16, 95% CI: 1.13–1.19, $P < 0.001$; numbers needed to treat: 35, 95% CI: 30–43). The interaction term of transport mode and region was significant ($P = 0.01$). HT was associated with an increased odds of discharge to home across all regions. The magnitude of the treatment effect varied significantly across regions in matched patients, with the Northeast region having the greatest increase in odds of discharge to home (AOR: 1.29; 95% CI: 1.18–1.41, $P < 0.001$) and the Midwest region having the smallest increase in odds of discharge to home (AOR: 1.09; 95% CI: 1.01–1.17, $P < 0.001$) with no overlap of the 95% CI between the Northeast and Midwest regions (Table 3).

The models demonstrated adequate fit of the data with good approximation of predicted and observed survival across risk deciles (see Supplemental Digital Content Fig. 1, available at http://links.lww.com/SLA/A687). No qualitative differences in primary or secondary outcomes were present in complete case sensitivity analysis.

Of the region-level characteristics, only ratio of HT:GT trauma center access was not significantly different across regions (Table 4). For the primary outcome of survival, significant interactions with transport mode were seen in a subset of region-level characteristics including proportion of HT (FDR: *P* = 0.031), prehospital time (FDR: *P* = 0.028), ISS (FDR: *P* = 0.026), trauma centers per 10,000 square miles (FDR: *P* = 0.002), helicopter bases per 1 million people (FDR: *P* = 0.033), access to trauma center within 60 minutes (FDR: *P* = 0.019), ratio of HT:GT access to trauma center within 60 minutes (FDR: *P* = 0.017), average nearest neighbor distance (FDR: *P* = 0.005), income (FDR: *P* = 0.014), proportion with respiratory rate less than 10 breaths per minute or greater than 29 breaths per minute (FDR: *P* = 0.012), proportion with GCS score less than 14 (FDR: *P* = 0.010), and proportion with PHY + ANA criteria (FDR: *P* = 0.007). For the secondary outcome of discharge to home, significant interactions with transport mode were seen in a subset of region-level characteristics including ISS (FDR: *P* = 0.012), trauma centers per 1 million people (FDR: *P* = 0.024), trauma centers per 10,000 square miles (FDR: *P* = 0.002), helicopter bases per 1 million people (FDR: *P* = 0.021), helicopters per 1 million people (FDR: *P* = 0.017), urbanicity (FDR: *P* = 0.009), access to trauma center within 60 minutes (FDR: *P* = 0.007), travel time index (FDR: *P* = 0.005), and proportion with age more than 55 years (FDR: *P* = 0.014).

Discussion

This study confirms a survival and discharge disposition benefit of HT compared with GT in trauma patients. Although controversy still surrounds the role of HT in trauma, these findings are similar to recent studies.[4,6, 8–10] The treatment effect reported here is slightly larger than that previously reported by some and may be due to the inclusion of in-hospital covariates in the outcome models, which we felt important to control for competing risks during hospitalization, especially when evaluating the effect of a prehospital intervention on in-hospital survival and discharge disposition.[6] Furthermore, more recent years of the NTDB have less missing data for total prehospital time that had been excluded in prior studies, allowing imputation and inclusion of this important variable in the outcome models for this study.

Although there was a survival and discharge disposition benefit across all US census regions, the magnitude of these outcome benefits varied significantly across geographic regions. Such variation across geographic regions points toward the potential role of region-level variables in the benefit of HT for trauma. Several have investigated regional variation in trauma care. Minei et al[19] reported significant variations in incidence and outcomes for severe injury among geographic regions in North America. Others have noted that the southern United States has a higher injury and mortality rate for motor vehicle collisions than other regions.[21,23, 45] Traffic fatality rate has also been linked to population density and vehicle miles traveled.[20,22] Authors propose that these findings may relate to timely access to high-quality care. At a region level, access to emergency medical services, distribution of trauma centers and helicopters,[46] traffic conditions, and resource availability may impact outcomes after HT for trauma.

Access to care is a key issue in trauma. Trauma center care has been shown to reduce 1-year mortality by up to 25%, making timely access to care critical.[12] More than 15% of the US population cannot reach a level I or II trauma center within 60 minutes; however, this disparity is not evenly distributed geographically in the United States.[2] Although organized regional trauma systems improve outcomes, it may take up to 10 years to mature and produce these results.[14,47] Rural location also adversely impacts potential access to trauma center care.[2,17] Furthermore, Gomez and colleagues[16] reported regional discrepancies between potential and realized trauma center access, demonstrating that processes and allocation of resources in addition to geography impact access to care within trauma systems.

Importantly, this analysis revealed a subset of region-level characteristics that modified the treatment effect of HT on survival and discharge disposition, suggesting these may underlie some of the variation in outcome seen across regions. Furthermore, different region-level variables were important for influencing survival versus discharge disposition in HT. Differences among regions in this subset of region-level variables may offer potential reasons underlying why certain regions had greater outcome benefits. For survival, the South had the greatest benefit whereas the Northeast had the smallest benefit. Among the region-level variables found to modify this relationship, the South had the highest proportion of HT, highest number of helicopter bases per 1million people, and longest transport times, indicating that helicopter utilization and allocation may play a role in geographic variation of outcomes. The South had the highest number of trauma centers per 10,000 square miles and greatest distance between nearest neighboring trauma centers, indicating that geographic distribution of trauma centers may influence outcome for HT. The ratio of HT:GT access within 60 minutes was highest in the South, indicating that HT accounted for a larger increase in trauma center access than in other regions. The South had the highest injury severity and proportion of patients that met each of the 5 triage criteria previously associated with improved survival for patients undergoing HT.[37] A study of regional compliance with HT triage guidelines found that compliance rates varied between 50% and 94%.[11] Optimal patient selection may underlie some of the regional variation in benefit for HT.

For discharge to home, the Northeast had the greatest benefit. Among the region-level variables found to modify this relationship, the Northeast had lower injury severity but highest urbanicity and highest travel time index, indicating that HT patients in the Northeast may be at a lower risk of death but are more often flown for logistic reasons such as traffic congestion delaying GT. The Northeast also had highest access to a trauma center within 60 minutes and higher proportion of HT subjects older than 55 year. Thus, ready access to trauma centers through HT for older patients may result in improved discharge disposition through optimized care.[48,49]

Some region-level variables are nonmodifiable within the scope of trauma system development, whereas others can be improved such as geographic distribution of resources and triage guidelines. Optimal distribution of transport resources may allow for increases in timely access to trauma center care over a regional population. This may be particularly important, as access to trauma centers was identified as a region-level factor influencing outcomes after HT in this study. Likely, a constellation of these factors representing the overall system and resources is reflected in the outcome variation, rather than any individual characteristic. As different region-level variables influence either survival or discharge disposition, it should be possible to evaluate region-level factors in a trauma system to optimize modifiable factors in an effort to improve these valuable outcomes for HT of injured patients.

This study has several limitations. First are those inherent to a retrospective design. This study used propensity score matching and accounted for hospital clustering to reduce bias in the estimation of treatment effects. Despite this, only observed confounders can be utilized in the propensity score and unmeasured confounding may remain. Although the NTDB data quality has improved substantially, high levels of missing data persist, particularly in prehospital variables. Multiple imputation was used to mitigate this and less than 21% of any imputed variable was missing. The NTDB is not a population-based data set and skewed toward large trauma centers.[50] We used prehospital time in the propensity score to reduce bias in the contact time with prehospital providers; however, no measure of distance between the scene of injury and receiving trauma center was available the data set. Although time and distance are correlated, the exact nature of the relationship is affected by many factors, such as traffic and weather. Future investigations of geographic variation for HT should aim to incorporate geographic transport distances in the analysis to explore the effect of this factor on outcomes. Data on HT availability was not present in the database but would likely influence outcomes and may be differentially distributed across geographic regions. For example, weather patterns may affect HT availability, and the South region may have more days helicopters can safely fly as reflected in the higher utilization than those in other regions. Other important outcomes such as health-related quality of life are not available, and discharge disposition represents only a partial view of quality of life in survivors. We cannot explore the underlying mechanisms that may drive the outcome benefits. Finally, it is difficult to establish the true magnitude of effect or causality for the region-level variables on the benefit of HT.

Conclusions

This is the first study to evaluate geographic variation in outcome of HT for trauma and most importantly the underlying region-level factors that influence this relationship. Geographic region significantly impacts the magnitude of outcome benefits for HT in trauma. There is geographic variation in logistical, system, and utilization characteristics that partially underlie these differences in outcomes. Policy makers should consider geographic and regional factors to better assess and allocate resources in an effort to optimize the role of HT within individual trauma systems.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

No funding or support was directly received to perform the current study. Dr Brown receives support from an institutional T-32 Ruth L. Kischstein National Research Service Award training grant (5-T32-GM-008516-20) from the National Institutes of Health. Dr Sperry receives support from a career development award (K23GM093032) from the National Institute of General Medical Sciences.

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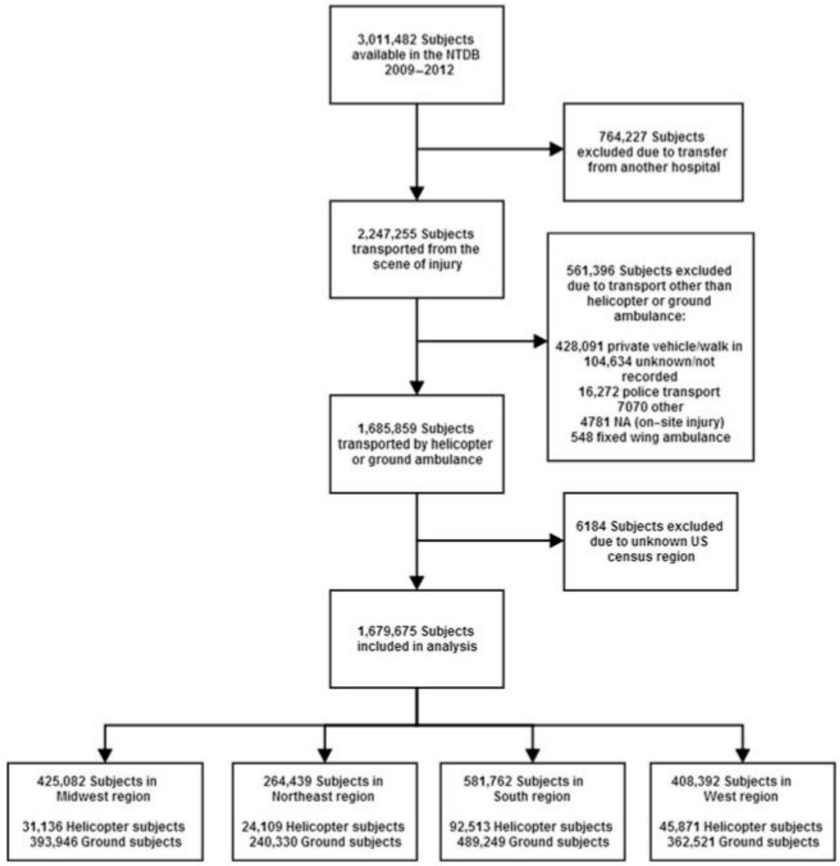

Figure 1.
Study participant selection from the National Trauma Databank 2009–2012.

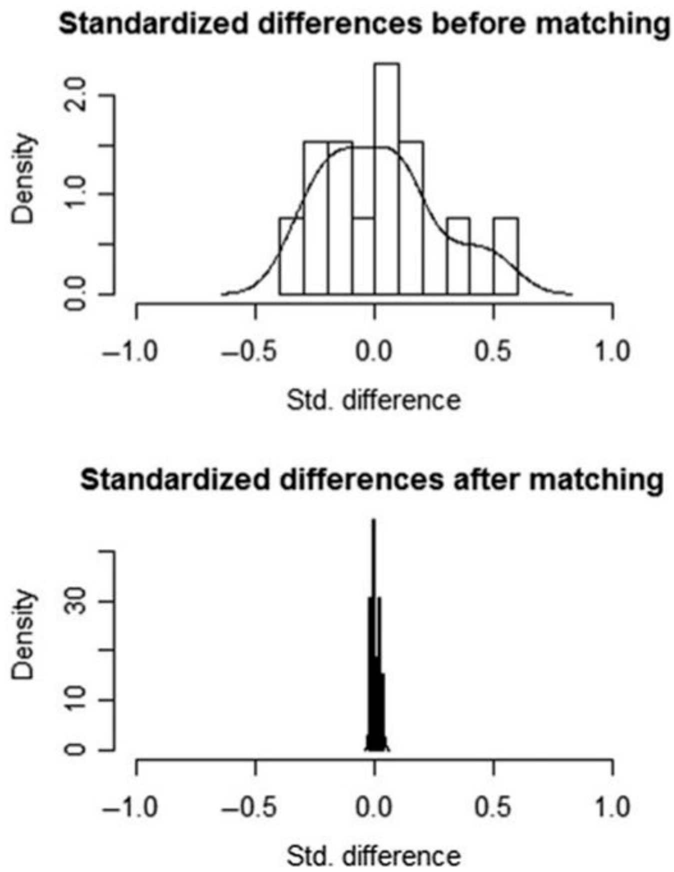

Figure 2.

Standardized differences for variables included in the propensity score before and after the matching procedure.

Table 1

Characteristics of All Subjects Transported by Helicopter or Ground Ambulance From the Scene of Injury

	Helicopter (n = 193,629)	Ground (n = 1,486,046)	*P*[*]	Standardized Difference[†]
Age [median (IQR)], yr	37 (22–53)	46 (26–68)	<0.001	0.012
Sex (% male)	70	61	<0.001	0.019
Mechanism of injury			<0.001	0.005
Blunt (%)	92	89	—	—
Penetrating (%)	8	11	—	—
Admitted to level I or II trauma center (%)	54	53	<0.001	—
Prehospital time [median (IQR)], min	66 (51–105)	46 (34–93)	<0.001	0.010
Prehospital systolic blood pressure [median (IQR)], mm Hg,	130 (113–145)	134 (118–150)	<0.001	0.010
Prehospital heart rate [median (IQR)], beats/min	94 (80–110)	90 (78–104)	<0.001	0.008
Prehospital respiratory rate [median (IQR)], bpm	18 (16–21)	18 (16–20)	0.650	0.018
Prehospital Glasgow Coma Scale score [median (IQR)]	14 (12–15)	15 (14–15)	<0.001	0.020
Injury severity score [median (IQR)]	12 (5–22)	9 (4–11)	<0.001	0.026
TMPM probability of death [median (IQR)]	0.025 (0.011–0.103)	0.016 (0.008–0.033)	<0.001	0.025
Required urgent operation (%)	19	11	<0.001	—
Required mechanical ventilation (%)	28	10	<0.001	—
In-hospital survival (%)	92	96	<0.001	—
Discharge to home (%)	70	73	<0.001	—

[*] Chi-square tests were used to compare categorical variables and Wilcoxon rank sum tests were used to compare continuous variables.

[†] Standardized difference between groups after matching for variables used in propensity score estimation. Differences >0.2 are considered significant residual imbalance between groups after matching.

bpm indicates breaths per minute; IQR, interquartile range.

Table 2

Adjusted Odds Ratio of in-Hospital Survival for Helicopter Compared With Ground Transport Across US Census Regions

	AOR (95% CI)	*P*	NNT (95% CI)[*]
South region	1.44 (1.39–1.49)	$P < 0.001$	29 (26–32)
Midwest region	1.36 (1.28–1.45)	$P < 0.001$	35 (28–45)
West region	1.31 (1.23–1.40)	$P < 0.001$	40 (32–54)
Northeast region	1.27 (1.17–1.37)	$P < 0.001$	46 (34–73)

[*]NNT was calculated as [CER (AOR − 1) + 1]/[CER (AOR − 1) (1 − CER)], where CER is the control event rate or mortality rate in the control group (ground transport group).

NNT indicates number needed to treat.

Table 3

Adjusted Odds Ratio of Discharge to Home Among Survivors for Helicopter Compared With Ground Transport Across US Census Regions

	AOR (95% CI)	*P*	NNT* (95% CI)
Northeast region	1.29 (1.18–1.41)	$P < 0.001$	20 (15–32)
South region	1.15 (1.10–1.20)	$P < 0.001$	38 (29–56)
West region	1.15 (1.08–1.23)	$P < 0.001$	38 (25–69)
Midwest region	1.09 (1.01–1.17)	$P < 0.001$	62 (33–545)

*NNT was calculated as [CER (AOR − 1) + 1]/[CER (AOR − 1) (1 − CER)], where CER is the control event rate or mortality rate in the control group (ground transport group).

NNT indicates number needed to treat.

Table 4

Region-Level Characteristics Across US Census Regions

Region Characteristic	Midwest (n = 425,082)	Northeast (n = 264,439)	South (n = 581,762)	West (n = 408,392)	*P**
Transports by helicopter (%)	7	9	16	11	<0.001
Prehospital time [median (IQR)]	42 (32–58)	45 (33–64)	50 (36–71)	42 (32–61)	<0.001
HT	65 (52–82)	55 (45–69)	64 (50–85)	64 (50–91)	<0.001
GT	41 (31–55)	43 (32–63)	47 (35–67)	40 (31–56)	<0.001
ISS [median (IQR)]	9 (4–10)	9 (4–14)	9 (4–14)	8 (4–13)	<0.001
HT	13 (6–22)	12 (5–22)	13 (6–22)	10 (5–19)	<0.001
GT	8 (4–10)	9 (4–13)	9 (4–12)	6 (4–12)	<0.001
Trauma centers/1 million people (mean ± SD)	3.3 ± 0.2	1.7 ± 0.1	2.0 ± 0.2	1.9 ± 0.4	<0.001
Trauma centers/10,000 square miles (mean ± SD)	2.1 ± 0.1	7.4 ± 0.4	7.8 ± 0.7	0.8 ± 0.1	0.001
Helicopter bases/1 million people (mean ± SD)	2.5 ± 0.1	1.4 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	<0.001
Helicopters/1 million people (mean ± SD)	2.8 ± 0.1	1.8 ± 0.1	3.1 ± 0.1	3.7 ± 0.1	<0.001
Urbanicity (mean ± SD)	6.9 ± 1.9	9.7 ± 1.9	8.9 ± 1.6	6.9 ± 2.1	<0.001
Access to trauma center within 60 min (mean ± SD), %	81 ± 20	96 ± 7	84 ± 20	65 ± 31	0.018
Ratio HT:GT access to trauma center (mean ± SD)	1.48 ± 0.3	1.59 ± 0.6	2.38 ± 2.4	1.35 ± 0.6	0.202
Average nearest neighbor distance (mean ± SD), degrees	0.27 ± 0.3	0.27 ± 0.2	0.56 ± 0.5	0.43 ± 0.5	<0.001
Roadway congestion index (mean ± SD)	0.89 ± 0.1	0.87 ± 0.1	0.98 ± 0.1	1.04 ± 0.1	<0.001
Travel time index (mean ± SD)	1.15 ± 0.1	1.20 ± 0.1	1.17 ± 0.1	1.17 ± 0.1	<0.001
Median income (mean ± SD), US dollars	$51,178 ± $3882	$58,470 ± $7641	$48,242 ± $8915	$53,750 ± $6206	0.008
Penetrating injury (%)	4.6	4.8	9.0	8.9	<0.001
RR <10 bpm or >29 bpm (%)	10.3	7.5	10.7	8.4	<0.001
GCS <14 (%)	30.6	27.1	30.6	23.8	<0.001
Age >55 yr (%)	20.6	24.1	20.9	20.3	<0.001
At least 1 physiologic +1 anatomic criterion (%)	9.1	6.7	9.3	7.1	<0.001

*Chi-square tests were used to compare categorical variables and analysis of variance used to compare continuous variables.

bpm indicates breaths per minute; GCS, Glasgow Coma Scale; IQR, interquartile range; RR, respiratory rate.