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Factors Associated with the Use of Helicopter Inter-facility Transport of Trauma Patients to Tertiary Trauma Centers within an Organized Rural Trauma System

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Abstract

Objective—A review of the literature yielded little information regarding factors associated with the decision to use ground (GEMS) or helicopter (HEMS) emergency medical services for trauma patients transferred inter-facility. Furthermore, studies evaluating the impact of inter-facility transport mode on mortality have reported mixed findings. Since HEMS transport is generally reserved for more severely injured patients, this introduces indication bias, which may explain the mixed findings. Our objective was to identify factors at referring non-tertiary trauma centers (NTC) influencing transport mode decision.

Methods—This was a case-control study of trauma patients transferred from a Level III or IV NTC to a tertiary trauma center (TTC) within 24-hours reported to the Oklahoma State Trauma Registry between 2005 and 2012. Multivariable logistic regression was used to determine clinical and non-clinical factors associated with the decision to use HEMS.

Results—A total of 7380 patients met the study eligibility. Of these, 2803(38%) were transported inter-facility by HEMS. Penetrating injury, prehospital EMS transport, severe torso injury, hypovolemic shock, and TBI were significant predictors ($p < 0.05$) of HEMS use regardless of distance to a TTC. Association between HEMS use and male gender, Level IV NTC, and local ground EMS resources varied by distance from the TTC. Many HEMS transported patients had minor injuries and normal vital signs.

Conclusions—Our results suggest that while distance remains the most influential factor associated with HEMS use, significant differences exist in clinical and non-clinical factors between patients transported by HEMS versus GEMS. To ensure comparability of study groups,

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studies evaluating outcome differences between HEMS and GEMS should take factors determining transport mode into account. The findings will be used to develop propensity scores to balance baseline risk between GEMS and HEMS patients for use in subsequent studies of outcomes.

Keywords

air ambulances; wounds and injuries; trauma centers; Inter-Facility; Helicopter; Transport; Rural

Background

Despite decades of research exploring the use of helicopter emergency medical service (HEMS) transport for the transport of trauma patients, questions remain as to the effectiveness and appropriate use of this resource.¹⁻¹² Though numerous studies have examined the characteristics and outcomes of patients transported by ground emergency medical services (GEMS) or HEMS from the scene of injury, there is a relative paucity of research comparing patients transported inter-facility by GEMS or HEMS or the factors at a non-tertiary (Level III or IV) trauma center (NTC) impacting the choice of transport modality. In states with large rural populations, trauma patients are frequently taken to the nearest hospital and subsequently transferred to a tertiary (Level I or II) trauma center (TTC) by GEMS or HEMS. Often the closest hospital is a NTC with limited resources aimed at initial evaluation and stabilization making the choice of mode of inter-facility transport for patients a critical decision staff at these rural hospitals must routinely make.

Helicopters can cover larger distances more quickly than ground ambulances and are staffed by expert personnel but at a cost 10-15 times that of a similar ground transport.¹³⁻¹⁴ In addition, the increasing number of HEMS crashes over the past several years has heightened concerns regarding HEMS safety.¹⁵⁻¹⁷ Trauma patients transferred to a TTC who are physiologically stable and without serious injuries can overburden trauma resources and results in substantially higher cost of care for the patient and an overall less effective trauma system.^{14,18-21} At the scene of injury, where diagnostic capability is limited, a greater degree of over-triage and consequently a lower threshold for using HEMS might be expected than for patients already in a hospital setting.^{4,22} We could find no published research focused specifically on factors influencing the decision to use HEMS resources for the inter-facility transfer of trauma patients in a predominantly rural state such as Oklahoma.

Since HEMS transport is generally reserved for more severely injured patients, indication bias must be considered in studies evaluating the impact of transport mode on outcomes, because the factors that are indications for helicopter inter-facility transport may also be strongly related to the risk of adverse outcomes. If indication bias is not adequately accounted for, estimates of the “transport mode” effect on mortality will be biased. Two recent studies comparing outcomes for trauma patients transported inter-facility by HEMS or GEMS reported conflicting results. Brown et al. found higher odds of survival among HEMS patients, but only for patients with an Injury Severity Score (ISS) 16 or higher;²³ whereas, a study by Borst et al. found no benefit for HEMS transport after adjusting for ground crew expertise.²⁴ Similarly, two older studies also found conflicting results, one

finding a survival benefit with HEMS for patients with a probability of survival $< .90$,²⁵ while the other found no statistically significant difference in mortality between HEMS and GEMS.²⁶ Traditional multivariable techniques may be inadequate in removing indication bias and residual confounding may significantly explain observed associations. Integrating propensity scores (a conditional probability of assignment to a particular group given a set of observed covariates)²⁷ with traditional multivariable models may offer a methodological advantage in reducing indication bias, particularly if there are relatively few subjects with the outcome of interest and many confounders.²⁷⁻³⁰

Our objective was to identify factors at the NTC associated with the decision to use GEMS or HEMS for the inter-facility transport of trauma patients to a TTC. The results will also serve to identify selection biases, and guide development of propensity scores to balance group differences in subsequent studies of outcomes among trauma patients transported inter-facility by GEMS or HEMS.

Methods

Study Design and Setting

This was a case-control study of all trauma patients who initially presented to a NTC before subsequent transfer to a TTC within 24-hours reported to the Oklahoma State Trauma Registry (OSTR) between 2005 and 2012. As of December 2012, there were 80 Level IV NTCs (primarily located in rural areas), 26 Level III NTCs, two Level II TTCs, and one Level I TTC in Oklahoma. The only Level I TTC is located centrally (Oklahoma City) and is verified by the American College of Surgeons Committee on Trauma (ACS-COT), while the two Level II TTCs (of which one is ACS verified) are located in the northeastern (Tulsa) part of the state. The State of Oklahoma has a mandatory, inclusive trauma system, and all state-licensed hospitals designated as trauma centers are required to report data to the state trauma registry on a monthly basis. All inter-facility transfers of injured patients are required to be reported regardless of severity. Patient records from NTCs and TTCs are routinely linked and a unique identification number is then assigned to records related to the same event. Both the Oklahoma State Department of Health (OSDH) and the University of Oklahoma Health Sciences Center Institutional Review Boards approved this study.

Study Population

All injured patients initially presenting to an Oklahoma NTC and transferred by GEMS or HEMS to an Oklahoma TTC within 24-hours were identified (N=18,695). Patients transferred from a NTC 20 miles or closer to a Level I or II TTC (n=4,763), for whom burns were their primary injury (n=297), who were younger than 18 years (n=7,291), who were not transferred by EMS (n=3,167), or for whom transport mode was unknown (n=252) were excluded. Patients within 20 miles of a TTC were excluded because they had little chance of being transferred by HEMS to a TTC. Finally, patients who died within 3 hours of arrival at a TTC were excluded (n=77) as most of these deaths were deemed non-preventable. Many patients (n=4,532) met more than one of the aforementioned exclusions. After applying all exclusion criteria, 7,380 (39.5% of 18,695) patients were included in the analyses.

Variables and Statistical Analyses

To identify factors at NTCs associated with the decision to use GEMS or HEMS for inter-facility transport, a case-control design was used where HEMS patients were designated 'cases' and GEMS patients as 'controls'. A number of factors documented primarily by the NTC were considered for analyses. Non-clinical factors of interest included age, gender, race, prehospital mode of transport, and primary payer. Incidents were classified according to the licensure level of the primary GEMS agency serving the area of the NTC. The number of EMS vehicles, paramedics, and total personnel for the local GEMS agency were also considered. This information was obtained from the OSDH EMS Agency Database.

Factors related to time and distance were either collected or calculated; road distance (in miles) from the transferring NTC center to the receiving TTC, elapsed time between arrival at the transferring facility ED and arrival at TTC ED, and whether transfer occurred on a weekend (Fri-Sun). Using the physical addresses of the NTCs and TTCs, publicly accessible navigation tools were used to create road distance lookup tables. Each patient record was then matched to the corresponding distance based on a 16-digit code identifying a specific NTC-TTC combination. Road distance was used for all transports because it seemed most relevant to persons selecting mode of transport for inter-facility transfer.

Clinical factors of interest included mechanism of injury, initial NTC vital signs (systolic blood pressure[SBP], Glasgow coma scale[GCS], heart rate[HR], respiratory rate[RR]), overall ISS, as well as the maximum Abbreviated Injury Scale (AIS) value for each ISS body region (head/neck/face, chest, abdominal or pelvic contents, extremities, or pelvic girdle). Additional clinical factors included multi-system injury (defined multiple times based on AIS values ranging from 1 to 3 in at least two ISS body regions), presence of a comorbid condition (pulmonary disease, diabetes, cardiac disease, coagulopathy, liver disease, metastatic cancer, and chronic renal failure) coded as y/n based on either NTC or TTC reported ICD-9 codes, and EMS/ED intubation either at the NTC or TTC. Initial NTC SBP and GCS were considered both as continuous and categorical variables; hypovolemic shock was defined as SBP less than 90 mm Hg and traumatic brain injury (TBI) was defined as GCS<10.

Initial analyses included screening of individual covariates for inclusion in the multivariable model predicting inter-facility transport mode. Bivariate assessments of associations between mode of transport and individual categorical covariates were done using chi-square and Cochran-Mantel-Haenszel tests. Individual continuous covariates were screened for between-group differences using t-tests. Covariates were included in the initial multivariable models if a test yielded a p-value less than 0.2. Because potentially related covariates were considered for the multivariable model, we evaluated the correlation between coefficients of the variables. In addition, a crude evaluation of multi-collinearity among covariates retained in final models was performed using the multiple linear regression Proc REG SAS procedure (i.e., Eigen-value analysis). Whenever two variables were highly correlated, only one variable providing the best model fit was included in the multivariable model.

Multivariable analysis was done with multiple logistic regression (SAS/STAT Proc LOGISTIC) with inter-facility mode of transport (HEMS vs GEMS) as the dependent

variable; the model was based on predicting the use of HEMS for inter-facility transport. Because distance was strongly associated with mode of transport and there were several statistically significant interactions between distance and other covariates (number of local GEMS vehicles available and transferring facility level [III vs IV]), multivariable prediction models were fit within three distance strata. The three strata were based on road distance from transferring NTC to the TTC to which the patient was taken for definitive care: 21-59 miles, 60-90 miles, and >90 miles. Because there are no generally accepted distances guiding HEMS use, these distance strata were developed by examining the distribution of mode of transport by distance.

Within each distance stratum, the set of independent variables identified from the bivariate analyses were entered into an initial multivariable model. Individual covariates with the highest p-values were removed one at a time through a process of backward elimination. Variables were considered for selection in the multivariable prediction model if they met a p-value of 0.2 or were deemed *a priori* to be potentially important factors in the decision to use HEMS or GEMS. C statistics assessed how well the model discriminated between transport decisions, and the Hosmer-Lemeshow goodness-of-fit test assessed the final model's overall adequacy of fit with the data. A more conservative p-value of 0.2 was chosen because a subsequent goal of this analysis is to incorporate predictors of transport mode as propensity scores in models evaluating mortality differences between patients transferred by HEMS or GEMS. Because parsimony is not a goal in propensity score modeling but rather, the goal is to obtain a model that best predicts exposure assignment, both weak and strong predictors were included in the model.^{30,31}

All data analyses were performed using SAS software version 9.3 (SAS 9.3, SAS Institute, Cary, NC).

Results

Attrition analysis

Excluded from the multivariable models were 217 patients (2.9%) due to extensive missing NTC vital sign information. The proportion of patients with missing data did not vary by transport mode (3% GEMS vs 2.9% HEMS, $p=0.95$). There were no deaths among the 217 excluded from multivariable analyses and their mean ISS (based on TTC coding) was lower than that of those included in the multivariable analyses (13 vs 11, $p=0.015$). Of the excluded cases, a majority (179/217, 82.5%) received initial treatment at a Level IV NTC before transfer to a TTC. The mean age of patients excluded from analyses of outcomes was 48 years (standard deviation [SD] ± 18) and did not differ significantly from those included in the analyses (mean age, 46 ± 20 , $p=0.15$).

A total of 7,380 patients met study eligibility. Of these, 2,803 (38%) were transported to a TTC by HEMS for higher level of trauma care. Some significant ($p<0.05$) differences were noted in the distribution of non-clinical factors (Table 1). Patients in the HEMS group were younger, predominantly male, likely to have a traffic-related or penetrating injury, more likely to be transported by EMS from scene of injury, more likely to present to a Level IV NTC, and were generally transferred from NTCs served by fewer GEMS resources

(vehicles, personnel, paramedics). A majority of the patients in the HEMS group (52% vs 28% in GEMS) presented to NTCs located at least 90 miles from a TTC. While the distribution of race, primary payer, and GEMS level serving the NTC were deemed statistically different, the magnitude of the differences observed were small, unlikely to be of public health significance, and derive primarily from the large sample size. No difference was noted in the proportion of patients transferred during weekend days between the two groups.

There were also notable clinical differences between the two groups (Table 2). Patients transported by HEMS to a TTC were significantly more likely to be intubated, present to the NTC with lower SBP and GCS, and more likely to have a pre-existing condition, heart disease in particular. Based on ISS, patients in the HEMS group were more severely injured than GEMS patients. Regardless of level of AIS value (1, 2, or 3) used to define multi-system injury, patients in the HEMS group were significantly more likely to have a multi-system injury. Furthermore, patients in the HEMS group had disproportionately more severe head, chest, and abdominal injuries, but no significant difference was noted in the distribution of severe extremity injuries between GEMS and HEMS.

Because we detected multiple statistical interactions between distance and GEMS resources and between distance and trauma level of the NTC, stratified multivariable analyses were performed based on distance strata (Table 3). For each distance stratum, penetrating injury, prehospital EMS transport, severe torso injury, hypovolemic shock, and TBI were significant predictors of HEMS use. Male sex was a significant independent predictor of HEMS use for patients initially presenting to NTCs <60 miles of a TTC, a marginally significant predictor ($p=0.1139$) of patients presenting to NTCs 60-90 miles from a TTC, but was not associated with transport mode for patients presenting to NTCs >90 miles away from a TTC. Initially presenting to a level IV NTC was predictive of HEMS use for patients presenting to NTCs <60 miles and at >90 miles away, but not for patients within 60-90 miles of a TTC. The influence of number of vehicles available to the GEMS agency serving the NTC (as a proxy for local GEMS resources) on transport decision varied by distance from the TTC. Within 60 miles of a TTC, having a higher number of GEMS vehicles available was associated with HEMS use, while for distances > 60 miles to a TTC, having fewer number of GEMS vehicles available was predictive of HEMS use, albeit not statistically significant for distances >90 miles.

Discussion

Oklahoma has no specific guidelines for the use of HEMS for inter-facility transfer of trauma patients, and to our knowledge, there are no generally accepted national inter-facility HEMS use guidelines. The aim of our study was to identify actual factors that are independently associated with inter-facility HEMS transport from a NTC to a TTC within a rural trauma system. Similar to previous work regarding determinants of prehospital HEMS use²², our results suggest that distance was the most influential factor associated with the use of HEMS transport for inter-facility transfers. Despite associations with a number of clinical factors indicating more severely injured patients were transported by HEMS, hundreds of patients transported to TTCs by both HEMS and GEMS had low injury severity and no

indication of physiologic abnormalities. Rural GEMS services nationwide are struggling to stay in business and existing services are asked to cover more area.³²⁻³⁴ A lack of GEMS resources or local pressure for GEMS units to stay in their service area is frequently given as the reason HEMS was used for patients whose condition did not seem to merit such high level resources³⁵.

Also similar to previous work²² regarding transports directly from the scene of injury, the magnitude of several of the associations with HEMS use in this study also decreased with increasing distance. However, unlike transports directly from the scene, even at the most distant NTCs several patient-related factors remained significantly associated with HEMS use and may reflect the ability for more thorough evaluation possible in a hospital setting. It appears though as the distance increases, the threshold for choosing HEMS over GEMS transport decreases, resulting in greater numbers of lesser injured patients being transported by HEMS. Concerns that a currently stable patient may begin to decompensate may be heightened by the distance from the TTC and a perceived time advantage, in combination with fewer GEMS resources, may further sway the provider to choose to transfer by HEMS.

As previously noted by others, a helicopter is a means of transport not of treatment and any benefit of HEMS must be related to a shorter transport time to a TTC or an increased treatment level provided by HEMS personnel^{4,8,36,37}. Clearly, a helicopter would be faster than a ground ambulance if travel began at the same time from the same location, but in real practice this is rarely the case.^{2,22} For patients transported directly to a TTC from the scene of injury, prior studies have shown total time to definitive care for HEMS and GEMS do not differ statistically until the distance reached as much as 45-60 miles.^{2,38,39} In our study, average total time to a TTC for HEMS was shorter than GEMS in all three distance strata. For injury scene responses there is often a significant lag in HEMS arrival time compared to arrival times for GEMS because of non-simultaneous dispatch, which reduces or completely negates any time savings that may result from faster travel speed. It appears though for inter-facility flights, there is time for HEMS to arrive while treatment is being rendered by the NTC. However, even from distant locations, we have found the average time from injury to TTC arrival was 3 times longer for inter-facility transfers than for those taken directly from the scene of injury to a TTC. Given some evidence of survival benefit for direct transport of severely injured patients to a trauma center^{40,41} and conflicting evidence for survival benefit associated with inter-facility HEMS transport,²³⁻²⁶ the shorter times for inter-facility HEMS transport should be interpreted cautiously.

In our study, there were many differences among HEMS and GEMS patients identified from the NTC information. Many of these factors were associated with both HEMS use and mortality confirming that our concerns regarding indication bias were warranted. Examination of these factors has laid the groundwork for the development of propensity scores to balance baseline risk among HEMS and GEMS transported patients.

Altered neurologic status, as indicated by a GCS of less than 10, was most strongly associated with increased odds of HEMS transport with odds ratios (ORs) across distance strata ranging from 2.7 to 3.6. The need for an invasive airway may partly explain the relationship since a basic level GEMS unit would not be allowed to transport patients with

an invasive airway in place unless accompanied by a nurse, PA, physician or respiratory therapist. Given recent findings regarding TBI outcomes and the importance of early airway management,⁴²⁻⁴⁵ low GCS may be an appropriate indicator for inter-facility HEMS transport if personnel capable of managing the patient's airway are not immediately available for GEMS transport.

The observation of increased odds of HEMS transport associated with a SBP below 90 mmHg, severe injury to head, thorax, abdomen, and penetrating injury was not surprising given these factors are part of the Centers for Disease Control and Prevention's National Field Trauma Triage algorithm⁴⁶ as well as Oklahoma's Trauma Triage and Transfer algorithms⁴⁷ as criteria indicating high-priority/time-sensitive trauma patients.

The association with transfer from a Level IV NTC actually reversed in the 60-90 mile stratum with reduced odds of HEMS transport. As a possible explanation, we found Level III NTCs within the 60-90 mile stratum were all locations with a HEMS agency near the hospital and one of these hospitals had a high proportion of patients transferred by HEMS. The lower odds of HEMS transported patients initially brought to the NTC by POV may simply reflect overall lower injury severity among these patients.

An explanation for greater HEMS use for male patients was not clear. Males may be more frequently injured by a mechanism of injury that may itself raise the index of suspicion for severe injury, or they may have specific injuries with the same AIS severity, but are more concerning to the clinician. Since we did not examine detailed mechanism of injury (e.g., MVC rollover), the association of HEMS transport with male sex may be the result of unmeasured or residual confounding.

The study has a few limitations that warrant discussion. The data are retrospective in nature with the inherent susceptibility to biases and unmeasured confounders. However, our study included a large statewide cohort of trauma patients within an inclusive trauma system that requires reporting of all inter-facility transfers of trauma patients. Though we did examine mechanisms of injury and 'severe' injury to certain body regions, further refinement of these measures may have identified additional associations with HEMS transport and specific injuries or mechanisms of injury. Specific injuries or combinations of specific injuries are so numerous it would be difficult to conduct meaningful analyses. As mentioned previously, measures of local ground resources were limited to an administrative database maintained by the OSDH, EMS division. The database cannot provide information on day-to-day operations, real-time personnel availability, influence of the local government, or influence of the local hospital they serve and these factors may heavily affect the decision to use HEMS transport.³⁵

Conclusion

Despite some significant association with markers of severity, hundreds of patients transferred to a TTC by HEMS had low injury severity and normal vital signs. The transfer for minor trauma patients to a TTC especially if completed using HEMS can unnecessarily tie up high level resources from both EMS and TTC and result in much higher costs for the

patient and/or their insurance. In addition, one must also consider the safety of the HEMS crew and patient when requesting HEMS transport of patients without apparent time-sensitive injuries.^{4,15-17, 48}

Identifying factors associated with inter-facility transport mode will aid development of mode of transport guidelines to increase efficient use of EMS transport resources and potentially protect patients from unnecessarily high costs. Moreover, a better understanding of local GEMS assets (paramedic units, availability to transfer) as well as accurate, real-time information regarding HEMS resources (estimated times of arrival, current locations) could help providers make the best transport decisions for their patients.

Finally, part of the intent of our study was methodologic allowing us to assess baseline comparability of patients by inter-facility transport mode. An understanding of the selection factors or biases and subsequent minimization of the impact of the biases will improve the validity of future studies comparing the impact of transport mode (HEMS vs GEMS) on trauma outcomes.

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Table 1

Demographic, Injury, and Initial Facility Characteristics by Inter-facility Transport Mode

	HEMS ^a n=2803	GEMS ^b n=4577	p-value
Variable			
Mean Age (SD ^c)	45 (20)	47 (20)	<0.001
Age ≥55 yrs, n (%)	840 (30)	1517 (33)	0.0045
Male, n (%)	2016 (72)	3113 (68)	0.0003
Race, (%)			0.0229
White	2148 (77)	3600 (79)	
Black	140 (5)	239 (5)	
American Indian	210 (8)	344 (8)	
Asian/Pac Island/Alaskan	10 (0.4)	18 (0.4)	
Other	295 (11)	376 (8)	
Penetrating Injury, n (%)	438 (16)	599 (13)	0.0023
Mechanism of Injury, n (%)			<0.0001
MVC	1096 (39)	1446 (32)	
Motorcycle	196 (7)	179 (4)	
Pedestrian	48 (2)	70 (1.5)	
Gunshot	184 (7)	155 (3)	
Stabbing	161 (6)	254 (6)	
Falls	540 (19)	1295 (28)	
Other	578 (21)	1178 (26)	
Prehospital Mode of Transport, n (%)			<0.0001
EMS	2016 (72)	2712 (59)	
POV ^d	734 (26)	1723 (38)	
Other	53 (2)	142 (3)	
NTC ^e Trauma Level, n (%)	1689 (60)	2569 (56)	0.0005
Local GEMS Level Serving NTC, (%)			0.0013
Basic	789 (28)	1144 (25)	
Intermediate	1168 (42)	1891 (41)	
Paramedic	846 (30)	1542 (34)	
Local GEMS Resources Serving NTC, Mean (SD)			
Num. of vehicles	6 (4)	7 (5)	<0.0001
Num. of personnel	31 (22)	38 (27)	<0.0001
Num. of paramedics	14 (11)	18 (14)	<0.0001
Mean Distance to TTC ^f , miles (SD)	96 (45)	70 (35)	<0.0001
Distance to TTC, n (%)			<0.0001
21-59	640 (23)	2176 (48)	

	HEMS^a n=2803	GEMS^b n=4577	p-value
Variable			
60-90	699 (25)	1141 (25)	
>90	1464 (52)	1260 (28)	
Mean Elapsed Time Between Facilities, hrs (SD)	4 (2)	5 (3)	<0.0001
Weekend Transfer, n (%)	278 (10)	457 (10)	0.9259
Primary Payer, n (%)			0.0173
Insurance	929 (33)	1510 (33)	
Self-pay	912 (33)	1367 (30)	
Medicaid	163 (6)	296 (7)	
Medicare	475 (17)	896 (20)	
Other	324 (12)	508 (11)	

^a Helicopter Emergency Medical Services;

^b Ground Emergency Medical Services;

^c Standard Deviation;

^d Privately Owned Vehicle;

^e Non-Tertiary Trauma Center;

^f Tertiary Trauma Center

Table 2

Patients' Clinical Characteristics at Initial Facility by Inter-facility Transport Mode

	HEMS^a n=2803	GEMS^b n=4577	p-value
Variable			
EMS/Emergency Dept. Intubation, n (%)	102 (4)	58 (1.3)	<0.0001
Initial NTC ^d Vital Signs Mean (SD ^c)			
Systolic Blood Pressure	132 (29)	138 (28)	<0.0001
Glasgow Coma Scale	13 (3)	14 (2)	<0.0001
Respiratory Rate	20 (6)	20(4)	0.11
Heart Rate	92 (23)	89 (19)	<0.0001
Shock (SB < 90 mm Hg), n (%)	201 (7)	126 (3)	<0.0001
TBI ^e (GCS <10), n (%)	316 (11)	138 (3)	<0.0001
Overall comorbidity, n (%)	537 (19)	782 (17)	0.0241
Pulmonary Disease, n (%)	138 (5)	269 (6)	0.0814
Diabetes, n (%)	24 (0.9)	50 (1.1)	0.3229
Cardiac Disease, n (%)	367 (13)	479 (10)	0.0006
Coagulopathy, n (%)	77 (3)	71 (1.6)	0.0004
Liver disease/metastatic cancer, n (%)	22 (0.8)	34 (0.7)	0.84
Chronic Renal Failure, n (%)	30 (1)	70 (1.5)	0.0978
Mean ISS ^f (SD)	11 (9)	8(6)	<0.0001
ISS Group, n (%)			<0.0001
<9	1076 (39)	2506 (55)	
9-14	966 (35)	1493 (33)	
16-24	519 (19)	443 (10)	
>=25	242 (9)	135 (3)	
Multisystem Injury (AIS ^g >=1), n (%)	1456 (52)	1951 (43)	<0.0001
Multisystem Injury (AIS >=2), n (%)	859 (31)	906 (20)	<0.0001
Severe Injury (AIS>=3), n (%)			
Head/Neck/Face	984 (35)	1442 (32)	0.00014
Chest	527 (19)	444 (10)	<0.0001
Abdomen	117 (4)	92 (2)	<0.0001
Extremities	331 (12)	552 (12)	0.7466

^aHelicopter Emergency Medical Services;^bGround Emergency Medical Services;^cStandard Deviation;^dNon-Tertiary Trauma Center;^eTraumatic Brain Injury;

^fInjury Severity Score;

^gAbbreviated Injury Scale

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Table 3

Factors independently associated with HEMS use for inter-facility transport of patients to a tertiary trauma center stratified by distance.

Variable	Odds Ratio, 95%CI		
	21-59 miles	60-90 miles	>90 miles
Male Sex	1.26, 1.02-1.54	*1.20, 0.96-1.50	$\ddagger$
Penetrating Injury	1.44, 1.10-1.87	1.67, 1.24-2.25	1.43, 1.13-1.81
Prehospital Transport Mode			
EMS	Reference	Reference	Reference
POV ^a	0.69, 0.56-0.86	0.62, 0.50-0.78	0.62, 0.51-0.74
Other	0.29, 0.10-0.81	0.91, 0.51-1.62	0.32, 0.20-0.52
Severe Injury (AIS ^b $\geq$ 3)			
Head	1.30, 1.06-1.61	$\ddagger$	1.19, 1.01-1.41
Chest	1.99, 1.53-2.59	2.15, 1.59-2.90	1.96, 1.55-2.47
Abdomen	3.48, 2.09-5.80	1.67, 0.85-3.28	1.65, 1.06-2.57
SBP ^c < 90 mmHg	2.94, 2.01-4.29	2.75, 1.65-4.61	1.63, 1.06-2.51
GCS ^d <10	3.21, 2.29-4.50	3.62, 2.35-5.57	2.67, 1.89-3.76
Level IV Trauma Facility	2.49, 1.99-3.12	0.55, 0.43-0.69	1.60, 1.35-1.89
Local EMS No. of Vehicles	1.03, 1.01-1.04	0.96, 0.93-0.99	*0.99, 0.96-1.02

$\ddagger$ variable dropped from the model, $p > 0.20$;

* $p > 0.05$

^a Privately Owned Vehicle;

^b Abbreviated Injury Scale;

^c Systolic Blood Pressure;

^d GCS=Glasgow Coma Scale