Disparities in Inter-hospital Helicopter Transportation for Hispanics by Geographic Region: A Threat to Fairness in the Era of Thrombectomy

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Background and Purpose: Mechanical thrombectomy (MT) is a time-dependent therapy that is only available at a limited number of hospitals. As such, patients that live at a considerable distance of those specialized centers often require rapid interhospital emergent evacuation with Helicopter Emergency Medical Services (HEMS) to be considered for MT. It is not known whether the use of HEMS is equitable across different groups of patients. *Methods*: Acute ischemic stroke patients emergently transferred to another facility were identified in a retrospective review of a large Medicare claims database. Mode of transportation (HEMS, advanced, or basic ground ambulances) was determined by CPT codes. Distance from patient's residence to the closest center with MT capabilities was calculated. Generalized linear mixed logit models were used to determine the odds of HEMS relative to ground services for Hispanic and non-Hispanic black (NHB) patients relative to non-Hispanic white (NHW) patients while controlling for confounders. *Results*: A total of 8027 patients that underwent emergent interhospital transportation were analyzed. HEMS utilization was 18.1% for NHB, 20.6% for Hispanics, and 21.6% for NHW ($P = .054$). In adjusted analyses for confounders, including distance to a MT-capable hospital, Hispanic patients were less likely than NHWs to be transported by HEMS. While that association had marginal significance for the whole United States (OR = .76; 95% CI, .57-1.01; $P = .055$), it was statistically significant for patients living in the southern region of the United States (OR = .6; 95% CI, .40-.92; $P = .019$). *Discussion*: Our findings suggest there is a disparity in the use of HEMS in Hispanic stroke patients compared to NHW. Such a disparity may delay arrival to a MT-capable hospital, delay treatment times, or lead to ineligibility for MT altogether. Given the known benefit of MT and known existing disparities in stroke treatment and outcomes, it is important to further investigate and address disparities in mode of interhospital transportation.

Key Words: HEMS—EMS—inter-hospital—helicopter—ambulances—disparity

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Introduction

Mechanical thrombectomy (MT) is the new standard of care in patients with a stroke due to a proximal arterial occlusion.[1] Randomized trials indicate that MT is efficacious up to 16-24 hour in a subset of patients.[2,3] Still, for the majority of patients the window of opportunity is much shorter, and the efficacy is greater the sooner the treatment is applied.[4] MT is a complex therapy that requires specific equipment and human expertise only available at a limited number of hospitals in the United States.[5] Patients are often first evaluated at a local emergent facility. Because of the geographical dispersion of patients and local small hospitals in relationship to tertiary stroke centers,[6] interhospital transportation becomes critical for successful MT treatment.[7] Given the urgency for delivering MT,[4] emergent interhospital Helicopter Emergency Medical Services (HEMS) are typically preferred and often used in rural dispersed areas, as well as in traffic-congested areas of the country.[8,9] Besides the obvious advantage in speed, evidence demonstrates that HEMS-transported patients receive higher rates of IV thrombolysis locally[10] as well as more specialized care and interventions.[8] In circumstances where ground transportation is the only option, an advanced life support (ALS) ambulance will be able to deliver better ancillary care en route than basic life support (BLS) teams.[11,12]

The Emergency Medical Treatment and Active Labor Act authorizes the referring physician to choose the mode of transport. This decision is influenced by a variety of factors, including the severity of the stroke and the perceived need for MT, as well as system limitations such as distance to the stroke center, availability of critical care air or ground ambulances, and weather.[9,13,14] In this new MT era, it is imperative to ensure that stroke patients have fair access to interhospital HEMS, or ALS if not available, to avoid disparities with respect to functional outcomes. In this study we explore associations between race/ethnicity and the choice of HEMS/ALS for interhospital transfer of stroke patients in the US.

Methods

This study was a retrospective review of a large Medicare claims database from Centers for Medicare and Medicaid Services (CMS). Our data source included Medicare Part A and Part B claims for Medicare beneficiaries with a new diagnosis of atrial fibrillation during 2010-2013. We identified all acute hospital inpatient admissions with a primary diagnosis of ischemic stroke who also underwent an interhospital transfer within 1 day prior to the stroke admission. Stroke diagnoses included ICD-9-CM codes 433 (occlusion of carotid artery with or without cerebral infarction), 434 (cerebral embolism with or without cerebral infarction), 435 (transient cerebral ischemia), and 436 (acute but ill-defined cerebrovascular event).

The mode of interhospital transportation was identified by Current Procedural Terminology (CPT) code and CPT modifier on claims incurred within 1 day prior to the stroke admission date. Transportation was categorized as BLS ground ambulance (CPT codes A0428, A0429, and A0432), ALS ground ambulance (codes A0426, A0427, and A0433), or HEMS (codes A04321, and A0436). Hospital to hospital transfers were identified using CPT modifiers indicating the origin and destination of the transportation as an acute care hospital. Because our intention was to capture only emergency ambulance transfers, patients who were admitted to the originating hospital with a length of stay >1 day were excluded.

The study categorized race/ethnicity as non-Hispanic White (NHW), non-Hispanic Black (NHB), or Hispanic/Latino (Hispanic) using the race and ethnicity code developed by the Research Triangle Institute (RTI) that is available on the CMS Beneficiary Summary File. The RTI race code is an enhanced race/ethnicity designation based on first and last name algorithms. The RTI race code has excellent agreement with self-reported race/ethnicity, with kappa coefficients $\geq$.80 for Hispanic beneficiaries and $\geq$.90 for NHB beneficiaries.[15]

The type of stroke was categorized as embolic (ICD-9-CM code 434.xx) or other based on primary ICD-9-CM code. Additional patient characteristics were identified in CMS enrollment and encounter data. Sex, age, and dual enrollment in Medicaid at the time of stroke diagnosis were identified from the CMS Beneficiary Enrollment Summary. Other comorbid conditions were identified in inpatient and outpatient claims during the 12 months prior to stroke and were defined using algorithms originally developed by Elixhauser et al[16] and updated by the Agency for Healthcare Research and Quality. Previous cerebrovascular events and prior bleeding episodes were identified using previously published algorithms.[17,18] We also calculated the CHA_2DS_2-VASc stroke risk score (based on the presence of congestive heart failure, hypertension, age category, diabetes, previous stroke, vascular disease, and female sex).[19] The patients' residence was categorized as urban/rural based on patient residence zip code categorized by Rural Urban Commuting Area codes, which measure rurality based on population density as well as commuting patterns to urban centers.[20] Distance from patient's residence to the closest acute care hospital and closest tertiary stroke center with MT capabilities were calculated as euclidean distances since they are more relevant for HEMS flights. Hospitals with MT capabilities were identified using 100% Medicare Provider Analysis and Review files to identify hospitals performing cerebrovascular endovascular procedures during the year of discharge. Region was assigned as West, South, Midwest, and Northeast based on patient state of residence.

The associations between patient ethnicity and type of interhospital transport and baseline variables were tested using the chi-square statistic for proportions, and Wilcoxon rank-sum or analysis of variance for continuous variables. Generalized linear mixed models with a multinomial logit link were used to determine the odds of HEMS relative to ALS ground service, and ALS ground relative to BLS service use for Black and Hispanic patients relative to White patients, by different race/ethnicity in models that sequentially controlled for confounders such as patient state of residence (as random effects) and patient demographic, geographic, and clinical characteristics described previously. Variables that were significantly related to transportation type in bivariable analyses were considered candidates for risk adjustment models. Variables for final models were identified using a combination of forward and backward selection to maximize discrimination while avoiding multicollinearity among selected variables, using a statistical criterion of $P < .05$ for variable selection. We also estimated the odds of transport by HEMS relative to any ground service using similar models estimated with a logit link. Finally, additional analyses were conducted separately by region of the country (South, Northeast, Midwest, and West). All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc, Cary, NC). This study was approved with a waiver of consent from the University of Iowa Institutional Review Board.

Results

We identified a total of 8274 ischemic stroke patients with a hospital-to-hospital transfer by ambulance within 1 day of the stroke admission. Of those, 247 were

Table 1. *Baseline characteristics of 8027 acute stroke patients with history of atrial fibrillation that underwent emergent interhospital transfer, stratified by their race/ethnicity*

	NHB (n = 647)	Hispanic (n = 389)	NHW (n = 6991)	*P* value
% Female sex	416 (64.3%)	211 (54.2%)	4259 (60.9%)	.006
Patient age				
66-75	274 (41.5%)	145 (36.3%)	2528(36.2%)	<.001
76-85	252 (39.0%)	182 (45.8%)	3071 (43.9%)	
86 or older	121 (18.7%)	62 (15.9%)	1392(19.9%)	
Mean (95% CI)	77.9 (77.5-78.5)	78.1 (77.5-78.7)	78.8 (78.6-78.9)	<.001
% Embolic stroke	548 (84.7%)	314 (80.7%)	5544 (79.3%)	.013
Distance from residence to nearest MT-capable hospital				
0-5 miles	130 (20.1%)	85 (21.9%)	611 (8.7%)	<.001
>5-15 miles	113 (17.5%)	78 (20.1%)	1114 (15.9%)	
>15 miles	404 (62.4%)	226 (58.1%)	5264 (75.3%)	
Mean (95% CI)	31.8 (29.7-33.9)	42.5 (39.9-45.1)	38.2 (37.5-38.9)	<.001
Distance from residence to any hospital				
0-3 miles	361 (55.8%)	208 (53.5%)	2784 (39.8%)	<.001
>3-10 miles	129 (19.9%)	102 (26.2%)	1750 (25.0%)	
>10 miles	157 (24.3%)	79 (20.3%)	2455 (35.1%)	
Mean (95% CI)	5.7 (4.9-6.4)	7.3 (6.3-8.3)	9.4 (9.1-9.6)	
Rural residence				
Isolated rural	22 (3.4%)	12 (3.1%)	624 (8.9%)	<.001
Small town	85 (13.1%)	23 (5.9%)	876 (12.6%)	
Large town	64 (9.9%)	58 (14.9%)	1099 (15.7%)	
Urban	476 (75.6%)	296 (76.1%)	4382 (62.8%)	
Region of the US				
Midwest	108 (16.7%)	36 (9.3%)	2303 (32.9%)	<.001
Northeast	60 (9.3%)	29 (7.5%)	1012 (14.5%)	
South	461 (71.3%)	181 (46.5%)	2881 (41.2%)	
West	18 (2.8%)	143 (36.8%)	795 (11.4%)	
% Dual medicaid enrolment	428 (65.2%)	283 (72.8%)	1878 (26.9%)	<.001
% Myocardial infarction	75 (11.6%)	61 (15.7%)	799 (11.4%)	.039
% Cardiac valve disease	184 (28.4%)	107 (27.5%)	1957 (28.0%)	.95
% Peripheral vascular disease	183 (28.3%)	107 (27.5%)	1686 (24.2%)	.025
% Congestive Heart Failure	284 (43.9%)	157 (40.4%)	2274 (32.5%)	<.001
% Diabetes	289 (44.7%)	195 (50.1%)	2219 (31.7%)	<.001
% Hypertension	514 (79.4%)	296 (76.1%)	5384 (77.0%)	.32
% Renal disease	174 (26.9%)	97 (24.9%)	1181 (16.9%)	<.001
% Previous intracranial hemorrhage	21 (3.5%)	11 (2.8%)	138 (2.0%)	.060
% Previous ischemic stroke	220 (34.0%)	94 (24.2%)	1337 (19.1%)	<.001

Abbreviations: MT, mechanical thrombectomy; NHB, non-Hispanic black; NHW, non-Hispanic white; US, United States.

Table 2. *Type of interhospital transportation used in 8027 acute stroke patients with history of atrial fibrillation stratified by race/ethnicity*

Mode of transportation	Black (n = 647)	Hispanic (n = 389)	White (n = 6991)	*P* value
BLS Ground EMS	64 (9.9%)	46 (11.8%)	603 (8.6%)	.054
ALS Ground EMS	466 (72.0%)	263 (67.6%)	4879 (69.8%)	
HEMS	117 (18.1%)	80 (20.6%)	1509 (21.6%)	

Abbreviations: EMS, emergency medical services; HEMS, helicopter emergency medical services.

excluded due to a previous hospital admission with a length of stay >1 day and discharge date within 1 day prior to the qualifying stroke admission. Table 1 shows patient baseline characteristics for the remaining 8027 patients who met the study criteria, including 647 NHB, 389 Hispanic, and 6991 NHW patients. Compared to NHW, NHB, and Hispanic patients were more likely to have Medicaid and vascular comorbidities. NHW patients tended to live further from MT-capable hospitals than NHB patients, but not Hispanics.

Table 2 shows the overall proportion of patients transferred by BLS ground, ALS ground, or HEMS. NHW patients were more likely to use HEMS than patients of NHB or Hispanic ethnicity. Patients of Hispanic ethnicity were most likely to be transported by BLS ground ambulances (11.8% versus 9.9% and 8.6% of Hispanic, Black, and White patients were transported by BLS, respectively).

Table 3 shows results of multivariable models estimating the relative odds of transportation by HEMS relative to ALS ground ambulance, ALS relative to BLS ground ambulance, and HEMS relative to any ground ambulance. In a multinomial model controlling for potential confounders such as state of residence (as random effects) and patient characteristics, the odds of being transported by HEMS relative to ALS ground ambulance, ALS relative to BLS ground ambulance were not different for NHB and NHW patients. Similarly, multivariable logit models found no difference between NHB and NHW patients in the odds of being transported by HEMS relative to any ground ambulance. There was borderline evidence that patients of Hispanic ethnicity are less likely than NHW patients to be transported by HEMS rather than any ground ambulance (Odds Ratio [OR] = .76; 95% Confidence Interval [CI], .57-1.01; *P* = .055) for the whole United States.

Table 4 shows the odds of HEMS relative to advanced or basic ground transportation from multivariable logistic regression models, stratified by region of the country. The relative odds of transfer by HEMS, ALS, or BLS did not differ for NHB and NHW patients, regardless of region of the country. In the South of the US, Hispanic patients had significantly lower odds of transport by HEMS relative to white counterparts after controlling for confounding factors (OR = .6; 95% CI, .40-.92; *P* = .019). No differences in mode of transport were noted between Hispanic and NHW patients in other regions.

Discussion

In this new era of MT, it is critical that potentially eligible patients are transferred to a facility capable of delivering MT as soon as possible.[4,21] Because MT must be administered as soon as possible from symptom onset, delays in transport can result in ineligibility for MT, or administration of MT at an ineffective treatment time.[4] Moreover, ambulances capable of delivering advanced services provide important ancillary medical management en route.[11] In this paper, we found an unexplainable disparity in the use of HEMS for interhospital transportation in detriment of Hispanic stroke patients—particularly among patients residing in the South region of the US. Differences in the use of interhospital HEMS may negatively amplify the effect of disparities previously documented regarding the treatment and outcomes for Hispanic patients, including lower prehospital emergency medical services (EMS) utilization,[22] lower use of IV rtPA,[23] lower use of rehabilitation services,[24] and worse mortality.[25]

The origin of the disparity in interhospital transportation in detriment of Hispanic is unclear. While the Emergency Medical Treatment and Active Labor Act authorizes the referring physician to choose the mode of transport, a variety of factors play a role, including service availability, clinical circumstances, and patient preferences.[9,13,14] In our study, all patients were enrolled in Medicare, making it unlikely that insurance influenced the decision. It is also unlikely that immigration status is a factor in patients enrolled in Medicare. Our multivariable models also controlled for geographical factors, so that differences in the availability of EMS services across states or distances to MT facilities cannot explain the disparity. It is possible that the disparity is driven by the decision of providers, the patient's or surrogate preferences, cultural factors (eg, fear of flights), or other exogenous patient circumstances, although we are not able to ascertain the influence of these factors.

Our findings are important for understanding disparities and regional systems of care—with implications that will grow in importance as the use of HEMS increases. A

Table 3. *Odds of HEMS and Advanced Ground Transportation (relative to basic ground) from multivariable multinomial models, and odds of HEMS (relative to any ground transportation) from multivariable logistic regression models*

	Black relative to White			Hispanic relative to White		
	Odds of HEMS relative to advanced ground	Odds of advanced ground relative to basic ground	Odds of HEMS relative to any ground transportation	Odds of HEMS relative to advanced ground	Odds of advanced ground relative to basic ground	Odds of HEMS relative to any ground transportation
Unadjusted	**.81 (95% CI, .66-1.00; $P = .05$)**	.90 (95% CI, .68-1.18; $P = .45$)	**.80 (95% CI, .65-.99; $P = .037$)**	.98 (95% CI, .76-1.27; $P = .89$)	**.71 (95% CI, .51-.98; $P = .036$)**	.94 (95% CI, .73-1.21; $P = .63$)
Controlling for state and patient covariates*	.90 (95% CI, .72-1.13; $P = .36$)	.85 (95% CI, .63-1.13; $P = .26$)	.88 (95% CI, .70-1.11; $P = .27$)	.79 (95% CI, .59-1.05; $P = .11$)	.79 (95% CI, .55-1.13; $P = .20$)	**.76 (95% CI, .57-1.01; $P = .055$)**

*Patient covariates included patient sex, age, ischemic stroke category (embolic with cerebral infarction, occlusion of carotid artery with or without cerebral infarction, transient cerebral ischemia, and other ischemic stroke), rural residence (isolated, small town, large town, urban), shortest distance to MT capable hospital, history of stroke, and region of the country (Northeast, South, Midwest, West). Models also included random intercepts for patient's state of residence.
Bolded values are statistically significant ($p \leq .05$)

large 10-year sample of HEMS flights has shown a gradual increase in the ischemic stroke related missions which comprised 4% of flight missions in 2011[9]—suggesting roughly 16,000 ischemic stroke helicopter missions each year in the United States. However, that data might be an underestimation since it preceded the establishment of MT which requires expeditious transportation.[8,26] While the use of MT increased dramatically from 2003 to 2013,[27,28] evidence indicates there is still significant potential to increase the use of MT, and a corresponding need to develop systems of care to provide access to MT equitable to all eligible patients.[29] Thus, the impact of racial and ethnic differences in the use of HEMS on disparities in stroke treatment and outcomes will likely grow without a better understanding of the source of disparities and policies to address them.

We recognize there are limitations of this research. First, our data source has important drawbacks that are present in any study using administrative data, due to the reliance on patient demographics and ICD-9-CM diagnosis codes to measure clinical status. Our analysis therefore does not reflect other factors that have important prognostic value, such as stroke severity, time from stroke onset to transport, or other criteria eligibility for treatment. In addition, the accuracy of ICD-9-CM codes in administrative data is sometimes questionable. While agreement between ICD-9-CM diagnosis codes contained in administrative data and patient medical records has been shown to be excellent,[30] agreement may be poorer for some comorbid conditions, leading to inadequate risk adjustment. Second, we relied on postal zip codes to measure distances to the nearest hospitals, which were subject to 2 shortcomings: (1) we were not able to identify the zip code of the originating hospital (due to ambiguity in billing data), and thus used patient residence zip codes under the assumption that patients likely travelled to the nearest emergency department (ED) upon stroke onset; and (2) distance calculation based on zip codes are not as precise as calculations based on smaller geographic regions, such as census tracts. Third, this study is limited to patients with atrial fibrillation, and the majority of strokes included in our data were probably cardioembolic. It is unclear whether these results could be extrapolated to noncardioembolic strokes, although it seems unlikely that patients would be treated differently based on presumed stroke mechanism/subtype, a diagnosis that is typically reached in the days following emergent hospitalization.[31] Finally, our analysis was also limited to ambulance transport services identified in Part B (carrier) claims. A small proportion of ambulance claims may be included in CMS outpatient hospital (Part A) claims, although based on previously acquired CMS data we expect that this represents fewer than 5% of ambulance services. Finally, we recognize that volunteer EMS services play an important role in many rural states. There is no formal definition of

Table 4. *Odds of HEMS (relative to advanced or basic ground transportation) from multivariable logistic regression models, stratified by region of the country*

	Number of patients	Black relative to White patients	Hispanic relative to White patients
Midwest*	2447	1.14 (95% CI, .63-2.06; *P* = .66)	053 (95% CI, .15-1.84; *P* = .32)
Northeast	1101	.82 (95% CI, .36-1.88; *P* = 064)	1.22 (95% CI, .45-3.29; *P* = .70)
South	3523	.82 (95% CI, .63-1.07; *P* = .138)	**.61 (95% CI, .40-.92; *P* = .019)**
West	956	.64 (95% CI, .16-2.52; *P* = .52)	.95 (95% CI, .60-1.51; *P* = .82)

*Patient covariates included patient sex, age, ischemic stroke category (embolic with cerebral infarction, occlusion of carotid artery with or without cerebral infarction, or transient cerebral ischemia, other ischemic stroke), rural residence (isolated, small town, large town, and urban), shortest distance to MT capable hospital, and history of stroke. Models also included random intercepts for patient's state of residence.

Bolded values are statistically significant ($p \leq .05$)

"volunteerism" in EMS, but many EMS agencies are considered volunteer if a portion of their staff is not compensated or if the EMS agency does not bill for its services. Thus, while it is possible that some services provided by volunteer EMS agencies are not reflected in our data, we see no reason why the activities of volunteer agencies would vary by race or ethnicity of patients. Moreover, the majority of activities provided by such agencies are responding to 911 emergencies.[32]

In summary, the importance of HEMS in the care of stroke patients will continue to increase as community implementation expands. Failure to understand and address the lower use of HEMS for interhospital transport for Hispanic patients may amplify existing disparities in the treatment and outcomes of Hispanics with stroke, particularly in the era of increasing use of MT to improve stroke outcomes.

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