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Functional Independence after Inpatient Rehabilitation for Traumatic Brain Injury among Minority Children and Adolescents

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Abstract

Objective—To compare motor and cognitive functional independence scores between Hispanic, non-Hispanic Black (NHB) and non-Hispanic White (NHW) children with traumatic brain injury (TBI) after discharge from inpatient rehabilitation.

Design—Retrospective cohort study using the Uniform Data System for Medical Rehabilitation national dataset from years 2002–2012.

Setting—Inpatient rehabilitation units.

Participants—10,141 children 6 months to 18 years of age who received inpatient rehabilitation for TBI.

Interventions—not applicable.

Main outcome measures—Motor and cognitive functional independence after discharge from inpatient rehabilitation; adjusting for age, gender, admission function, length of stay, insurance and region.

Results—Inpatient rehabilitation therapy improved functional independence for all children. Younger age, lower admission functional independence scores and Medicaid insurance were

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associated with lower functional independence at discharge. Hispanic and NHB children had lower discharge cognitive scores compared to NHW children; however differences were small and were partially explained by insurance status and region. Children who received rehabilitation therapy at pediatric facilities had greater cognitive improvement.

Conclusion—While racial/ethnic disparities are small, minority children are more likely to be younger, to have Medicaid and to be cared for at non-pediatric facilities, factors that increase their risk for lower functional outcomes.

Keywords

Traumatic Brain Injury; minority children; disability; inpatient rehabilitation

Introduction

Traumatic brain injury (TBI) disproportionally affects minority children. Hispanic and Non-Hispanic Black (NHB) children with TBI are more likely to be younger, and to sustain intentional and more severe injuries compared with non-Hispanic White children (NHW).[1] Prior studies report higher mortality for injured NHB children compared with Hispanic and NHW children. [2,3] A retrospective study using the National Pediatric Trauma Registry reported that NHB children experienced higher acute disability and were more likely to be discharged to inpatient rehabilitation services than were Hispanic and NHW children.[2] While Haider et al. found no disparities in rates of acute disability and discharge rates to acute inpatient rehabilitation care for Hispanic patients relative to NHW patients, a recent prospective study reported that Hispanic children compared with NHW children had significantly poorer functional outcomes for up to three years following a TBI.[1] The reasons for these reported differences are not clear. The study did not have specific information regarding inpatient or outpatient rehabilitation services provided for these patients and therefore it was not possible to ascertain if poor outcomes were associated with lower access to rehabilitation services.

Acute inpatient rehabilitation following acute trauma care focuses on treatment of current impairments with the goal of maximizing a patient's functional potential. Comprehensive care and coordination of rehabilitation activities have been shown to improve functional status even among patients with severe injuries.[4,5] It is not known if the benefit of acute inpatient rehabilitation results in similar functional improvements for all children. Poor minority children may be more likely to face psychosocial and family factors that may put them at risk of experiencing higher functional disability.[6]

In this study we compared motor and cognitive functional independence after inpatient rehabilitation for TBI, between Hispanic, NHB and NHW children. We hypothesized that functional independence at discharge may be lower among minority children.

Methods

Patient Population

This retrospective cohort study included patients 6 months to 18 years of age, who had inpatient rehabilitation following traumatic brain injury between 2002 and 2012. Data were extracted from the Uniform Data System for Medical Rehabilitation (UDSMR). The UDSMR collects demographic, clinical and facility data from approximately 820 rehabilitation institutions in the United States representing approximately 70% of all US inpatient rehabilitation facilities. Rehabilitation units report their pediatric data to the UDSMR system using one of two instruments to measure functional independence: the FIM® instrument for children 8 years and older, or the pediatric derivative the WeeFIM® instrument for all children regardless of their age. No identifiable data was used, and the study was therefore considered exempt from IRB review. For the purpose of this study we included children who sustained a TBI and were identified as Hispanic, NHB or NHW in the UDSMR® database. We excluded participants of other racial backgrounds as well as multiracial patients. We used the racial and ethnic categories provided by the UDSMR® dataset in which race and ethnicity are considered as mutually exclusive categories. We also excluded children younger than 6 months of age because the WeeFIM® instrument is only validated for children 6 months and older. Our study is a secondary data analysis of an administrative cohort therefore our sample size was predetermined. However it was large enough to determine a minimum detectable difference between NHW and Hispanics of 1.8 and between NHW and NHBs of 1.7 points with an alpha of 0.05 and power of 80%.

Definition of Injuries

We defined TBI as an injury coded with an impairment group code 2.2 (Traumatic brain disfunction), 6.2 or 14.2 (brain injury with multiple fractures for WeeFIM® and FIM® respectively) by the UDSMR® database. Under these categories, open, closed and unspecified traumatic brain injuries were included. We restricted the study population to those who had ICD-9 diagnosis codes consistent with traumatic injury (800–999).

Measures of disability

The UDSMR® database includes functional independence measures at admission to the rehabilitation facility (within three days of admission) and at discharge. All children less than 8 years of age were evaluated using the WeeFIM® instrument. Children 8 and older were evaluated with the FIM® or the WeeFIM® instruments, depending on institutional practice. Both WeeFIM® and FIM® instruments evaluate 18 domains (13 motor and 5 cognitive). Each domain is scored from 1 (completely dependent) to 7 (completely independent).[7] Typically developing children are expected to achieve independence in all domains by 8 years of age. Children younger than 8 years of age are not expected to be independent in all domains; therefore age norms are used to determine functional independence for these younger children.

Because child age is strongly associated with WeeFIM® instrument ratings, we elected to use developmental functional quotients (DFQ) to standardized comparisons across age groups. Other investigators have employed DFQs for TBI studies.[8,9] In brief, DFQs provide

a quotient score based on age-norm scores, ranging from 14 (lowest possible quotient for a patient who receives a score of 1 in all domains and for whom the age-norm is 7) to more than 100 (a patient who performs at a level that exceeds the age-norm). DFQs are provided by UDSMR® for all patients who were assessed using the WeeFIM® instrument. For patients older than 8 years of age for whom the adult FIM® instrument was used, we calculated DFQs using a maximum score of 126 following the same methodology of the WeeFIM® instrument.

Covariates

In addition to evaluating the association of race/ethnicity on cognitive and motor discharge DFQs, we evaluated the association of other known risk factors for disability after injury in conjunction to race/ethnicity. Age was included as a categorical variable: 6 months–3 years, 4–7 years, 8–14 years and 15–18 years. Categories were constructed *a priori* based on age differences in injury mechanisms and age-development independence. Insurance status was included as a categorical variable: private, medicaid/medicare and other governmental insurance, and other (including Tricare, self-pay and unreimbursed care). We included geographical region (Northeast, South, Midwest and West) in analyses to account for regional variation in clinical practices and insurance policies.

Data on the pediatric makeup of the rehabilitation facility (rehabilitation unit within a pediatric hospital, general hospital or free standing rehabilitation unit) was available only for patients whose information was recorded using the WeeFIM® instrument. Because practices may vary between facilities, we conducted prespecified sub analyses among this subgroup of children to examine possible associations between rehabilitation outcomes and facility type.

Statistical Analysis

Demographic and clinical characteristics were compared between Hispanic, NHB and NHW children using the chi-square and ANOVA F-test statistics for categorical and continuous variables respectively. We used multiple linear regression models to assess the association between race/ethnicity and motor, cognitive and total discharge DFQs. In the initial model (model 1) we evaluated the crude association between race/ethnicity and functional outcomes adjusting only for baseline functional scores at admission. In model 2 we adjusted for biological risk factors (age and gender) in addition to baseline functional scores In model 3, in addition to age, gender, and baseline functional scores we evaluated the additional impact of sociodemographic variables (insurance status and geographical region). All models were adjusted for length of stay and year of discharge. As well, to account for institutional variation all analyses were conducted clustering by individual facility, using the cluster option (STATA) in all regressions (N=604 facilities).

An additional subgroup analysis was done among those patients whose functional independence was assessed using the WeeFIM® instrument and for whom we had information on the pediatric makeup of the rehabilitation facility that cared for them. As in the main analyses, we used multiple regression analyses, resulting in four models. Model 1 crude association between race/ethnicity and functional outcomes adjusting only for baseline functional scores. Model 2 included biological factors (age and sex) in addition to baseline

functional scores. Model 3 added insurance status and region. Model 4 evaluated the association of the type of rehabilitation unit (rehabilitation unit within a pediatric hospital, general hospital or free standing rehabilitation unit) in addition to the variables used in Model 3. These rehabilitation unit categories are provided by the UDSMR® database in which units are de-identified. What we inferred from the given categories is that units within a pediatric hospital care exclusively for pediatric patients while units within a general hospital as well as free standing rehabilitation units could care for both adult and pediatric patients. All analyses adjusted for length of stay and year of discharge, and clustered by facility (N=60 individual facilities). Statistical analyses were conducted using Stata/SE version 12.1 (StataCorp LP, College Station, TX).

Results

Patient characteristics

A total of 10,141 patients, cared for at 604 different rehabilitation units, were included in this study: 1,118 Hispanic, 1,776 NHB and 7,247 NHW children. Hispanic and NHB children were significantly younger, more likely to be male and less likely to have private insurance (Table 1). There were no differences in length of stay by group. There were significant differences in the type of rehabilitation facility that cared for these patients. Hispanic children were significantly less likely to be cared for at rehabilitation facilities within pediatric hospitals when compared with NHB and NHW children (Hispanic 43%, NHB 50% and NHW 53%) ($p<0.001$). There were significant differences in the regional distribution of the rehabilitation facilities where these patients received care. Hispanic patients were more likely to receive care at facilities located in the West, while NHB children were more likely to be treated at facilities in the South ($p<0.001$).

Functional independence at admission

When comparing unadjusted total, motor and cognitive DFQs at admission to the rehabilitation facility, we found that NHB children had significantly lower scores in all categories, with larger differences in the motor domain. Mean admission motor quotient for NHB children was 38.30 95% confidence interval (CI) 37.28–39.31 compared to 41.23 for Hispanic children (95% CI 39.94–42.53) and 40.24 for NHW children (95% CI 39.73–40.74) ($p<0.001$). Hispanic children had similar admission quotients when compared to NHW children. (Table 1)

Functional independence at discharge

Unadjusted analyses show significantly lower total, motor and cognitive functional independence scores for minority children. (Table 2) In the fully adjusted models, functional independence at discharge was significantly associated with functional independence at admission, patient age, and insurance status. Children with lower motor, cognitive and total DFQs at admission also had lower discharge scores. ($p<0.001$) After accounting for developmental differences in scores, younger patients had smaller functional improvements compared to older patients ($p<0.001$). Patients with Medicaid and other governmental insurance also had lower discharge scores when compared to those with private insurance ($p<0.001$), (Table 2).

We found significant differences between racial groups for cognitive DFQs. After controlling for admission scores, length of stay, age and sex, Hispanic and NHB children had lower cognitive scores at discharge compared to NHW children: −1.598 (95%CI: −3.07, −0.13) and −1.535 (95% CI: −2.56, −0.51), respectively. These differences became smaller and non-significant after adjusting for insurance and region in models 2 and 3 (Table 2).

We also found a statistically significant association between total and motor discharge scores and geographical region. Patients cared for at rehabilitation units located in the South region of the U.S had lower discharge scores (average of 2.0 points lower) compared with children treated at facilities in the Northeast, after adjusting for other factors in the model. There were no differences in discharge scores between children cared for at rehabilitation units in the Midwest, West and in the Northeast (Table 2).

Rehabilitation facilities in pediatric hospitals

The subgroup analyses studying the association between type of rehabilitation facility and functional outcomes, included 4,839 children (3,245 NHW, 451 Hispanic and 1,143 NHB) cared for at 60 different rehabilitation facilities; corresponding to 48% of the study sample. In these analyses we found that children cared for at facilities within general hospitals had lower discharge cognitive DFQs (−3.79, 95% CI −7.42, −0.18) compared with those who were cared for at facilities located in pediatric hospitals. There were no significant differences in discharge scores of children cared for at rehabilitation units within pediatric hospitals and free standing units. Findings did not change after accounting for type of insurance or geographical region; therefore we only show the results of the final model (model 4). Motor scores did not vary by type of rehabilitation facility (Table 3).

Discussion

Our study, conducted among a cohort of Hispanic, non-Hispanic Black, and non-Hispanic White children with traumatic brain injury, documented an association between race and ethnicity and cognitive functional independence at discharge from the rehabilitation facility. At discharge, Hispanic and NHB children with traumatic brain injury had on average 1.6 and 1.5 points lower scores respectively compared to NHW children. The clinical implications of these differences are difficult to ascertain given that there are no current definitions for clinically significant differences in independence scores for patients with TBI.

We found a large effect of age on motor and cognitive discharge functional scores. Younger patients had lower discharge scores; even after using developmental functional quotients which provide a quotient score based on age-norms. These findings are in agreement with prior literature describing higher levels of disability following TBI in younger patients. [10] We also found that type of insurance was strongly associated with functional discharge scores; patients with Medicaid and governmental insurance had lower discharge scores. This finding is also in agreement with prior literature in which poor children with Medicaid insurance were more likely to have unmet rehabilitation needs when compared with children with private insurance coverage.[6]

We also found that patients cared for at rehabilitation facilities within pediatric hospitals had higher cognitive scores than did those who received care at facilities serving the needs of adults as well as children. These results are consistent with findings from a prior study on quality indicators for pediatric rehabilitation care. In this study, quality indicators such as having pediatric trained providers, adequate specialized pediatric equipment and classrooms were more likely to be present in pediatric rehabilitation facilities.[11,12] Our finding supports the results of the quality indicator study. Further research is needed in order to examine if these child-specific services contribute to the higher discharge scores among children who received care at pediatric rehabilitation facilities.

The reasons that minority children have poorer outcomes after rehabilitation for TBI is at least partly explained by the compounding presence of many risk factors for poor outcomes in the same child. Minority children were younger at the time of injury, were more likely to be insured by Medicaid, and, for Hispanic children, they were more likely to be treated in non-pediatric facilities. These risk factors likely have a cumulative effect on the function of minority children on discharge from rehabilitation. Our findings highlight the critical need for access to high quality outpatient rehabilitation care, school and community support services for Hispanic and NHB children following discharge from the hospital.

Study limitations

Our study has a number of limitations. This dataset from inpatient rehabilitation facilities does not contain data on pre-injury function, nor on injury severity scores, though each patient is presumed to have moderate to severe injuries for which inpatient rehabilitation was needed. However admission functional independence scores were incorporated into each analysis as a measure of pre-rehabilitation functional independence status and thus a measure of injury severity. In all cohort studies there is the possibility of unmeasured confounding, though analyses were controlled for measured biological (age, gender, admission scores), and health care (length of stay, insurance, region and type of facility) factors. Also, the present study is limited to patients who received inpatient rehabilitation care; many children do not receive this care, relying solely on outpatient visits for their rehabilitation therapy.

Conclusions

Minority children are at higher risk for poor outcomes after TBI due to the combined presence of many risk factors in the same child. Younger age, Medicaid insurance and, for Hispanic children, lower likelihood of being treated in non-pediatric facilities have a cumulative effect on the function of these children on discharge from rehabilitation. Our finding of smaller disparities after acute inpatient care in comparison to the large long term disparities previously described is encouraging. It indicates that the long term differences previously described are more likely due to inadequate rehabilitation care after discharge rather than during the acute care phase. Interventions to coordinate outpatient care while patients are still hospitalized could help to reduce long-term disability for minority patients. Interventions may also be needed for patients who receive all their rehabilitation therapy as an outpatient. While these patients potentially have less severe injuries, they are still at risk

for poor functional outcomes.[13] As minority children are also more likely to be poor; they bear a disproportionate burden of risk for failing to reach their potential following rehabilitation. Further studies are needed to understand reasons for these persistent inequalities and to design interventions to improve outcomes among this vulnerable population.

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Abbreviations

DFQ	developmental functional quotient
CI	confidence interval
NHB	non-Hispanic Black
NHW	non-Hispanic White
TBI	traumatic brain injury

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Table 1

Patient characteristics by race and ethnicity

Characteristics	**TBI (N=10,141)**			
	NHW N=7,247	**Hispanic N=1,118**	**NHB N=1,776**	**p-Value**
Age in years mean (SD)	14 (0.5)	13 (0.2)	12(0.1)	<0.001
Age categories %				
6mo–3y	5%	9%	11%	<0.001
4–7y	7%	10%	14%	
8–14y	21%	22%	28%	
15–18y	68%	59%	46%	
Sex n (%)				
male	67%	71%	70%	0.004
female	33%	29%	30%	
Insurance %				
Commercial	68%	36%	36%	<0.001
Medicaid/Government	25%	50%	56%	
Other	7%	15%	8%	
Facility type* n (%)				
Unit within a pediatric hospital	1733(53%)	195 (43%)	574 (50%)	<0.001
Unit within a general hospital	1,100 (34%)	203 (45%)	383 ((31%)	
Free standing unit	406 (13%)	52 (22%)	183 (16%)	
Region %				<0.001
Northeast	19%	11%	19%	
South	36%	31%	57%	
Midwest	20%	9%	13%	
West	26%	50%	11%	
Length of Stay in days median (IQR [25–27])	15 (8–18)	16 (9–28)	16 (9–29)	0.9
Unadjusted developmental quotient scores DQS mean (95% CI)				
FIM DQS admission	40.89 (40.41–41.38)	42.43 (41.19–43.68)	39.45 (38.48–40.43)	<0.001
FIM DQS discharge	70.52 (70.04–71.00)	69.61 (68.38–70.85)	66.61 (65.60–67.61)	<0.001
Motor DQS admission	40.24 (39.73–40.74)	41.23 (39.94–42.53)	38.30 (37.28–39.31)	<0.001
Motor DQS discharge	72.15 (71.63–72.67)	70.86 (69.52–72.19)	67.78 (66.69–68.87)	<0.001
Cognitive DQS admission	42.62 (42.06–43.17)	45.60 (44.11–47.10)	42.50 (41.39–43.60)	0.009
Cognitive DQS discharge	66.31 (65.81–66.82)	66.44 (64.97–67.90)	63.60 (62.55–64.64)	<0.001

* only patients with information on facility type

Table 2

Factors associated with discharge functional independence scores

	TOTAL QUOTIENT SCORE			MOTOR QUOTIENT SCORE			COGNITIVE QUOTIENT SCORE		
	Model 1	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
Variables	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**	**Coefficient (95%CI)**
Admission Quotient score	**0.60 [0.55,0.64]**	**0.60 [0.55,0.64]**	**0.60 [0.54,0.62]**	**0.59 [0.54,0.64]**	**0.58 [0.54,0.63]**	**0.56 [0.52,0.60]**	**0.61 [0.58,0.65]**	**0.615 [0.58,0.65]**	**0.60 [0.58,0.64]**
Race									
NHW	ref	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Hispanic	**−1.82 [−2.98,−0.66]**	−0.79 [−2.03,0.43]	−0.54 [−1.87,0.80]	**−1.87 [−3.12,−0.39]**	−0.50 [−1.85,0.84]	−0.33 [−1.80,1.13]	**−2.16 [−3.50,−0.83]**	**−1.59 [−3.07,−0.13]**	−1.15 [−2.54,0.23]
NHB	**−2.95 [−4.02,−1.88]**	**−1.04 [−1.99,−0.09]**	0.09 [−0.82,1.00]	**−3.05 [−4.30,−1.80]**	0.79 [−1.83,0.23]	0.47 [−0.52,1.47]	**−2.65 [−3.60,−1.70]**	**−1.53 [−2.56,−0.51]**	−0.78 [−1.74,0.17]
Age									
6m–3y	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
4–7 y		**9.35 [7.43,11.28]**	**9.02 [7.01,11.03]**		**11.59 [9.50,13.68]**	**11.22 [9.01,13.44]**		**4.55 [2.24,6.87]**	**4.37 [2.01,6.74]**
8–14 y		**15.56 [13.84,17.29]**	**15.03 [13.00,17.06]**		**18.84 [16.82,20.88]**	**18.27 [15.88,20.67]**		**8.23 [6.02,10.45]**	**7.86 [5.47,10.25]**
15–18y		**17.57 [15.55,19.60]**	**16.73 [14.48,18.97]**		**21.20 [18.89,23.51]**	**20.24 [17.62,22.87]**		**9.46 [7.15,11.77]**	**8.96 [6.56,11.36]**
Sex									
male	ref	ref	ref	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Female		0.44 [−0.37,1.25]	0.53 [−0.27,1.33]		−0.11 [−0.79,1.02]	0.20 [−0.70,1.11]		**1.11 [0.40,1.83]**	**1.17 [0.48,1.87]**
Insurance									
Commercial	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**	**ref**
Medicaid/governmental			**−1.48 [−2.24,−0.72]**			**−1.52 [−2.34,−0.70]**			**−1.27 [−2.16,− 0.39]**
other			−0.61 [−2.19,0.98]			−0.46 [−2.21,1.29]			−1.04 [−2.61,0.52]
Region									
Northeast	ref	ref	ref	ref	ref	ref	ref	ref	ref
South			**−2.41 [−4.21,−0.61]**			**−2.82 [−4.83,−0.82]**			−1.43 [−3.50,0.64]
Midwest			1.74 [−0.29,3.77]			1.48 [−0.59,3.57]			2.43 [−0.70,5.56]
West			1.43 [−0.46,3.32]			1.88 [−0.31,4.09]			0.30 [−1.33,1.93]
Overall R-squared	0.42	0.47	0.47	0.39	0.45	0.46	0.46	0.47	0.47

Significance is indicated in bold. All models adjust by year of discharge and length of stay. Coefficients are unstandardized.

Table 3

Subgroup analysis among patients with information on type of facility

	Total quotient score	Motor quotient score	Cognitive quotient score
Variables	**Coefficient (95% CI)**	**Coefficient (95% CI)**	**Coefficient (95% CI)**
Admission Quotient score	**0.59 [0.53,0.66]**	**0.55 [0.49,0.62]**	**0.65 [0.60,0.70]**
Race			
NHW	**Ref**	**Ref**	**Ref**
Hispanica	0.54 [−1.69,2.78]	0.68 [−1.67,3.03]	0.17 [−2.13,2.49]
NHB	0.53 [−0.60,1.66]	1.01 [−0.19,2.21]	−0.48 [−1.73,0.76]
Age			
6m–3y	**Ref**	**Ref**	**Ref**
4–7 y	**9.40 [7.43,11.38]**	**11.39 [9.23,13.57]**	**5.16 [2.92,7.42]**
8–14 y	**15.04 [13.13,16.96]**	**18.02 [15.72,20.32]**	**8.54 [6.02,11.07]**
15–18y	**17.53 [15.11,19.97]**	**21.11 [17.90,24.33]**	**9.68 [7.04,12.32]**
Sex			
Male	**Ref**	**Ref**	**Ref**
Female	**1.30 [0.18,2.43]**	1.05 [−0.19,2.31]	**1.64 [0.63,2.66]**
Facility type			
pediatric hospital	Ref	Ref	Ref
General hospital	−0.58 [−3.50,2.39]	0.57 [−2.43,3.57]	**−3.79 [−7.42,−0.18]**
Free standing	−0.30 [−3.18,3.79]	1.25 [−2.61,5.12]	−1.98 [−5.84, 1.88]
Insurance			
Commercial	**Ref**	**Ref**	**Ref**
Medicaid/governmental	**−1.61 [−2.63,−0.61]**	**−1.69 [−2.75,−0.65]**	−1.25 [−2.59,0.07]
other	0.20 [−2.32,2.72]	0.02 [−2.80,2.64]	0.56 [−1.99,3.12]
Region			
Northeast	Ref	Ref	Ref
South	**−4.16 [−7.46,−0.8]**	**−4.68 [−8.65,−0.71]**	−3.02 [−6.53,0.48]
Midwest	1.09 [−2.29,4.49]	**0.69 [3.27,4.67]**	2.15 [−1.60,5.90]
West	0.87 [−3.70,5.46]	1.86 [−3.22,6.96]	−1.43 [−5.84,2.97]

All models adjusted year of discharge and length of stay.

Total number of patients included 4,839: 3,245 NHW, 451 Hispanic and 1,143 NHB.