Favorable Outcomes for Native Hawaiians and Other Pacific Islanders with Severe Traumatic Brain Injury

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Abstract

Traumatic brain injury (TBI) disproportionately impacts minority racial groups. However, limited information exists on TBI outcomes among Native Hawaiians and other Pacific Islanders (NHPI). All patients with severe TBI (Glasgow Coma Scale (GCS) <9) who were hospitalized at the state-designated trauma center in Hawai'i from March 2006 to February 2011 were studied. The primary outcome measure was discharge Glasgow Outcome Scale ([GOS]: 1, death; 2, vegetative state; 3, severe disability; 4, moderate disability; 5, good recovery), which was dichotomized to unfavorable (GOS 1-2) and favorable (GOS 3-5). Logistic regression analyses were performed to assess factors predictive of discharge functional outcome. A total of 181 patients with severe TBI (NHPI 27%, Asians 25%, Whites 30%, and others 17%) were studied. NHPI had a higher prevalence of assault-related TBI (25% vs 6.5%, P=.046), higher prevalence of chronic drug abuse (20% vs 4%, P=.02) and chronic alcohol abuse (22% vs 2%, P=.003), and longer intensive care unit length of stay (15±10 days vs 11±9 days, P<.05) compared to Asians. NHPI had lower prevalence of unfavorable functional outcomes compared to Asians (33% vs 61%, P=.006) and Whites (33% vs 56%, P=.02). Logistic regression analyses showed that Asian race (OR, 6.41; 95% CI, 1.68–24.50) and White race (OR, 4.32; 95% CI, 1.27–14.62) are independently associated with unfavorable outcome compared to NHPI. Contrary to the hypothesis, NHPI with severe TBI have better discharge functional outcomes compared to other major racial groups.

Introduction

In the United States, 1.7 million people experience a traumatic brain injury (TBI) each year, 52,000 of whom die in-hospital.[1] Direct medical costs and indirect costs such as lost productivity as a result of TBI are estimated to be $60 billion annually in the United States.[2] Furthermore, recent evidence suggests that the burden of TBI is not borne equally by all, with racial minority groups reported to have higher incidence and poorer outcomes than non-Hispanic Whites.[3-5] Prior studies have shown that African-Americans and Asians had higher in-hospital mortality than non-Hispanic Whites after TBI.[3] One longitudinal study of TBI patients showed that African Americans and Hispanics had worse functional outcome at discharge and 1-year post-injury compared to non-Hispanic Whites.[6] The long-term functional outcomes after severe TBI were also worse among the racial-ethnic minorities compared to non-Hispanic Whites.[4,5,7] Asian Americans with TBI have also shown similar disparities in the in-hospital mortality rate compared to non-Hispanic Whites.[8,9] Despite the racial disparities seen among many racial minorities with TBI, little is known about the outcomes of Native Hawaiians and other Pacific Islanders (NHPI) in Hawai'i who suffer severe TBI. According to the definition used in the 2010 Census, NHPI refers to persons with origins in any of the original peoples of Hawai'i, Guam, Samoa or other Pacific Islands.[10] Therefore, racial/ethnic differences in the discharge functional outcome after severe TBI were assessed among a unique patient population that primarily consists of NHPI, Asians, and non-Hispanic Whites. The hypothesis of the study was that NHPI race is an independent predictor of unfavorable outcomes among persons with severe TBI.

Methods

This was a single-center, retrospective study of all patients with severe TBI (Glasgow Coma Scale [GCS] score <9) from March 2006 to February 2011 who were hospitalized at The Queen's Medical Center (QMC). QMC is a 505-bed medical center located in Honolulu, and is the largest tertiary referral center for the Pacific Basin. As the only state-designated trauma center in Hawai'i, QMC receives all major trauma victims from the Hawaiian Islands. All patients with significant head injuries, including isolated head injuries as well as multitrauma victims admitted to QMC are treated in the neuroscience intensive care unit (NSICU) by a multidisciplinary team according to existing evidence-based guidelines for TBI.[11] Intracranial pressure (ICP) monitors and brain tissue oxygen ($PbtO_2$) monitors are placed when clinically indicated as part of standard neurocritical care practices. Decompressive craniectomy is performed for patients with clinical cerebral herniation syndromes due to mass effect or refractory intracranial hypertension. When indicated, removal of mass lesions is also performed at the time of surgery.

This study was approved by the QMC institutional research review committee. We reviewed the TBI-trac database™, a prospectively collected database of severe TBI patients who are treated at our institution. Additional clinical data were obtained from a retrospective chart review by 6 people. Abstracted data include patient demographics, mechanism of injury, whether the patient had undergone decompressive craniectomy, body mass index (BMI), admission GCS, Injury Severity Score (ISS), medical co-morbidities including history of diabetes mellitus, hypertension, coronary artery disease, prior stroke, and chronic obstructive pulmonary disease. Substance abuse history and urine toxicology results, if available, were also obtained. The race and ethnicity information were collected by the administrative personnel during the registration process, nurses during the intake process, or by the research staff personnel through chart review process. Since mixed racial background is relatively common in Hawai'i, race was defined as the racial background that the patient most closely associated with and was based on patient self-identification or family's identification if the patient

was incapacitated. The Native Hawaiian race and other Pacific Islander race were combined into one racial category (NHPI) for ease of comparison with national census-based data. Race was categorized as NHPI, Asian, White, and other. Clinical outcome measures such as total hospital length of stay (LOS), Intensive Care Unit (ICU) LOS, in-hospital mortality, and discharge Glasgow Outcome Scale (GOS) were also obtained. The GOS is commonly used to assess physical functioning after neurological injuries, and classifies subjects into broad categories: 1, death; 2, vegetative state; 3, severe disability; 4, moderate disability; 5, good recovery. The discharge GOS was estimated from the documentation provided by the physical therapists, occupational therapists, speech therapists, nurses, and physicians at the time of discharge. The primary outcome measure was discharge functional outcome, which was dichotomized to unfavorable outcome (GOS 1-2) and favorable outcome (GOS 3-5). All initial head computed tomography (CT) scans were retrospectively reviewed by a board-certified neurointensivist, blinded to race, ethnicity and clinical data, and scored according to the Marshall CT classification[12] and Rotterdam CT score.[13]

Data were analyzed using commercially available statistical software (SPSS 18.0, Chicago, IL). Patient characteristics were summarized using descriptive statistics appropriate to variable type. The Asian and White racial groups were compared to the NHPI group (reference group) using χ^2 test or Fisher's Exact test for categorical data and 2-tailed t-test for normally distributed, continuous variables. To determine racial disparities in functional outcome at discharge, multivariable analyses using a logistic regression model were performed to assess whether race, compared to NHPI race, is an independent predictor of functional outcome at discharge. Variables with $P \leq .10$ in the univariate testing were selected for entry in the model. Race was forced to enter in the model regardless of the statistical significance in the univariate testing. In the model, only the Rotterdam CT score, and not the Marshall CT classification, was included since the two CT scores are collinear. Levels of $P < .05$ were considered statistically significant.

Results

A total of 181 patients with severe TBI (NHPI 27%, Asians 25%, Whites 30%, and others 17%) were studied. Clinical characteristics are shown in Table 1. Among the severe TBI patients admitted to our institution, NHPI were younger (NHPI: 30 ± 15 years vs Asians: 45 ± 24 years, $P = .001$; vs Whites: 40 ± 18 years, $P = .005$) compared to Asians and Whites. Compared to Asians, NHPI had a higher prevalence of assault-related TBI (25% vs 6.5%, $P = .046$), higher prevalence of chronic drug abuse (20% vs 4%, $P = .02$), chronic alcohol abuse (22% vs 2%, $P = .003$), presence of alcohol on the urine toxicology study (39% vs 12%, $P = .009$), and longer ICU LOS (15 ± 10 days vs 11 ± 9 days, $P = .049$). There was no difference in the CT characteristics among the three racial groups. There was a trend toward lower in-hospital age-adjusted mortality in NHPI compared to Asians (27% vs 48%, $P = .06$). The proportions of patients with unfavorable discharge functional outcome (GOS 1-2) were lower among NHPI compared to Asians (33% vs 61% respectively, $P = .006$) and Whites (33% vs 56% respectively, $P = .02$; Figure 1).

Univariate analyses showed that the group with unfavorable discharge functional outcome (n = 90) had a different proportion of racial groups ($P = .03$), lower admission GCS score ($P = .01$), higher ISS score ($P = .045$), higher prevalence of fixed and dilated pupils ($P = .006$), higher prevalence of traumatic subarachnoid hemorrhage ($P = .009$) and compression of the basal cisterns ($P = .007$) seen on the head CT, and higher Rotterdam ($P < .001$) and Marshall ($P < .001$) CT scores compared to those with favorable discharge functional outcome (n = 91; Table 2). In the multivariable analyses (Table 3), after adjusting for age and variables with pre-specified significance, the independent predictors for unfavorable discharge outcome were Asian race (OR, 6.41; 95% CI, 1.68 – 24.50, $P = .007$) and White race (OR, 4.32; 95% CI, 1.27 – 14.62, $P = .02$) compared to NHPI race, and Rotterdam CT score (OR, 2.72; 95% CI, 1.25 – 5.90, $P = .01$).

Discussion

Contrary to the initial hypothesis, this study shows that NHPI are less likely to have an unfavorable outcome after severe TBI compared to Asians and Whites, after adjusting for age and other confounders. Furthermore, NHPI were younger compared to Asians and Whites, and had a higher proportion of assault-related injuries and history of chronic drug and alcohol abuse compared to Asians. To our knowledge, this is the first study to describe the clinical characteristics and disparities in outcome after severe TBI in a population that contains a large proportion of NHPI. Most prior studies assessing the racial disparities in the TBI population suggest worse outcome among the minority groups. In patients who visited an Emergency Department (ED) for mild TBI, Hispanics were more likely to receive nasogastric tube placement compared to non-Hispanics, possibly due to language barriers.[14] Similarly, ethnic minority groups with mild TBI were more likely to receive ED care by a resident than a staff physician and were also less likely to return to the referring physician for follow-up.[14] In a pediatric TBI population, African-American children with TBI were found to have worse functional outcomes at discharge compared to equivalently injured non-Hispanic White children with TBI.[15] Despite the disparities seen in other minority groups, there are no published data regarding TBI in the NHPI population. Overall, NHPI are underrepresented in TBI studies and are often grouped together with Asians into a single racial category, despite evidence that NHPI may substantially differ from Asian patients.

Reasons for racial differences in outcome seen in this study are likely complex. Since NHPI had a higher prevalence of assault-related injuries and lower prevalence of fall-related injuries compared to Asians and non-Hispanic Whites, it is possible that assault-related injuries would lead to a lower mechanical impact on the brain compared to fall-related injuries. However, since the mechanism of injury was not a significant factor in the univariate and multivariable analyses, it is unlikely that it contributed to the observed differences in outcome.

Table 1. Racial characteristics of severe TBI patients at The Queen's Medical Center (2006 – 2011)							
	NHPI	**Asians**	***P***	**Whites**	***P***	**Others**	***P***
n	49	46		55		31	
Age, years	30 ± 16	45 ± 24	**.001**	40 ± 18	**.005**	33 ± 16	**.46**
Female	8 (16)	12 (26)	.24	12 (22)	.48	6 (19)	.73
BMI, kg/m2	29 ± 9	26 ± 5	.08	26 ± 5	.14	27 ± 8	.54
Mechanism of injury			**.046**		.21		.06
Assault	12 (25)	3 (6.5)		6 (11)		2 (7)	
Fall	6 (12)	12 (26)		13 (24)		8 (26)	
MVA	26 (53)	21 (46)		26 (47)		13 (42)	
Sports injury	4 (4)	3 (6.5)		2 (4)		2 (7)	
Other	11 (12)	7 (15)		8 (15)		6 (19)	
Admission GCS	5.5 [3.0 – 7.0]	5.5 [3.0 – 7.0]	.95	5.0 [4.0 – 7.0]	.31	4.0 [3.0 – 6.5]	.25
ISS	34 [26 – 42]	29 [26 – 39]	.51	34 [26 – 41]	.39	34 [26 – 42]	.63
Fixed and dilated pupils	5 (12)	6 (15)	.71	7 (14)	.79	4 (13)	.90
History of chronic drug abuse	10 (20)	2 (4)	**.02**	9 (16)	.59	6 (19)	.91
History of chronic alcohol abuse	11 (22)	1 (2)	**.003**	12 (22)	.94	4 (13)	.29
Positive Methamphetamine	4 (11)	3 (9)	.75	6 (14)	.73	4 (18)	.45
Positive Alcohol	14 (39)	4 (12)	.009	18 (41)	.85	8 (36)	.85
Diabetes	3 (6)	8 (17)	**.09**	3 (6)	.88	0 (0)	.16
Hypertension	6 (12)	15 (32)	**.02**	5 (9)	.60	4 (13)	.93
Coronary artery disease	3 (6)	5 (11)	.41	4 (7)	.82	2 (7)	.95
Congestive heart failure	0 (0)	1 (2)	.30	0 (0)	-	0 (0)	-
COPD	1 (2)	1 (2)	.96	0 (0)	.29	0 (0)	.42
History of stroke	0 (0)	3 (7)	.07	0 (0)	-	0 (0)	-
Initial CT findings							
Intraventricular hemorrhage	7 (14)	8 (17)	.68	7 (13)	.82	4 (13)	.86
Subarachnoid hemorrhage	20 (41)	28 (61)	.05	27 (49)	.40	16 (52)	.34
Diffuse axonal injury	38 (78)	35 (76)	.87	42 (76)	.89	22 (71)	.51
Compression of basal cisterns	32 (65)	31 (67)	.83	44 (80)	.09	28 (90)	.01
Rotterdam CT score	3.0 [2.5 – 4.0]	4.0 [2.0 – 4.0]	.61	4.0 [3.0 – 4.0]	.50	4.0 [3.0 – 4.0]	.41
Marshal CT score	3.0 [2.0 – 3.5]	3.0 [2.0 – 4.0]	.13	3.0 [3.0 – 4.0]	.08	3.0 [3.0 – 4.0]	.02
ICP monitor	41 (84)	32 (70)	.10	47 (86)	.80	26 (84)	.98
PbtO2 monitor	28 (64)	18 (49)	.18	31 (60)	.69	19 (61)	.84
Decompressive craniectomy	11 (22)	11 (24)	.87	6 (11)	.11	8 (26)	.73
ICU LOS, days	15 ± 10	11 ± 9	**.049**	12 ± 9	.15	12 ± 10	.20
Total hospital LOS, days	53 ± 105	24 ± 33	.08	38 ± 82	.42	18 ± 16	.08
Unfavorable outcome (GOS 1-2)	16 (33)	28 (61)	**.006**	31 (56)	**.02**	15 (48)	**.16**
Age-adjusted Mortality	13 (27)	22 (48)	**.06**	24 (44)	.26	12 (39)	.31

Baseline patient characteristics. BMI, body mass index; MVA, motor vehicle accident; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; COPD, chronic obstructive pulmonary disease; CT, computed tomography; ICP, intracranial pressure; $PbtO_2$, brain tissue oxygen; ICU, intensive care unit; LOS, length of stay. GOS, Glasgow Outcome Scale; NHPI is the reference category. Data are n (%), mean ± SD, or median [IQR].

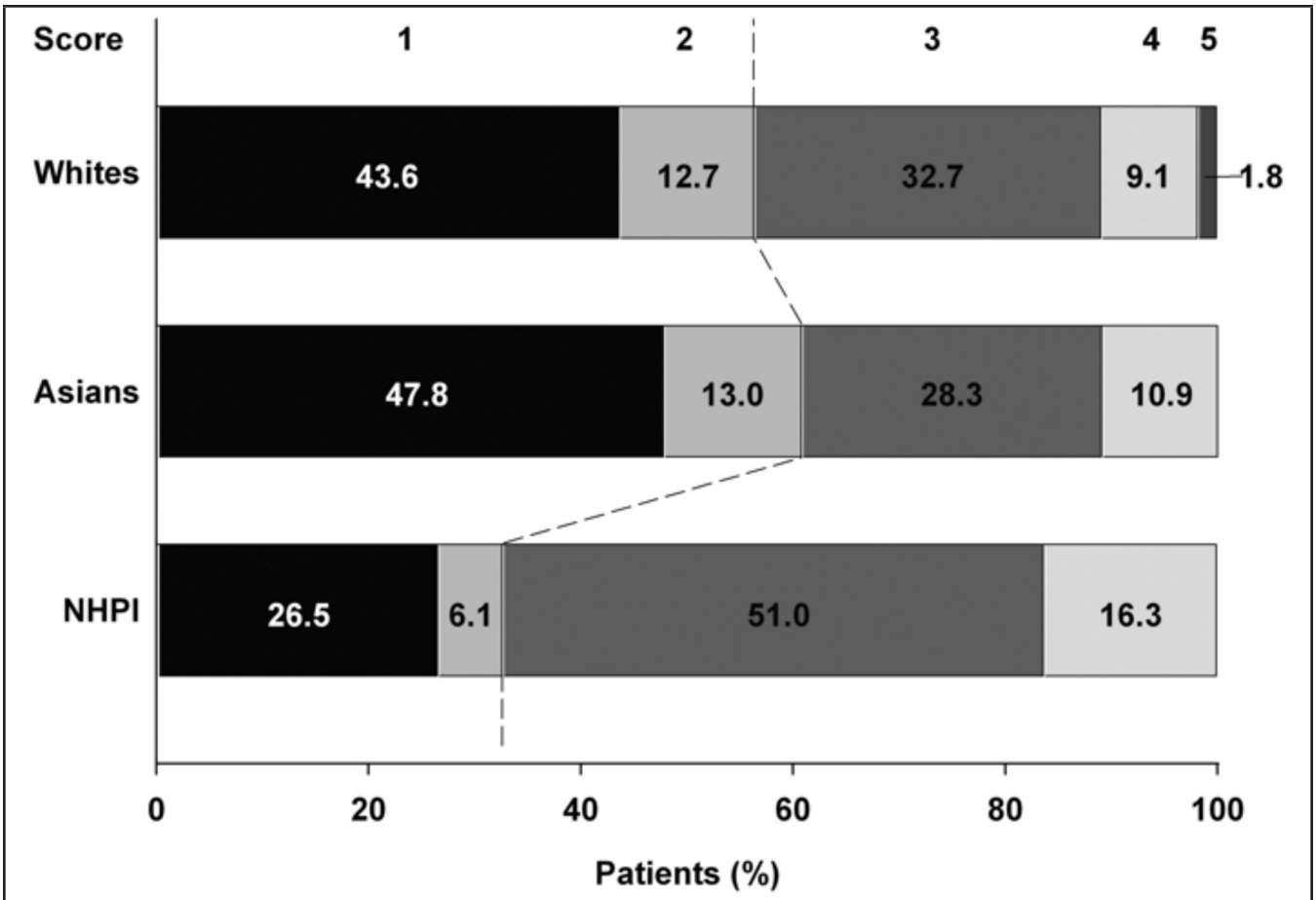

Figure 1. Distribution of the discharge Glasgow Outcome Scale (GOS) scores. The distribution of GOS scores is shown for Whites, Asians, and Native Hawaiians and other Pacific Islanders (NHPI). The dashed line separates unfavorable outcome (score of 1–2) from favorable outcome (score of 3–5).

Perhaps there may be biological differences in susceptibility to secondary brain injury after severe TBI among different racial and ethnic groups. The most extensively studied genotype associated with outcome after TBI is apolipoprotein E (APOE). Many studies have shown that APOE-ε4 allele is associated with poor outcome after TBI compared to those without the ε4 allele, possibly through various effects of APOE-ε4 allele on amyloid deposition, disruption of cytoskeletal stability, cholinergic dysfunction, oxidative stress, neuroprotection, and central nervous system plasticity in response to brain injury.[16-18] There are also other less well-studied genes that have been postulated to influence inflammatory, apoptotic, and blood flow regulatory pathways after TBI that may contribute to differences in outcome.[18] However, since most NHPI in Hawai'i are mixed race that include the genotype of NHPI, Asians, Hispanics and non-Hispanic Whites, it is unlikely that there were significant differences in genetic polymorphisms between races that led to our results.

Much of the differences in the discharge outcome could be explained by the racial differences in the aggressiveness of care that the patient's families seek in the neurocritical care setting, as supported by the longer ICU LOS seen among NHPI compared to Asians and Whites. The higher mortality and shorter ICU LOS among Asians and Whites compared to NHPI may reflect the fact the many of these patients' care were later changed to palliative care with expected natural death in the ICU. The changes in aggressiveness of care often occur after the providers and the patients' families discuss the long-term prognosis. Using the principle of autonomy as a guide to make decisions, patient families sometimes elect to stop the aggressive care if the expected long-term functional outcome and the quality of life are felt to be incongruent with the patient's known wishes. These decisions may be impacted by social, religious, or cultural factors that may differ by race. Since prior studies have shown that minority racial groups are more likely to seek aggressive care after brain injury and other critical conditions compared to non-Hispanic Whites, it is possible that NHPI may also have a similar attitude in the ICU setting.[19-23] Unfortunately, due to the retrospective nature of the study, all of the intricate end-of-life discussions that likely took place, including each patient's

Table 2. Factors Associated with Functional Outcome at Discharge			
	Unfavorable (GOS 1-2)	**Favorable (GOS 3-5)**	***P***
n	90	91	
Age, years	40 ± 21	35 ± 18	.10
Female, n (%)	19 (21)	19 (21)	.97
BMI	26 ± 7	28 ± 6	.17
Race			.03
White	31 (34)	24 (26)	
Asian	28 (31)	18 (20)	
NHPI	16 (18)	33 (36)	
Other	15 (17)	16 (18)	
Mechanism of injury			.22
Assault	15 (17)	8 (9)	
Fall	23 (26)	16 (18)	
MVA	36 (40)	50 (55)	
Sports injury	4 (4)	4 (4)	
Other	12 (13)	13 (14)	
Admission GCS	4.0 [3.0 – 6.0]	6.0 [4.0 – 7.0]	.01
ISS	34 [26 – 43]	33 [26 – 38]	.045
Fixed and dilated pupils, n (%)	17 (21)	5 (6)	.006
History of chronic drug abuse, n (%)	12 (13)	15 (17)	.55
History of chronic alcohol abuse, n (%)	12 (13)	16 (18)	.43
Positive Methamphetamine, n (%)	10 (15)	7 (10)	.33
Positive Alcohol, n (%)	20 (31)	24 (34)	.71
Diabetes, n (%)	6 (7)	8 (9)	.59
Hypertension, n (%)	19 (21)	11 (12)	.10
Coronary artery disease, n (%)	6 (7)	8 (9)	.59
Congestive heart failure, n (%)	1 (1)	0 (0)	.31
COPD, n (%)	1 (1)	1 (1)	.99
History of stroke	2 (2)	1 (1)	.55
Initial CT findings			
Intraventricular hemorrhage	14 (16)	12 (13)	.65
Subarachnoid hemorrhage	54 (60)	37 (41)	.009
Diffuse axonal injury	71 (79)	66 (73)	.32
Compression of basal cisterns	75 (83)	60 (66)	.007
Rotterdam CT score	4.0 [3.0 – 5.0]	3.0 [2.0 – 4.0]	<.001
Marshall CT score	3.0 [3.0 – 4.0]	3.0 [2.0 – 3.0]	<.001
ICP monitor, n (%)	69 (77)	77 (85)	.18
PbtO2 monitor, n (%)	40 (50)	56 (67)	.03
Decompressive craniectomy, n (%)	18 (20)	18 (20)	.97
ICU LOS, days	8 ± 7	17 ± 12	<.001
Total hospital LOS, days	13 ± 20	57 ± 98	<.001

Factors associated with functional outcome at discharge. BMI, body mass index; MVA, motor vehicle accident; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; COPD, chronic obstructive pulmonary disease; CT, computed tomography; ICP, $PbtO_2$, brain tissue oxygen; intracranial pressure; ICU, intensive care unit; LOS, length of stay. Data are n (%), mean ± SD, or median [IQR].

Table 3. Multivariable Models for Unfavorable Discharge Outcome (GOS 1-2)			
	Model 1 Unadjusted OR (95% CI)	**Model 2 Adjusted for Age OR (95% CI)**	**Model 3 Fully Adjusted OR (95% CI)**
Race (NHPI – reference group)			
Asians	3.21 (1.38, 7.44)*	2.89 (1.21, 6.90)*	6.41 (1.68, 24.50)*
Whites	2.66 (1.20, 5.93)*	2.49 (1.10, 5.62)*	4.32 (1.27, 14.62)*
Others	1.93 (0.77, 4.87)	1.90 (0.75, 4.79)	2.86 (0.74, 11.00)
Age		1.01 (0.99, 1.02)	1.00 (0.97, 1.03)
Admission GCS			0.84 (0.65, 1.07)
ISS			1.04 (0.99, 1.10)
Fixed and dilated pupils			1.11 (0.28, 4.47)
Hypertension			2.04 (0.55, 7.63)
Subarachnoid hemorrhage			0.96 (0.32, 2.90)
Compression of basal cisterns			0.39 (0.10, 1.60)
Rotterdam CT score			2.71 (1.25, 5.90)*
PbtO2 monitor			0.55 (0.23, 1.32)

GOS, Glasgow Outcome Scale; OR, odds ratio; CI, confidence interval; NHPI, Native Hawaiians and other Pacific Islanders; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; PbtO2, brain tissue oxygen; *statistically significant at $P < .05$.

previously stated wishes, known values, religion/spirituality, socioeconomic status, social support, etc, that ultimately led to the decisions to limit care in some of these patients could not be characterized. Also, the provider's attitude toward aggressiveness of care and the main factors that led to the decision to limit care in these patients could not be assessed.

Contrary to many prior TBI and stroke studies where long-term functional outcome is typically dichotomized to GOS of 1-3 (death, vegetative or severe disability) and 4-5 (moderate disability or good recovery), the dichotomized GOS cutpoint in this study was chosen between 2 and 3 for the following reasons: (1) Since the patient population was limited to severe TBI, excluding mild and moderate TBI, it was felt appropriate to include non-vegetative, severe disability as an acceptable outcome at the time of hospital discharge; (2) much of the disability in the acute setting may be confounded by other bodily injuries from multitrauma; (3) since the outcome measures were done at the time of hospital discharge, not at 6 or 12 months from admission as done by most prior studies, many of our survivors did not have sufficient recovery time to show the full potential of neurological improvement; and (4) GOS dichotomization using the more traditional cutpoint (1-3 vs 4-5) would have resulted in a disproportionately smaller number of patients with favorable outcome (n = 21), and the statistical power to show the impact of race on discharge outcome would have been lost.

This study has several limitations. Although the study population is representative of trauma patients in Hawai'i since QMC is the only state-designated trauma center, the results may not be generalizable to NHPI patients outside of Hawai'i. Also, specific information regarding the socioeconomic and insurance status of patients were not included in the study, which may have affected the clinical outcomes. The absence of data on pre-hospital hypotension and/or hypoxia, pre-hospital transport time and/or potential delay of care due to geographical factors may have also affected the prediction model. Due to the lack of long-term outcome data, any potential disparities that may exist in long-term outcome could not be assessed.

In summary, Native Hawaiians and other Pacific Islanders have different clinical characteristics and better discharge outcomes compared to the other major racial groups in Hawai'i. Further prospective studies are needed to determine other factors contributing to the differences in outcomes seen in this unique racial group.

The findings of this study do not necessarily represent the views of The Queen's Medical Center.

Disclosure and Conflict of Interest

The authors report no relevant disclosure or conflict of interest.

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