TRAUMATIC BRAIN INJURY: OUTCOMES OF A RURAL VERSUS URBAN POPULATION OVER A 5 YEAR PERIOD

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We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Biomedical Sciences.

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ABSTRACT

Problem: The death rate from trauma in rural regions is disproportionately high compared to urban areas. In order to establish guidelines and quality assurance measures for Traumatic Brain Injury (TBI) patients in Hawaii, it is necessary to understand their characteristics and demographics.

Methods: Data on TBI injuries in Hawaii from 1999-2004 was obtained from 2 separate data sources: The Queen's Medical Center Trauma Database and the administrative data of the largest insurer for the state of Hawaii. The sample was composed of those patients diagnosed with TBI treated at any hospital in the state of Hawaii. Mortality rates during hospitalization for patients transferred from rural areas were compared using chi-square tests and logistic regression analysis

Results: There were 3447 patients treated at Queen's Medical Center and 1050 patients in the Insurance Company's database who were treated during the same interval. Our findings confirm that male gender, alcohol use and lack of protective devices result in higher rates of head injury. Fatalities from TBI were highest in young adults and the elderly. Although rates of injury were higher in rural locations, mortality rates were not significantly different.

Conclusions: TBI is a major cause hospitalization in Hawaii. The greatest potential to reduce morbidity and mortality would result if preventive strategies were aimed at the highest risk groups.

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LIST OF ABBREVIATIONS

ACS	American College of Surgeons
ALS	advanced life support
ATLS	advanced trauma life support
Benzo	benzodiazepine
BLS	basic life support
EMS	emergency medical services
CDC	Center for Disease Control
DOH	Department of Health
GCS	Glascow Coma Score
Hypo	hypotensive
Hyper	hypertensive
ICU	intensive care unit
ICD-9	international classification of disease 9^{th} revision
IRB	institutional review board
MVA	motor vehicle accident
Meth	methamphetamine
Neuro	neurological
NMDA	N-methyl-D-aspartate
RTS	Revised Trauma Score
SBP	systolic blood pressure
TRISS	Trauma Injury Severity Score
TBI	Traumatic Brain Injury

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

Approximately 21% of the United States population resides in rural areas where the death rate from trauma is disproportionately high. [1, 2, 3] For example, motor vehicle deaths in rural areas have been shown to be twice as high as urban areas. [4] While the rates of pedestrian injuries are higher in urban areas, the rates of fatalities are elevated in rural communities even when controlling for speed, age and sex. [5] The reasons for this disparity are multifactorial and are not well characterized. Little emphasis has been placed on the development of organized trauma care in rural areas.[6] Mueller suggests, "Rural trauma is the neglected disease of the nineties." [5]

Definition of rural:

Rural is inconsistently defined in the literature, resulting in significant miscommunication between agencies or entities. According to the 2000 United States Census, the population of the United States (US) was 281,421,906 people. The rural population was quantified at 59,061,367 or 21% of the total US population. Rural is defined in this context as any region that is located out of an urbanized area or urban cluster for US Census purposes. Urban areas and urban clusters are classified as "core census block groups or blocks that have a population density of at least 1,000 people per square mile and surrounding census blocks that have an overall density of at least 500 people per square mile." [1]

Why do individual states and agencies define "rural" differently? While the definitions are population-based, they are often centered on an identified resource. For instance, the state of Washington defines rural hospitals as "those

located more than 5 miles from cities of at least 25,000 people and in a county of less than 200,000 people." [7]

The Federal Highway Administration classifies urban streets as places with a population of 5,000 or greater [8] The Office of Management and Budget 2003 designation of metropolitan (by extrapolation "urban") statistical areas requires a population of at least 50,000 must exist and adjacent counties have "high degree of economic and social interacting ties."[9] A micropolitan statistical area will have at least 10,000 but less than 50,000 people. The remaining areas are defined as "non-core-based statistical areas" by exclusion. The rural distinction falls into this category.

The American College of Surgeons (ACS) Committee on Trauma ha s attempted to address the rural and urban categorization in "Resources for the Optimal Care of the Injured Patient". [10] Rural is defined in terms of isolation from trauma resources, where access to definitive care is hence, limited.[10] This definition is useful to healthcare providers and pertinent to outreach goals but lacks specificity in the context of traditionally described population-centered statistics.

Rural Demographics:

According to the United States 1990 Census, the demographic composition of rural areas is similar to urban regions when assessed collectively. The median age of the urban population is 35.3 years and for the rural population is slightly higher at 38.1 years. The male to female ratio is similar at 50:50.[1] There are however, some distinct differences. According to the US Department of Commerce in 2002, non-metropolitan counties and hence rural, had a 14.2%

poverty rate compared to an 11.6% poverty rate for metropolitan counties.[11] Ethnically, there is a higher composition of Caucasians in rural (90%) versus urban (70%) areas.[1] The poverty rates for minorities (non-Caucasians) in non-metro regions are three times higher that in urban areas.[11] Not unexpectedly, 21% of rural children are without health insurance versus 14% in urban neighborhoods. [12]

Rural trauma statistics:

The most common injuries in rural areas result from automobile accidents. Predictably, the rates of pedestrian injuries are comparatively lower in the rural environment. Agricultural accidents and occupational injuries are clearly higher in rural areas. This is presumed to be secondary to the increased hazards of the mechanical labor utilized in rural areas.[5] Rural populations are less likely to be victims in violent crimes but have higher suicide rates[13]. Fire related deaths are also greater. This may be secondary to lack of fire safety education and equipment, as well as the number of older homes found in these regions.[13] Fire fighter personnel may also be located at a greater distance from these homes. There may be a decrease in available manpower compounding the distance.

Mortality rates are uniformly higher for rural trauma victims for all categories of traumatic injury. [3,5,13] Pedestrian fatality is higher, regardless of age or speed of vehicle, in rural areas. [5] Rural fatal crashes account for 61% of all traffic fatalities. In calculating population death rates in motor vehicle accidents (MVAs) in 48 states, Baker found mortality highest in populations of low density.[4] This death rate was also inversely correlated with per capita income. In another

analysis, mortality was significantly higher in rural areas even when controlling for speed, sex and age. [5,14] Rural MVA trauma victims in general are more likely to be under the influence of alcohol and less likely to be using safety restraints such as seatbelts or child seats compared to urban counterparts. [13] In addition, rural MVA victims who die tend to be older than MVA fatalities in urban areas. [15] Additionally, older victims (usually defined as greater than 65 years of age) were less likely to be unrestrained, intoxicated or traveling at a speed greater than 60 miles per hour.[15] The older victims tend to demonstrate higher complication rate than their younger counterparts.[16] When subset analysis was done, older patients were less likely to die at the scene than younger trauma victims despite lower injury severity scores.[2] Although these patients were less severely injured, their associated co-morbid conditions resulted in a higher incidence of multisystem organ failure and death. [2]

Pre-hospital period:

It is well established that more than 50% of trauma deaths occur in the immediate post trauma period[17]. The immediate period is defined as the first hour after an injury. This prehospital time (both scene time and transport time) has been documented to be as much as two times longer in rural locations.[7,18] Twice as many patients die at the scene in rural regions as in urban areas. [2,5,19] Rural victims are over 7 times more likely to die before arrival for definitive treatment if the Emergency Medical Service (EMS) response time was greater than 30 minutes. [7] A recent population-based evaluation in Vermont revealed that

87% of the trauma patients did not receive timely assistance in the prehospital period.[20]

Skill of providers:

Many prehospital care providers are volunteers, and prepared primarily for basic life support. In a recent report the lower success rates of rural basic medical technicians to achieve intubation for the control of airway compared to paramedic controls were clearly reported. [21] This places rural populations at a distinct disadvantage in working with injured trauma victims in comparison to populations serviced by advanced life support trained providers. The presence personnel qualified to deliver advanced life support qualified personnel in the pre-hospital care period is commonly thought to be associated with lower death rates. [22]

Emergency room (ER) physicians in rural regions see fewer trauma victims than ER physicians in urban centers. Furthermore, the incidence of severe trauma is low in rural settings, rendering limited opportunities for training and maintenance of skills. This may result in inappropriate or late treatment decisions.[23] Advanced Trauma Life Support (ATLS) interventions have been shown to improve survival for severely injured patients at rural hospitals [24] yet they are not routinely being performed. [25,26]

Rural Hospitals:

The availability of a hospital with 24-hour Emergency Department services in the rural counties was found to be associated with a decrease in mortality for trauma victims. [22,27] The relative risk of death decreased with increased ACS

trauma level classification of the hospitals.[27] Other investigations in urban regions have also shown that implementing a trauma system positively affects the preventable death rate. [25]

These findings are however, not equivocal. Chen et al., employed a mathematical model to compute the preventable death rates and reported that the quality of care at the acute trauma care center was not significant factor in predicting urban/rural differences in mortality. [28] Other studies have also failed to demonstrate that designating a trauma center in rural regions improves the outcome of trauma patients. [29,30,31,32] A comparison of outcomes from a non-trauma centers and a rural ACS verified trauma center yielded the same risk adjusted odds of death. However, all high-risk patients were routinely transferred to an urban center for care, confounding this comparison.[31] The rate of possible preventable deaths was found to be three times greater in Emergency Departments in rural areas when compared to urban centers. [6] In addition, rates of "inappropriate care" were notably higher for problems associated with airway management chest injury, blood and fluid management [6,33,34] Victims from rural areas that survive for at least 24 hours die at a greater rate than urban patients.[2] Therefore, it is impossible to separate the existence of a facility from the competence of the staff as a cause for this discrepancy in mortality. In addition the benefits of having a trauma facility available in rural areas continue to be debated.

Traumatic Brain Injury

Inconsistencies are found in the reported incidence of TBI between urban and rural areas. One report cited a higher incidence in areas with larger populations where as another study found a lower incidence of TBI in urban areas when

compared to rural regions.[35,36] Despite this disparity, both studies demonstrated higher mortality rates from TBI for those in the rural areas. Increased morbidity and costs for TBI patients in rural regions has also been reported [37] In addition a recent survey showed that survivors of TBI in rural areas were more likely to be functionally dependent than survivors from urban areas.[37]

The estimated cost of TBI per year in the United States is 37 billion dollars.[38] The incidence appears to be increasing and the cost can be expected to rise as well. The age groups most affected most by TBI are 15-24 year olds and those greater than 75 years.[38] T

TBI patients $\geq$ 65 are more likely to die in the hospital, be discharged to long-term care facilities and have the longest length of stay. Today, many regions have implemented programs focused on TBI prevention and outcome improvement.[38] Treatment focused on evidence based practices can improve outcome of the TBI patients. In addition, institution of traumatic brain injury programs have decreased length of stay.[38]

Thesis Statement

The 2000 census data shows that the total population of Hawaii is approximately 1,211,537. 103,312 of these people live in rural areas of Hawaii as determined by the U.S. Census Bureau. Four out of five counties in Hawaii contain less than 133 people per square mile. [1] Only Honolulu County meets the US census criteria (population estimates) for classification as an urban area.

In order to establish guidelines and quality assurance measures for TBI patients in Hawaii's rural regions an understanding of the characteristics and demographics of these areas is needed. A needs assessment can then be performed of the area as the foundation for treatment guidelines and quality assurance programs. The former is the goal of this initial evaluation. This study was performed in order to compare the mortality of patients admitted to Queen's Medical Center, the only ACS verified trauma center in the state, with a diagnosis of TBI, with emphasis placed on health care disparities between rural and urban patients. The hypothesis proposed was: TBI patients in rural areas of Hawaii will have a significantly higher mortality than their counterparts form urban areas. A secondary aim was to evaluate the epidemiology of head injury in the State of Hawaii.

CHAPTER 2: METHODOLOGY

Design:

A retrospective review of The Queen's Medical Center's (a university-affiliated tertiary care medical center) comprehensive trauma database was performed for the period from January 2000 until December 2004. Both the Queen's Medical Center and the University of Hawaii's Institutional Review Boards (IRB) approved the study. A review of data from the largest medical insurer in Hawaii, (56% of the population) for the period from January 2000 until December 2004 was also conducted after approval from the institution's research department and University of Hawaii's IRB.

Sample:

The sample was composed of those patients diagnosed with TBI treated at a hospital in the State of Hawaii. ICD-9 diagnostic codes of 800.00 to 801.99, 803.00 to 804.99, 850.00 to 854.19 or 959.01 were used to identify sample participants. (Table 1)

Table 1. International Classification of Diseases 9th Revision (ICD-9) of Included Patients

Description	ICD-9
Fracture of the vault or base of the skull	800.0-801.99
Other and unqualified multiple fractures of the skull	803.0-804.99
Intracranial injury, including concussion, contusion, laceration and hemorrhage	850-854.19
Head injury, unspecified	959.01

Measures:

Age, gender, race, mechanism of injury, protective device use, Glascow Coma Score (GCS), Revised Trauma Score (RTS), Trauma Injury Severity Score (TRISS) and systolic blood pressure on admission were obtained from the Trauma Center's database. (Appendix A) Length of stay, cost of hospitalization, cost of intensive care unit stay and survival status were obtained when available. Patients that underwent a neurosurgical procedure, as defined by intracranial monitor, craniectomy, or craniotomy, was also noted. Illicit drug, alcohol, coumadin, aspirin, or plavix use was recorded. These medications were collected as they alter the normal clotting mechanisms of the body and thus can have an effect on an intracranial bleed. (See Appendix B for entire list of data extraction.)

If a patient had two admissions during the period of study, only the first admission was included in the analysis as the outcome of the first injury may impact the second admission and confound the interpretation of outcome pertaining to the subsequent admissions to the hospital. Rural was defined as those hospitals outside of Honolulu County. Protective device use was defined as any use of seatbelt, airbag or helmet and was only evaluated in cases where it could have been used. The total cost of treatment was derived from the insurance carrier's charges only.

Statistics:

Primary Aim:

Mortality rates during hospitalization for patients transferred from rural areas were compared to those admitted from urban areas using the chi-square test. Factors associated with mortality were evaluated using logistic regression models. As a related issue, chi-square tests and logistic regression models were employed to compare patients with severe head injuries to those with mild to moderate injuries. Explanatory variables in the models included age, gender, transfer data, blood pressure, mechanism of injury, protective device status, payer status, time spent at outlying hospital, intubation status, TRISS, RTS, GCS, length of ICU stay, toxicology profile, and anticoagulation use.

Secondary Aims:

Secondary aims were to characterize patients in the Trauma Center and Insurer's databases and to compare the characteristics of patients from urban and rural areas. Descriptive statistics were used to summarize the patient characteristics (means and percentages for categorical data, means and standard deviations for continuous data). Categorical data were compared using the chi-square test. Continuous data were compared using the t-test. The incidence TBI during the study period was reported as number of cases per hospital admissions. A p -value $\leq$ than 0.05 was considered significant. SAS Enterprise 3.0, (Heidelberg, Germany) was used to perform the statistical analysis.

CHAPTER 3: RESULTS

Descriptive Epidemiology

There were 3447 people diagnosed with TBI treated at Queen's Medical Center from 2000-2004. (Table 2) The mean age was 36.6 years with a standard deviation of 20.9 years. The mean GCS at the scene was 12.5 (+/- 3.8) and the mean GCS on admission was 13.1 (+/-3.5). There was a peak frequency of injuries noted in the 19-30 year old age group. (Figure 1) Of the total number of patients diagnosed with a TBI, 315 (9.1%) died. Twenty-five percent (N=862) of all treated patients were female and 10.4% (N=358) of the injuries occurred at rural locations. There was no difference in mortality between rural (10.6%) compared to urban TBI patients (9.0%). A blunt mechanism was the most frequent cause of injury (98.8%).

Of the 1050 Insurance Company's patients diagnosed with a TBI, the mean age was 66.3 with a standard deviation of +/- 25.8 years. (Figure 2) The age most frequently associated with injury was in the elderly group (N=663/1050). There were 153 (14.6%) deaths in the total group of head injured patients. Thirty-nine percent of the group was female and twenty-nine percent (N=304/1036) of the injuries occurred at a rural location. Only 1.4% (N=15/1050) patients were documented to be transferred to Queen's Medical Center after injury for tertiary care.

In a logistic regression model, the lower the GCS score, the higher the odds of death. In addition, hypotension, penetrating trauma, and lack of use of

protective devices were associated with death. Rural location of injury trended toward higher death rates but was not statistically significant.

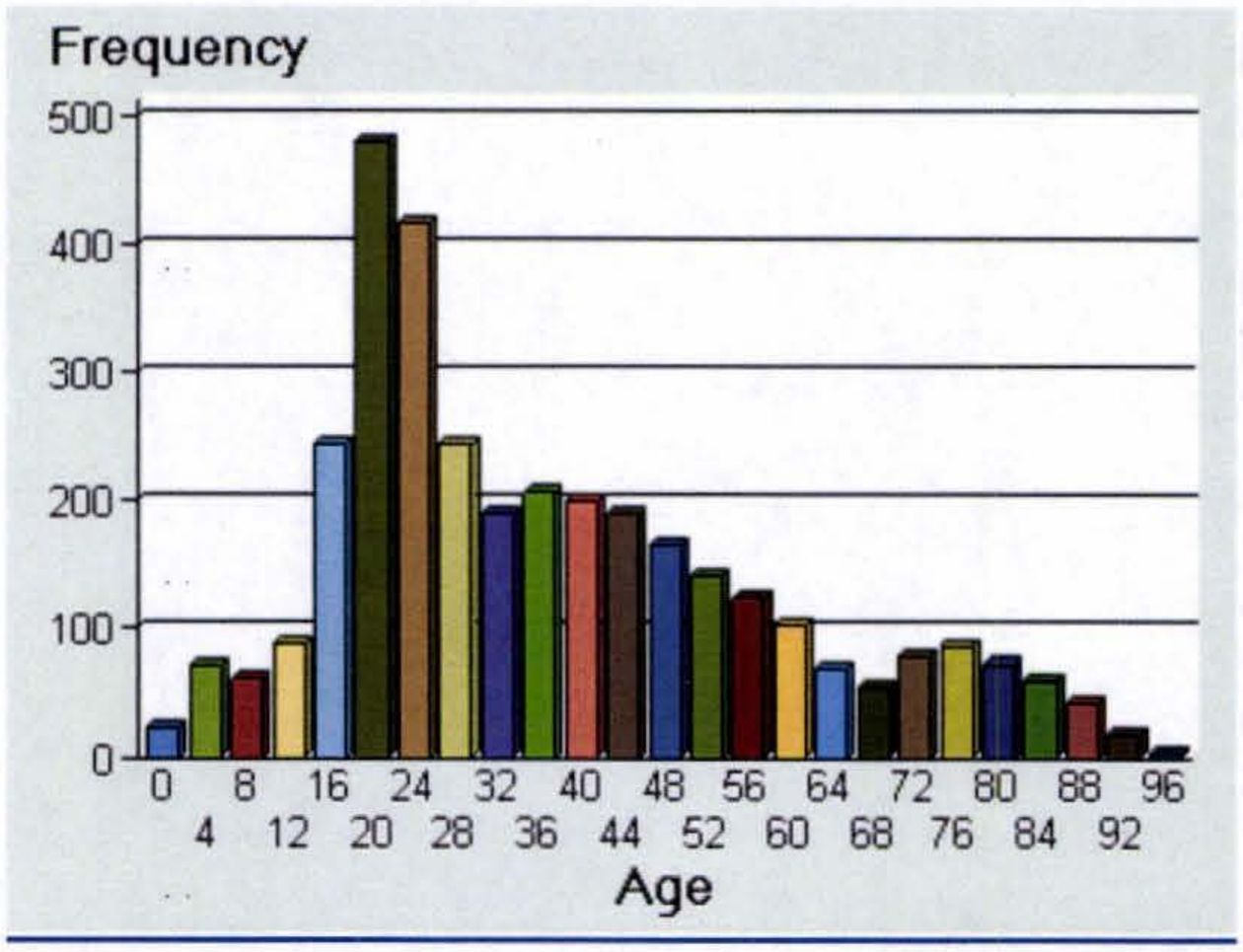

Figure 1. Queen's Medical Center Database Age Distribution of Traumatic Brain Injured patients. y-axis: actual number of patients, x-axis: age of patients

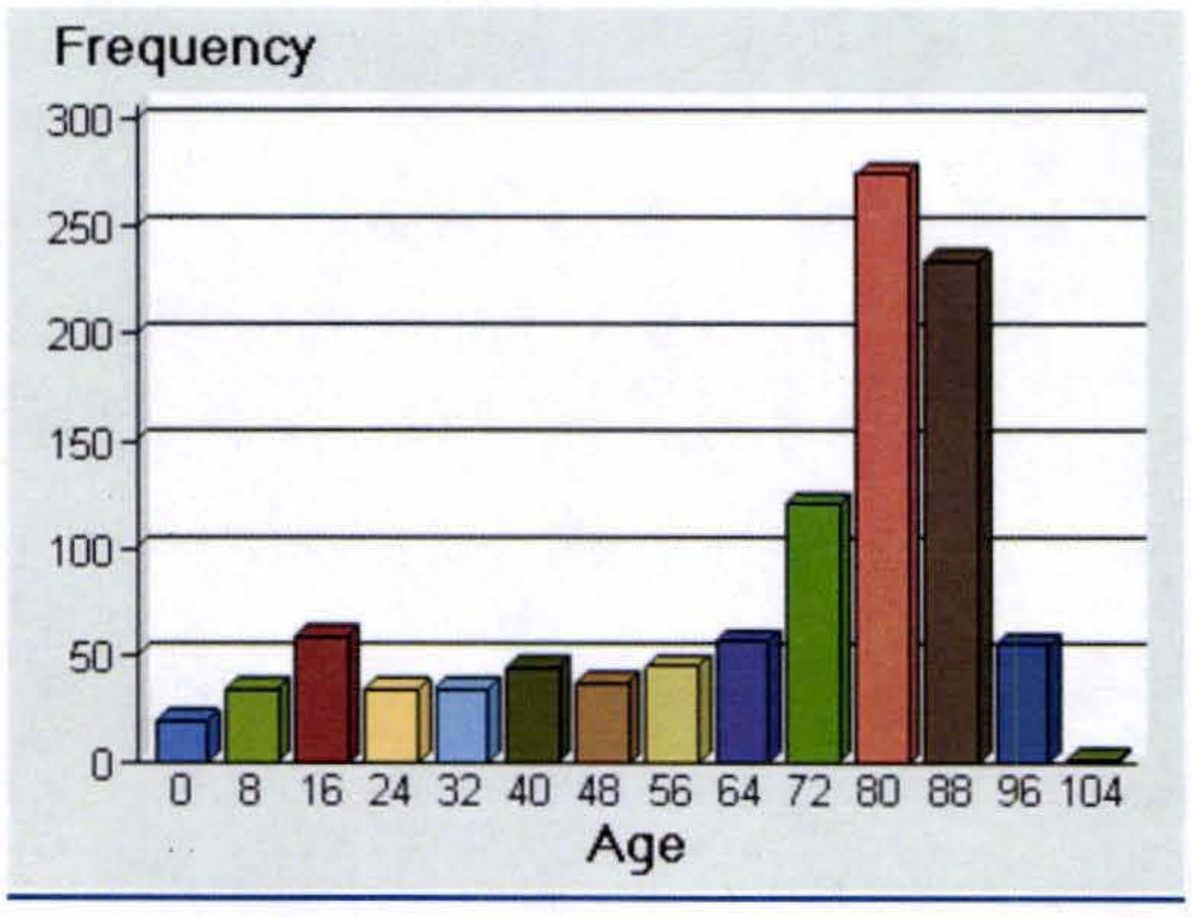

Figure 2. Insurance Company Age Distribution of Traumatic Brain Injured Patients. y-axis: actual number of patients, x-axis: age of patients

Severe Head Injured

The severe head injured patients from the Queen's Trauma Database were those patients who were diagnosed with a GCS of 3-8 at the scene or on admission. When comparing the total head injured group with the sub-group of severe head injured patients, there were no differences in seen age, ethnicity, anticoagulation status, or transport time. (Table 3) There were a higher percentage of rural patients, patients with abnormalities in blood pressure at the scene and patients that required a neurological procedure when compared to the total group. The severely injured patients were less likely to use protective devices, more likely to use alcohol, and had significantly lower TRISS and RTS scores. Mortality rates were also higher in those patients with a GCS score of 3-8. A rural location did result in higher odds of having a more severe injury.

The Insurer's database was analyzed for severe injury using those patients with a length of stay of less than 48 hours as a surrogate for severity scores. This analysis revealed there were no differences seen in gender, age, location, alcohol use or atrial fibrillation status. (Table 4) Mean costs of care for this group of patients to the insurance carrier were 14,156 dollars per patient and totaled to 14,863,645 dollars over the 5 year period.

Rural Trauma

When comparing urban to rural regions for differences in the severe head injured group, there was a statistically significant higher proportion of severe brain injury trauma that occurred in the rural regions compared to non-severe head injury. There was also a significant decrease in the use of alcohol in the rural group of patients. In addition those from rural regions were more likely to be

predicted to die, when using the TRISS. This did not translate to higher RTS scores. Death rates were similar between the groups.

Alcohol and Drug Use

Of the 1570 patients that were screened for illicit drug use, 878 (56.0%) tested positive. (Figure 3) Oahu had higher drug use in every category compared to the other locations, with minimal testing performed on outer Oahu locations. (72.2% Hawaii, 70.3% Kauai, 100% Lanai, 84.2% Maui, 52.9% Molokai not tested.) The patients that tested negative for drug had a 6.2% (43/649) mortality, while those testing positive for cannabis had a 3.2% (4/122), narcotic positive 3.9% (5/128), methamphetamine positive 4.4% (11/248), and benzodiazepines positive 10.9% (24/220) had their respective mortalities which were significantly different. There also appeared to be a greater proportion of persons who classified themselves as Hawaiian with methamphetamine use (70/606) compared to the other ethnicities. (Figure 4)

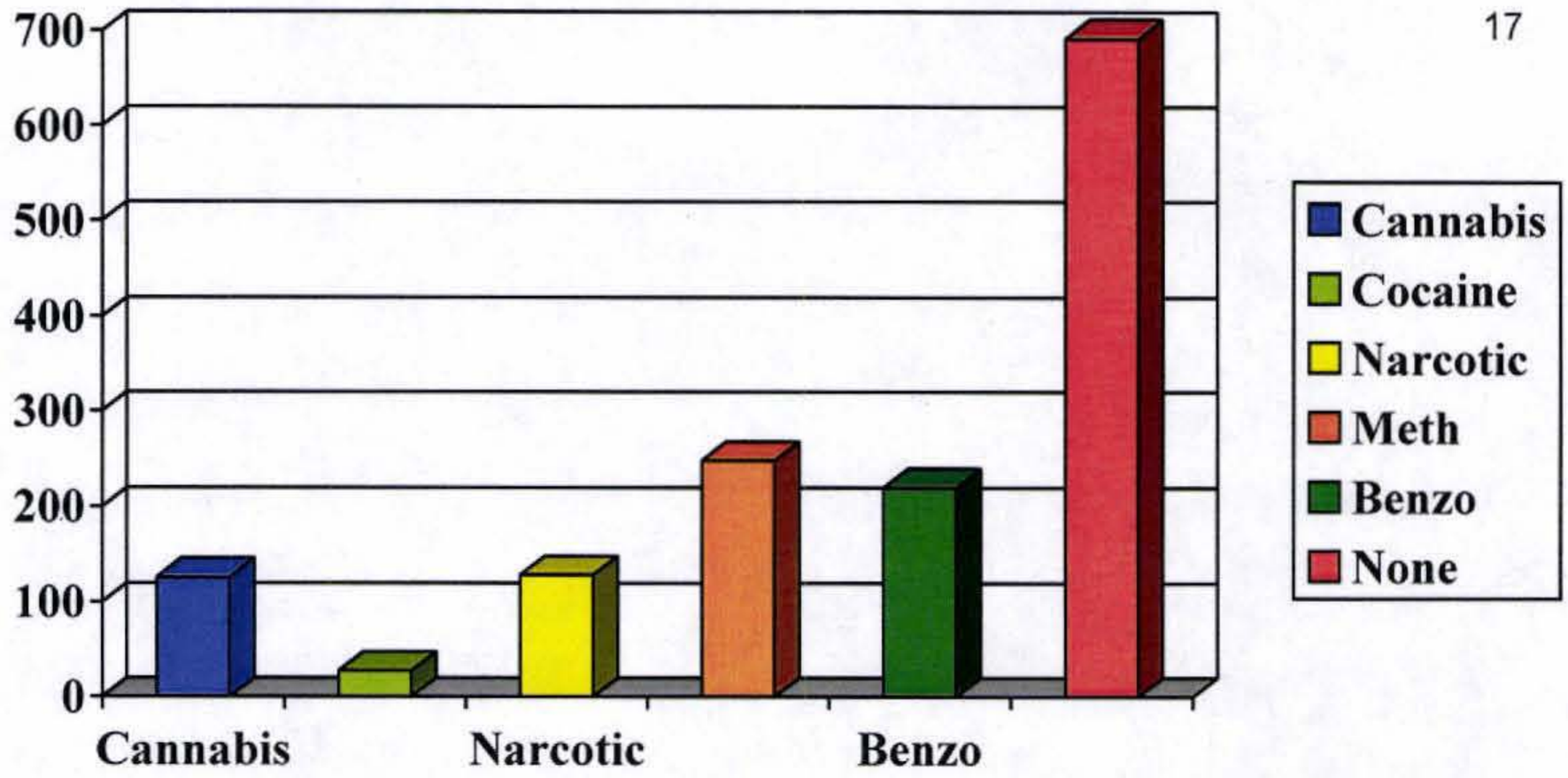

Figure 3. Illicit Drug Use in TBI Patients, y-axis: total number of patients

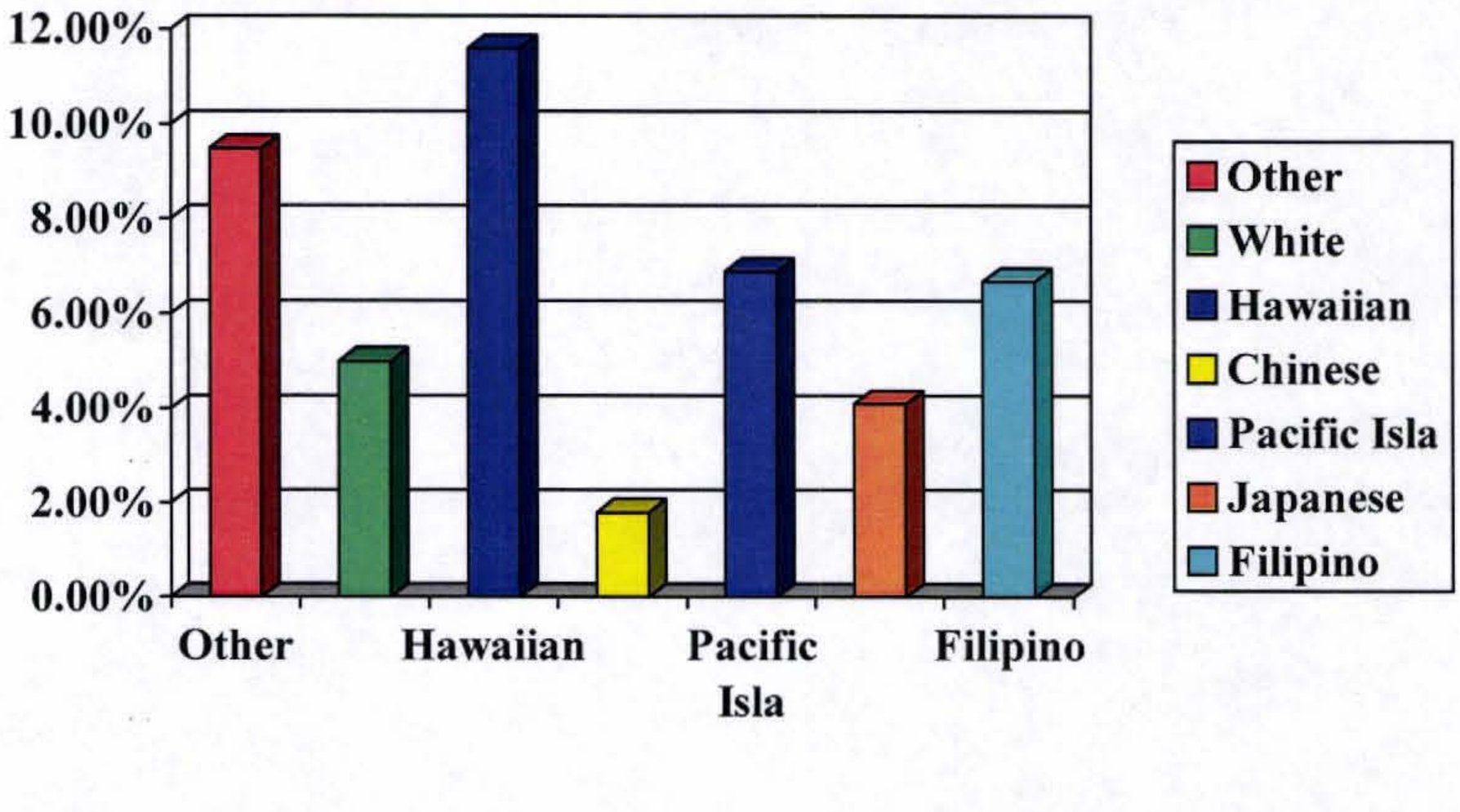

Figure 4. Methamphetamine Use by Ethnicity. y-axis: percentage of total ethnicities

In the Queen's database, 777/3447 (22.5%) of people were found to have used alcohol prior to their injury while only 4.0% (N=42/1050) of the Insurance Company's patients indicated use. More males 25.9% (N=666) than females 12.7% (N=111) used alcohol. Oahu (N=749/ 3089) and Molokai (N=7/17) had the highest alcohol use rates. Pacific Islanders (N=109/277) were the most common ethnic group to use alcohol. Of the total number of patients that used alcohol, mortality rates were lower than those patients that did not use alcohol and were injured. (281/2389 10.5% vs. 34/743 4.4% $p<0.0001$) In the regression model patients using alcohol had lower odds of death.

Table 2. Epidemiology of Traumatic Brain Injury in Hawaii

		Queen's n = 3447	Insurance Database n =1050
Age (years)	0-18	17.0% (587)	9.6% (101)
	19-30	31.7% (1093)	5.0% (52)
	31-50	27.6% (950)	9.6% (101)
	51-70	13.7% (470)	12.6% (133)
	71-106	10.0% (344)	63.14% (663)
	Mean age	36.6 +/- 20.9	66.3 +/- 25.8
Gender	Female	25% (874)	39.4% (414)
Island	Oahu	89.6% (3089)	70.7% (732)
	Rural	10.4% (358)	29.0% (304)
Ethnicity	Asian	32.8% (1132)	----------
	Caucasian	25.7% (888)	----------
	Pacific Is-lander	25.8% (890)	----------
	Other	15.6%(537)	----------
Drug Use	None	44.1% (692)	----------
n =1570	Cocaine	2.3% (47)	----------
	Meth	15.8% (248)	----------
	Cannabis	8.0% (126)	----------
	Opiods	8.2% (128)	----------
	Benzo	14.0% (220)	----------
	Other	2.5% (39)	----------
Alcohol Use		22.5% (777)	4% (42)
Scene SBP (mmHg)	Hypotensive <90	7.5% (226)	----------
	Normotensive 90-160	79.3% (2397)	----------
	Hypertensive >160	13.2% (398)	----------
Transport time (min)	<30 min	12.0 %	----------
	31-60 min	61.9%	----------
	> 1 hr	26.1%	----------
Insurance	Insured	89.8% (3060)	100%
	Self Pay	5.2% (178)	----------
	Military	6.0% (209)	----------
Neurological Procedure	Yes	6.1%	----------
Mechanism of injury	Blunt	98.8% (3403)	----------
	Penetrating	1.2% (41)	----------

Table 2. (Continued) Epidemiology of Hawaiian Traumatic Brain Injury

		Queen's n = 3447	Insurance Database n =1050
Anticoagulants		24.7% (852)	----------
Atrial Fibrilla-tion		----------	6.0% (62)
Hypertension		----------	11.0%
Hospital	Queen's	100%	42.3%
	Castle	----------	3.1% (32)
	Hilo	----------	4.2% (44)
	Pali Momi	----------	3.5% (37)
	Kapiolani	----------	3.6% (38)
	Kauai	----------	0.1% (1)
	Kona	----------	2.3% (24)
	Kuakini	----------	13.4% (143)
	North Hawaii	----------	0.6% (6)
	St. Francis	----------	4.5% (47)
	St Francis West	----------	1.0% (10)
	Straub	----------	9.1% (96)
	Tripler	----------	0.3% (3)
	Wahiawa	----------	0.9% (9)
	Wilcox	----------	1.8% (19)
Transfers		10.4% (358)	1.4% (15)
Death total		9.1% (315)	14.6% (153)
Death Oahu		9.0% 277/3089	16.3% 119/732
Death Rural		10.6% 38/358	10.7% 34/318

Table 3. Severe Head Injured Group (Glascow Coma Score (GCS) < or = 8) VS Mild to Moderately Head Injured Group (GCS > 8)

		GCS >8 n = 2898	GCS <8or =8 n = 549	P value
Age (years)				0.03
	0-18	17.5% (507)	15.0% (80)	
	19-30	31.1% (900)	35.3% (194)	
	31-50	27.7% (803)	26.9% (147)	
	51-70	14.1% (409)	11.2% (61)	
	71-96	9.6% (278)	12.1% (66)	
Sex				0.07
	Male	74.1% (2146)	77.8% (427)	
	Female	26.0% (277)	22.2% (81)	
Island				<0.001
	Oahu	90.4% (2621)	85.3% (468)	
	Rural	9.6% (277)	14.8% (81)	
Protective Device				<0.001
	NO	75.6% (2135)	86.3% (452)	
	YES	24.4% (690)	13.7% (72)	
SBP scene				<0.001
	Hypo (0-90)	4.7% (118)	21.9% (108)	
	Normal (91-160)	83.1% (2101)	60.0% (296)	
	Hyper (161-300)	12.2% (309)	18.1% (89)	
Anticoagulant				0.22
	no	75.7% (2193)	73.2% (402)	
	yes	24.3% (705)	26.8% (147)	
Neurological procedure				<0.001
	no	95.1% (2755)	88.0% (483)	
	yes	4.9% (143)	12.0% (66)	
Ethnicity				0.17
	Asian	21.1% (597)	18.5% (97)	
	Caucasian	26.0% (733)	26.7% (140)	
	Japanese	11.9% (337)	10.1% (53)	
	Pacific Islander	26.0% (734)	26.1% (137)	
	Other	15.0% (424)	18.5% (97)	
Drug use				<0.001
	None	44.5% (566)	40.4% (112)	
	Cannabis	8.3% (106)	6.1% (17)	

Table 3. (Continued) Severe Head Injured Group (GCS < or = 8) VS Mild to Moderately Head Injured Group (GCS > 8)

		GCS >8 n = 2898	GCS <8or =8 n = 549	P value
	Cocaine	3.2% (40)	1.8% (5)	
	Opiods	8.7% (111)	5.1% (14)	
	Meth	15.8% (201)	13.7% (38)	
	Benzo	11.3% (144)	26.4% (73)	
	Other	8.0% (103)	6.4% (18)	
Alcohol use				<0.001
	No	78.8% (2227)	69.3% (363)	
	Yes	21.1% (598)	30.7% (161)	
Transport time (min)				0.45
	< 30	15.7% (443)	15.3% (80)	
	30-60	58.7% (1658)	61.5% (322)	
	>60	25.6% (724)	23.3% (122)	
TRISS				<0.001
	<25%	9.0% (262)	67.4% (370)	
	26-50%	0.3% (8)	1.6% (9)	
	51-75%	1.1% (31)	2.4% (13)	
	76-100%	89.6% (2597)	28.6% (157)	
RTS scene				<0.001
	1	14.1% (408)	28.96% (159)	
	0	85.9% (2490)	71.0% (390)	
Length of Stay				<0.001
	0-24 hrs	37.2% (1077)	37.5% (206)	
	25-48 hrs	15.5% (448)	7.1% (39)	
	3-7 days	30.2% (876)	21.7% (119)	
	8-14 days	10.1% (293)	9.1% (50)	
	15-30 days	5.1% (148)	14.0% (77)	
	31-134 days	1.9% (56)	10.6% 58)	
ICU stay				<0.001
	0	67.5% (1957)	23.9% (131)	
	24 hrs or less	10.1% (294)	22.6% (124)	
	25-48 hrs	8.7% (253)	11.5% (63)	
	3-7 days	8.9% (259)	18.4% (101)	
	8-14 days	2.6% (76)	13.3% (73)	
	15-30 days	1.7% (48)	7.3% (40)	
	31-77 days	0.4% (11)	3.1% (17)	
Mortality		3.9% (110)	34.2% (179)	<0.001

GCS = Glasgow Coma Score; SBP = Systolic Blood Pressure; TRISS = Trauma Injury Severity Score; RTS = Revised Trauma Score; ICU = intensive care unit; benzo = benzodiazepine; meth = methamphetamine

		48 hr admission n = 305	Total group n =1050
Age (years)			
	0-18	17.0% (52)	9.6% (101)
	19-30	5.9% (18)	5.0% (52)
	31-50	10.4% (32)	9.6% (101)
	51-70	12.1% (37)	12.6% (133)
	71-96	52.8% (161)	63.14% (663)
Sex			
	Female	39.7% (121)	39.4% (414)

Table 4. Insurance Database Severe Group Characteristics Compared to Total Group

Island			
	Oahu	69.8% (211)	70.7% (732)
	Rural	30.8% (94)	29.0% (304)
Atrial Fibrillation		3.0% (9)	6.0% (62)
Alcohol Use		5.6% (17)	4% (42)
Hospital			----------
	Castle	3.3% (10)	3.1% (32)
	Hilo	4.6% (14)	4.2% (44)
	Kapiolani	9.8% (30)	3.6% (38)
	Pali Momi	2.6% (8)	3.5% (37)
	Kona	4.9% (15)	2.3% (24)
	Kuakini	8.2% (25)	13.4% (143)
	Maui	8.2% (25)	
	North Hi	1.0% (3)	0.6% (6)
	Queen's	42.9% (131)	42.3%
	St Francis	3.3% (10)	4.5% (47)
	St Francis West	1.6% (5)	1.0% (10)
	Straub	6.2% (19)	9.1% (96)
	Wahiawa	1.0% (3)	0.9% (9)

CHAPTER 5: DISCUSSION

TBI is a common public health problem. The nationwide incidence as reported by the Center for Disease Control (CDC) is about 1.4 million cases a year.[39] The majority of TBI patients are treated in the emergency department and discharged but 50,000 victims ultimately die from their injury. Although the death rates have been decreasing secondary to evidence based treatment regimens, the incidence of injury has been increasing nationwide. Patients that do get discharged from the Emergency Department can suffer significant sequela. Mild TBI can result in disability with many of these patients suffering from cognitive problems, behavioral issues, headaches and vertigo. These symptomatic patients require long-term follow-up in outpatient settings. Treatment requires access to multidisciplinary head injury programs which include neuropsychologists, therapists and support groups. These comprehensive programs are typically only found in major cities.

Hawaii is unique, as geography and transportation availability limits access to the only Trauma Center which is based in Honolulu County on Oahu. While the majority of trauma to the brain occurs on Oahu, the neighbor islands and Pacific region incur their share of severe injury that requires neurointensive treatment. The trauma referral system for these rural patients relies on fixed wing air transport. As trauma is not the only medical emergency that requires tertiary referral in the region, transport times can be a challenge for the head injured pa-

tient requiring urgent care. The transportation system is often times subjected to variable weather conditions which can further delay travel.

Against this background, this study was begun with the goal of identifying the disparities that are perceived by the trauma physicians in outcomes of the rural TBI patients. The resulting epidemiologic profile was generated to provide a foundation for quality improvement measures. These data were also collected to provide direction fro the development of prevention and outreach programs in the community. As TBI throughout the state remains a cause of significant physical disability and economic cost, incidence data is critical to the allocation of financial resources at the state level.

Although Queen's Medical Center is the only ACS verified Trauma Center for the state, the parallel analysis of the Insurer's data confirms that it is not the only place that treats Hawaii's head injured patients. Although there was evidence of differences in outcome by Institution, it was difficult to accurately determine the homogeneity of patients, and thus to interpret the significance of these findings. Evaluating the TBI patients using the two databases provided the distinct advantage of reviewing those patients in the trauma database with clinical indicators of severity, as well as those patients who may not have been successfully transported to, and those who may not have needed the higher level of care provided by a trauma center.

According to the Department of Health (DOH) for the State of Hawaii, over 5000 patients are seen at Hawaii's hospitals annually for a diagnosed head injury.[40] The annual number of TBI admissions ranged from 1300 to1500 in

2000-2003. This number has been increasing yearly. Of this number, only 9% of these patients were non-Hawaii residents. Our data confirms that almost 50% of these patients were treated at Queen's Medical Center. However, our analysis revealed that only 10.4% of Queen's patients were referred from rural regions. This finding is notable after recognizing a higher incidence of TBI on the Big Island of Hawaii. (Figure 5) Nonetheless, this data obtained by the DOH did not include any clinical measures of severity. The Queen's database also suggested that there were more rural patients with lower GCS scores in rural regions than urban indicating a disparity in severity of disease.

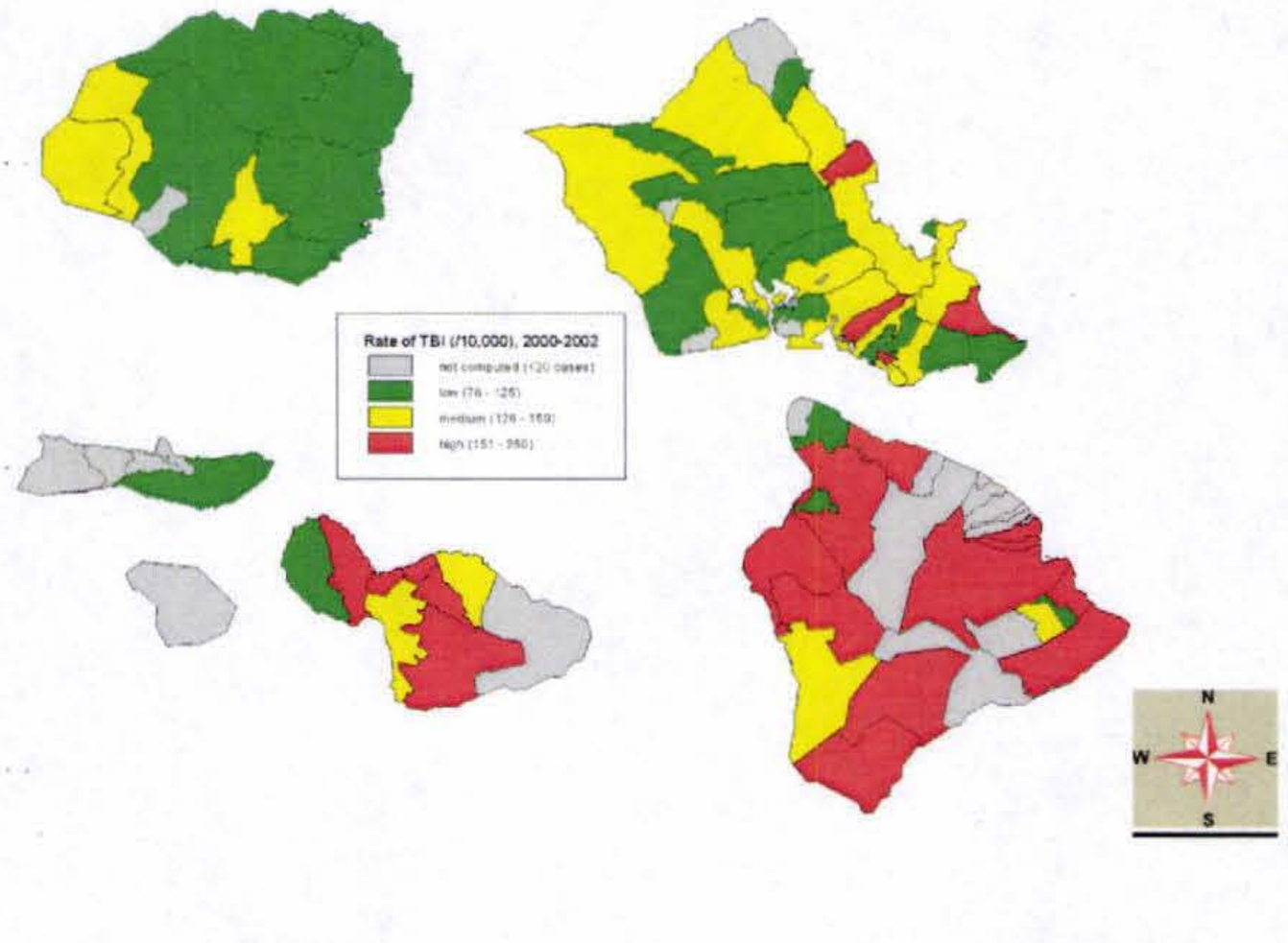

Figure 5. Demographic Map of Case of TBI in Hawaii

Courtesy of Daniel Galanis, Ph.D, Hawaii Department of Health

The severity illness in these patients was also assessed by calculating the Revised Trauma Scores (RTS) and Trauma Injury Severity Scores (TRISS).

(Table 3) The RTS is a physiological scoring system based on GCS, systolic blood pressure and respiratory rate. The TRISS is a mathematical model which factors in the RTS as well as area specific injury. Both of these scores have been demonstrated to be accurate in predicting death. [41,42,43,44] A RTS threshold of less than 4 has been proposed to identify those patients who should be treated in a trauma center. In analyzing those patients by island who had a score of 4 or less as an indicator of poor survivability, only Oahu and Hawaii had patients that scored this value. RTS did not discriminate rural versus urban mortality. TRISS scores of less than 25% were noted to be higher in rural patients, predicting lower rates of survival. In addition, rural patients required treatment at a trauma center 70% of the time. This model did not predict increases in mortality in these patients.

While this study confirmed an increased number of severely injured patients from rural regions, we were unable to document a higher mortality. Indeed, DOH also was unable to identify a disparity in mortality.[40] Lack of resources in Hawaii, such as a rural trauma center, trauma trained personnel or availability of helicopter transport apparently did not impact the outcome of the head injured patient in this analysis. In addition, increased transport times did not result in a higher mortality as would be expected. The explanation for this finding is complex and speculative. Perhaps using the GCS score is confounded by the addition of intoxicated patients. This could lead to higher than expected predicted deaths. Secondly, those patients that were more severely injured might have been transported in a more expedient fashion, actually decreasing the transport

time. The other limitation of this data is that it does not include those deaths that may have occurred at the scene which could represent more severely injured patients that had a delay in discovery due to the greater distances of uninhabited terrain and lack of ground transport availability, such as on the Big Island of Hawaii. This information is often difficult to obtain as many of these victims do not have an autopsy proven cause of death.

The use of protective devices was only practiced by 22.1% of all the patients. Those patients that did not use protective devices had higher odds of sustaining a severe injury and dying. This finding implies a deficit in education and outreach in our state or an increase in risk-taking behavior. For instance, Hawaii remains one of 20 states that exempt adult riders from wearing helmets while operating a motorcycle. Although it is debatable whether helmetless riders fall into either category, what is known is that there are higher rates of head injury and mortality where there exist no mandatory helmet laws. [45,46,47]

The epidemiology of Hawaii's patients was consistent with the national indices given that males were the more frequently injured group of patients and a blunt mechanism was the most frequent cause.[39] Falls were the most common cause of injury followed by motor vehicle accidents, including motorcycles in the United States and Hawaii. Penetrating trauma, like elsewhere, was associated with mortality; however the incidence of this type of injury was low in Hawaii. Although nationally, children and older adolescents are more likely than others to sustain a TBI, the Trauma Center's data shows higher rates in the 19-30 year old age groups. All datasets including the DOH, corroborated elevated rates in the

elderly groups, particularly those over 65 years [40](Figure 6) Perhaps this occurs as Hawaii has a high percentage of person's age 65 years and older in comparison to many other states. [1] This cohort of patients has increased mortality rates when compared to younger patients. [39,48] This group of patients has higher co-morbid conditions than their younger counterparts and also has less reserve when injured. This results in longer hospitalizations. [48] The elderly population is predicted to double in Hawaii by 2030, which will have implications on the provisions of healthcare and treatment of these patients.

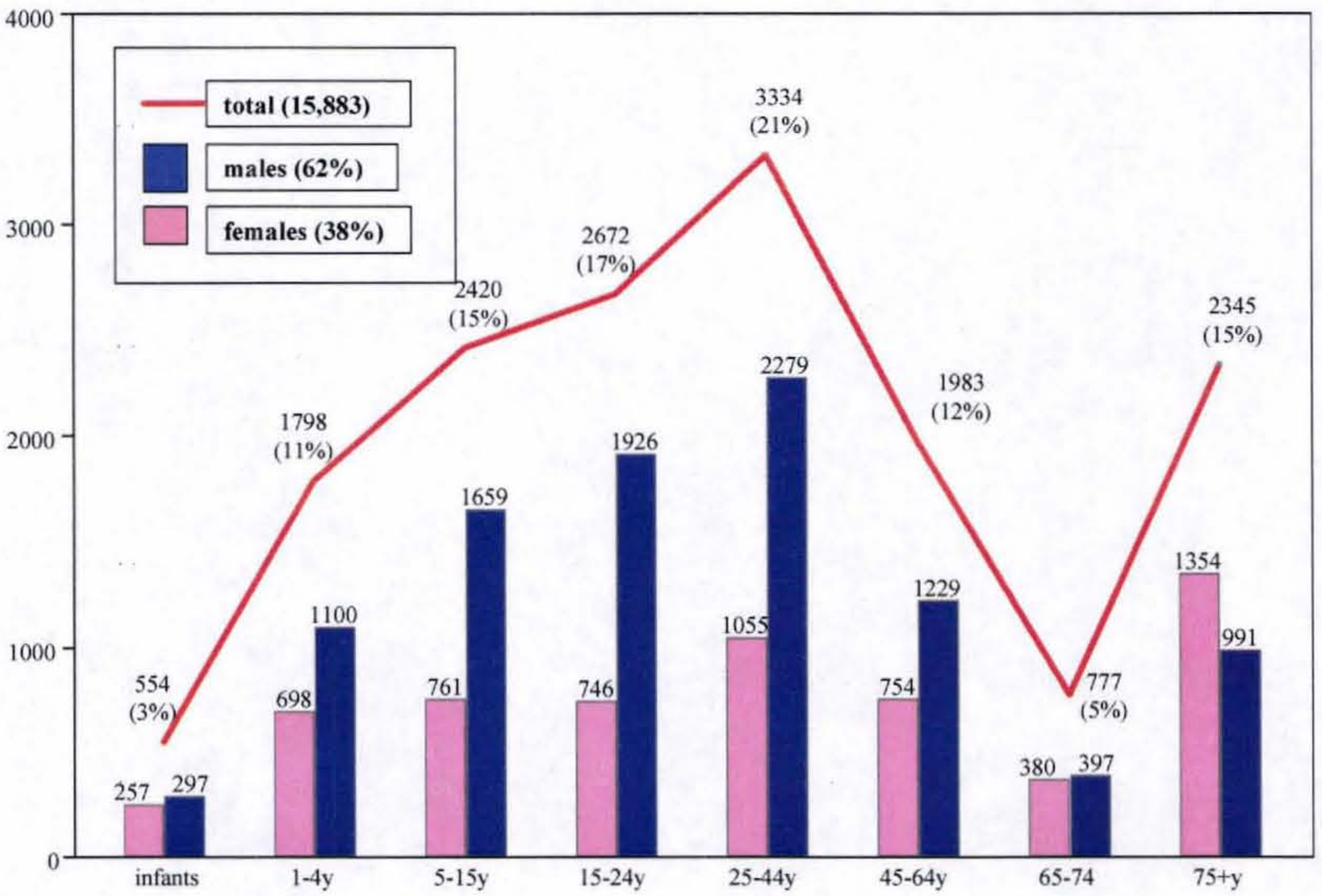

Figure 6. Age and Gender of TBI Patients in Hawaii, 2000-2002.

Courtesy of Daniel Galanis, Ph.D, Hawaii Department of Health

One of the more interesting relationships was the association of TBI and alcohol. Of the total injured patients seen at Queen's, 22.5% of these patients were using alcohol at the time of their injury. Alcohol was also found to be associated with more severe degree of injury based on GCS. Unexpectedly, there appeared to be a protective effect with use as this group of patients had a lower mortality. This effect is not a new phenomenon. It has been shown that ethanol inhibits N-methyl-D-aspartate (NMDA) excitotoxicity that increases neuronal death after trauma.[49] Ethanol may also have an effect on reducing contusion volume.[50] This finding could also be attributed to including patients who were only intoxicated without pathological injury with resultant abnormal GCS scores in this analysis. It is difficult to differentiate this subgroup in a retrospective study. Nonetheless, alcohol is associated nationwide with increased risk of head injury and this represents a target for improvement.

Methamphetamine is an illegally used stimulant that is readily accessible in Hawaii. 15.8% of the head injured patients treated at Queen's were found to be positive for use. Unlike alcohol, there was no association seen with severity of injury and mortality. Despite this, as one the goals of this report was to provide some epidemiology to develop preventative programs, a further stratification was undertaken. Methamphetamine use is amongst the nation's highest in Hawaii. [51] Use of this drug results in erratic and often times violent behavior which can have some implications on the etiology of the TBI patient. Our study identified 77% of the users with TBI to be male and 56% of them were 31-50 years of age. Hawaiian, Pacific Islander and non-Caucasian ethnicity were at risk for use. Ethnicity

was assessed by self-reporting and cultural factors were not truly able to be identified. However, this association warrants further exploration.

Conclusion and recommendations

Despite the recent advances in brain injury research, the mortality for the severely traumatic injured in Hawaii remains high. The findings from this investigation confirm that male gender, alcohol use and lack of protective devices result in higher rates of head injury in Hawaii. The study also documented a high rate of injury in Hawaii's elderly. This study had the advantage of having access to the largest insurer's database as well as the State's only Trauma Center's database. However, both the retrospective nature of this study which relied on the reporting ICD-9 codes performed by billing personnel to diagnose head injury, and the lack of uniformity between the two databases requires that prudence should dictate the interpretation of these results. In addition, the lack of complete neighbor island data regarding the severity of trauma seen by their centers possibly biased some of the results. However, including mild traumatic brain injury allowed some insight into the number of patients that may benefit from follow-up programs in the state. This preliminary analysis provides justification for prospectively collecting TBI data and initiating outreach and preventative programs throughout the State, especially in rural regions.

APPENDIX 1: TRAUMA SCORES

Glasgow Coma Score

Eye Opening	Verbal Response	Motor Response
4-Spontaneous	5-Oriented & converses	6-Obeys verbal commands
3-To verbal Commands	4-Disoriented & converses	5-Localizes pain
2-To pain	3-Inappropriate words	4-Withdraws from pain
1-No response	2-Inconprehensible sounds	3-Decorticate to pain
	1-No response	2-Decerebate to pain
		1-No response

13-15 mild head injury

9-12 moderate head injury

8 or < severe head injury

Revised Trauma Score

Glasgow Coma Score (GCS)	Systolic Blood Pressure	Respiratory Rate
4=(13-15)	4=(>89)	4=(10-29)
3=(9-12)	3=(76-89)	3=(>29)
2=(6-8)	2=(50-75)	2=(6-9)
1=(4-5)	1=(1-49)	1=(1-5)
0=(3)	0=(0)	0=(0)

Trauma Injury severity score

- Value correlated with risk of mortality
- Abbreviated Injury Scale (AIS) used to assign values from one to five to body regions: General, Head and Neck, Chest, Abdominal, and Extremities
- A higher score has a more severe injury

APPENDIX B: DATA COLLECTION SHEET

PATIENT ACCOUNT NUMBER
PATIENT MEDICAL RECORD NUMBER
CITY, COUNTY OF PATIENT ADDRESS
PAYER STATUS
INJURY DATE AND TIME

AGE
GENDER
ETHNICITY
MECHANISM OF INJURY
TRISS
RTS
GLASCOW COMA SCORE ON SCENE, ADMIT AND DISCHARGE
PROTECTIVE DEVICE USE
ANATOMIC PROFILE DESCRIPTION
- A- TO HEAD, BRAIN AND SPINAL CORD
- B- THORAX AND FRONT NECK
- C- OTHER

EMS RUN SHEET
- CITY, COUNTY OF INJURY
- SYSTOLIC BLOOD PRESSURE
- SCENE INTERVENTIONS
- TRANSPORT TIME

REASON FOR TRANSFER
EMERGENCY DEPARTMENT
- SYSTOLIC BLOOD PRESSURE

OUTPATIENT MEDICATIONS
- ASPIRIN
- PLAVIX
- COUMADIN

TOXICOLOGY
- DRUG SCREEN

ALCOHOL
INTRACEREBRAL MONITOR
PLACED
CRANIOTOMY PERFORMED
LENGTH OF STAY
LENGTH OF ICU STAY
TOTAL HOSPITAL CHARGES
DISPOSITION AT DISCHARGE (HOME, DEATH, REHAB)

APPENDIX C: IRB APPROVAL 1

UNIVERSITY OF HAWAI'I

Committee on Human Studies

MEMORANDUM

March 29, 2005

TO: Alyssa D. Chapital, M.D.
Principal Investigator
Department of Surgery

FROM: William H. Dendle
Executive Secretary

SUBJECT: CHS #13613- "Traumatic Brain Injury: Outcomes of a Rural vs. Urban Population Over a 5 Year Period"

Your project identified above was reviewed by the Chair of the Committee on Human Studies through Expedited Review procedures. The project qualifies for expedited review by CFR 46.110 and 21 CFR 56.110, Category (5) of the DHHS list of expedited review categories.

This project was approved on March 24, 2005 for one year. If in the active development of your project you intend to change the involvement of humans from plans indicated in the materials presented for review, prior approval must be received from the CHS before proceeding. If unanticipated problems arise involving the risks to subjects or others, report must be made promptly to the CHS, either to its Chairperson or to this office. This is required in order that (1) updating of protective measures for humans involved may be accomplished, and (2) prompt report to DHHS and FDA may be made by the University if required.

In accordance with the University policy, you are expected to maintain, as an essential part of your project records, all records pertaining to the involvement of humans in this project, including any summaries of information conveyed, data, complaints, correspondence, and any executed forms. These records must be retained for at least three years from the expiration/termination date of this study.

The CHS approval period for this project will expire on March 24, 2006. If your project continues beyond this date, you must submit a continuation application to the CHS at least four weeks prior to the expiration of this study.

We wish you success in this endeavor and are ready to assist you and your project personnel at any time.

Enclosed is your certification for this project.

Enclosure

2540 Maile Way, Spalding 252, Honolulu, Hawai'i 96822-2303
Telephone: (808) 539-3955/(808) 956-5007, Facsimile: (808) 539-3954, Web site: www.hawaii.edu/irb

APPENDIX D: IRB APPROVAL 2

THE QUEEN'S MEDICAL CENTER
RESEARCH & INSTITUTIONAL REVIEW COMMITTEE

Date: March 24, 2005

To: Alyssa Chapital, MD
1356 Lusitana St, 6th Floor
Honolulu, Hawaii 96813

Re: RA-2005-014
Traumatic Brain Injury: Outcomes of a Rural vs. Urban Population Over a 5 Year Period

Documentation of RIRC Approval of Waiver of Authorization For
Use or Disclosure of Protected Health Information for Research
(45 CFR 164.512(i)(2))

The Queen's Medical Center Research and Institutional Review Committee (RIRC), established in accordance with 45 CFR 46.107, has approved the waiver of authorization for the use and/or disclosure of Protected Health Information (PHI), in accordance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA), and the regulations as defined in 45 CFR 164.501, for the above referenced research study.

DATE OF APPROVAL: 03/24/2005 EXPEDITED REVIEW

Approval for a waiver of authorization for the entire research study

RIRC determined that the waiver of authorization satisfied the following criteria:

A. The use and/or disclosure of protected health information involves no more than a minimal risk to the privacy of the subjects based on the following:
   i. Investigator provided an adequate plan to protect identifiers from improper use and disclosure;
   ii. Investigator provided an adequate plan to destroy the identifiers at the earliest opportunity consistent with the conduct of the research described above, unless there is a health or research justification for retaining identifiers, or such retention is otherwise required by law; and
   iii. Investigator provided adequate written assurances that the PHI will not be reused or disclosed to any other person or entity, except as required by law, for authorized oversight of the research project referenced above, or for other research for which the use or disclosure of PHI would be permitted by HIPAA.
B. The research referenced above could not practicably be conducted without the alteration or waiver; and
C. The research referenced above could not practicably be conducted without access to and use of the PHI.

The PHI for which use or access has been determined to be necessary by RIRC is briefly described as follows:

Medical Records
Registry Information
Database Records

Sincerely,

Michael Meagher, MD, FACR
Chairman, Research and Institutional Review Committee

cc: file
John Firrell, PhD

University Tower 5th Floor • 1301 Punchbowl Street • Honolulu, Hawaii 96813 • Phone (808) 547-4512 • Fax (808) 537-7897
A Queen's Health System Company

APPENDIX E: IRB APPROVAL 3

THE QUEEN'S MEDICAL CENTER
RESEARCH & INSTITUTIONAL REVIEW COMMITTEE

Date: March 24, 2005

To: Alyssa Chapital, MD
1356 Lusitana St, 6th Floor
Honolulu, Hawaii 96813

EXPEDITED NEW PROTOCOL

Re: **RA-2005-014** **Traumatic Brain Injury: Outcomes of a Rural vs. Urban Population Over a 5 Year Period**

On behalf of the Research & Institutional Review Committee (RIRC) of The Queen's Medical Center, I am pleased to grant you expedited approval of the above referenced application assigned **#RA-2005-014**. This is an identification number and should be used on all correspondence, and documents related to this study.

APPROVAL DATE: 03/24/2005. Expedited approval. General review to follow.

EXPIRATION DATE: 02/28/2006. Application for its continued renewal must be made at least two months prior to the expiration date.

ADVERSE REACTIONS: All severe adverse events must be reported to the RIRC within 3-5 working days.

MODIFICATIONS: Any change (minor or major) must have prior RIRC approval.

DOCUMENTATION: All correspondence relating to this study must be kept on file; all relevant papers are subject to federal inspection.

COMMENTS: ***Expedited approval for retrospective records study only under Category 5 (Research involving materials that have been collected for nonresearch purposes). Data will be collected through the Trauma Database from 1/99 - 12/04. Appendix 1, received 3/18/05 lists all data fields to be collected. Waiver of informed consent is granted. See separate letter for waiver of authorization.***

QUESTIONS: Please contact the Research Regulatory Office at (808) 547-4512.

Yours sincerely,

Michael Meagher, MD, FACR
Chairman, Research and Institutional Review Committee

cc: file
Lisa Nishikawa

University Tower 5th Floor • 1301 Punchbowl Street • Honolulu, Hawaii 96813 • Phone (808) 547-4512 • Fax (808) 537-7897
A Queen's Health System Company

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