

Traumatic Brain Injury in Iowa: An Analysis of Core Surveillance Data 2006-2008

Report to the Advisory Council on Brain Injuries

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Table of Contents

LIST OF TABLES.....	3
LIST OF FIGURES.....	3
Introduction.....	7
Methods	7
Results	10
The Injury Pyramid.....	10
Demographics.....	10
Severity, Mechanism and Causes of TBI	13
TBI Severity among Hospitalized and Emergency Department Cases	13
TBI Causes in Iowa.....	14
Leading Causes of TBI mortality and morbidity, MVC and Falls	20
Motor Vehicle Crashes	20
Falls	24
Hospital Discharge Prognosis	25
Discharge location.....	25
Length of Stay (LOS).....	26
Hospital Charges.....	27
Average Charges by Causes of TBI:.....	27
Souce of Pay Information.....	28
Conclusions.....	31
REFERENCES	32

LIST OF TABLES

Table 1: International classification of disease codes ninth and tenth revision for TBI.....	9
Table 2: TBI mortality, hospitalization and ED visit rates per 100,000, 2006-2008	11
Table 3: Demographic Distribution of TBI hospitalization and ED visits.....	13
Table 4: Distribution of TBI Deaths, Hospitalizations and ED visits by Intent.....	14
Table 5: Leading cause of TBI Deaths, Hospitalizations and ED Visits, 2006-2008	14
Table 6: MVC deaths-hospital-ED by Gender and Race	22
Table 7: Patient Discharge Type after TBI hospitalizations and ED visits by Causes	26
Table 8: Total Hospital Charges by Causes and Expected Source (Dollars)	30

LIST OF FIGURES

Figure 1: Traumatic Brain Injury Pyramid (3-Year average), 2006-2008	10
Figure 2: Number of TBI Deaths by County	12
Figure 3: TBI Hospitalization Rate (per 10,000) by County	12
Figure 4: TBI Severity Distribution, Hospitalizations vs. ED visits	14
Figure 5: Percent Distribution of Causes of TBI Deaths by Age	15
Figure 6: Percent Distribution of Causes of TBI Hospitalizations by Age.....	16
Figure 7: Percent Distribution of Causes of TBI ED Visits by Age.....	16
Figure 8: Percent Distribution of Causes of TBI Deaths by Race.....	17
Figure 9: Percent Distribution of Causes of TBI Hospitalizations by Race	17
Figure 10: Percent Distribution of Causes of TBI ED visits by Race	18

Figure 11: Proportion of Male TBI deaths, hospitalizations and ED visits by Causes	18
Figure 12: TBI Mortality Rates per 10,000 by Causes and County Size.....	19
Figure 13: TBI Hospitalization Rates per 10,000 by Causes and County Size	20
Figure 14: TBI ED Visit Rates per 10,000 by Causes and County Size	20
Figure 15: Percent Distribution of TBI Deaths in MVC by Causes and Age.....	21
Figure 16: Percent Distribution of TBI Hospitalizations in MVC by Causes and Age	21
Figure 17: Percent Distribution of TBU ED Visits by Causes and Age	22
Figure 18: Percent Distribution of TBI Deaths due to Fall by Gender and Age.....	24
Figure 19: Percent Distribution of TBI Hospitalization due to Fall by Gender and Age.....	24
Figure 20: Percent Distribution of TBI ED visits due to Fall by Gender and age	25
Figure 21: Percent Distribution of TBI Discharge Type after Hospitalization or ED Visits	26
Figure 22: TBI hospitalization Burden: Total LOS per year by Causes	27
Figure 23: Average Total Hospital Charges by Causes of TBI.....	28
Figure 24: Total Charges for TBI Hospitalizations by Expected Source of Pay.....	29
Figure 25: Total Charges for TBI Hospitalizations by Expected Source of Pay.....	29

Executive Summary

Purpose of the Report

Traumatic Brain Injury (TBI) is a major public health problem in Iowa. The numbers and rates of hospitalizations and emergency department (ED) visits resulting from TBI are steadily increasing. On the backdrop of decreasing TBI service funds appropriated to the Iowa Department of Public Health, this report intends to present a better picture of the silent epidemic using vital records and hospital discharge data to raise awareness among policymakers, researchers and the general public about the magnitude and cost of TBI in Iowa

Results Highlights

- From 2006 to 2008, there were, on average, 545 TBI-related deaths per year. For every death from TBI in Iowa, there were three Iowans hospitalized and 32 who sought services in an emergency department. During the reporting period, on average, 33% of Iowans who lost their lives to injury (1,672), 10% of those hospitalized (16,289) or 7% of those who visited the emergency department visits (258,660) because of injury, did so because of TBI.
- Iowa's TBI age-adjusted mortality rate is consistent with the national rate. The mortality rate stayed close to 18 deaths per 100,000 Iowans with an age-adjusted rate of 17 per 100,000. The mortality rate for counties with less than 10,000 was 33 deaths per 100,000 and was 2.3 times greater than in counties with more than 50,000 people.
- The Iowa age-adjusted hospitalization rate in 2006 was significantly lower than the national rate. The county rate distribution showed that counties with less than 50,000 people had a greater rate of hospitalizations and ED visits.
- TBI mortality and morbidity cases were predominantly Caucasian males. Individuals over the age of 65 were more likely to die or be hospitalized for TBI. For ED visits, the age distribution displayed a bimodal distribution in the form of a U-shape with a higher peak among people 24 years and younger.
- Nearly 70% of TBI deaths and over 80% of the TBI hospitalizations and ED visits were due to unintentional injuries. Intentional injuries, including suicide attempts and assaults, constituted 28% of TBI deaths, 6% of TBI hospitalizations and 9% of TBI ED visits.
- The three leading causes of TBI deaths were motor vehicle crashes (MVC), falls and firearms. Falls were the leading cause of TBI hospitalizations and ED visits, with almost twice the magnitude of the next two causes [MVC and struck by or against (being struck on the head by an object or the head hitting against an object such as the floor or a wall)] combined.
- The leading cause of TBI death among Whites was MVC followed by falls, whereas in African Americans the leading cause of TBI related death was firearms followed by MVC.
- MVC was the main cause of TBI deaths for all Iowans under the age of 35 followed by firearms. The proportion of deaths due to MVC equaled the proportion of firearms deaths

in Iowans between the ages of 35 and 54. Among the 55 to 64 years old, firearms were the leading cause of TBI related deaths in Iowa. Males were more likely than females to die, be hospitalized or visit the ED because of motor vehicle crashes and “being struck by or against”.

- The average length of stay (LOS) for two leading cause of TBI, MVC and falls, was 4 and days, respectively. In terms of magnitude, falls had a higher total number of hospital stays compared to MVC.
- From 2006 to 2008, individuals who were hospitalized for TBI were discharged from the hospital back to their home (60.0%), to a long term care facility (16.7%), to a rehabilitation program (7.7%). Meanwhile, the remainder was transferred to another inpatient hospital (8.4%) and died (7.0%) during hospitalization. The magnitude of cases discharged to long-term care and rehabilitation programs brings to focus the issue of disability that can occur after a traumatic brain injury.
- Fifty-two percent of these hospitalizations and emergency department costs were paid for by private funds. Federal funding, including Medicaid and Medicare contributed to 40% of the costs of care. State and local funds (including workers compensation) carried 11 to 15% of the costs.

Conclusions

Although this report shows a stable trend of traumatic brain injury rates in Iowa, the burden of TBI is increasing among males and older adults. TBI deaths, hospitalizations and ED visits have different characteristics by race, gender and county size.

The true cost of TBI is not limited to hospital charges due to the proportion of cases that require ongoing care, services and supports including long-term care. To more fully understand the cost burden in Iowa, a more in-depth analysis is required.

The state of Iowa has supported preventive services to TBI survivors for several years. With these difficult financial times, an evaluation of TBI services may bring forth evidence for the continued need and increase for these programs.

Traumatic Brain Injury in Iowa Deaths, Inpatient & Outpatient Hospital Data 2006-2008

Introduction

Termed the “silent epidemic”, traumatic brain injury is the most debilitating outcome of injury characterized by the irreversibility of its damages, long-term effects on quality of life, and healthcare costs. The latest data available from the Centers for Disease Control and Prevention (CDC) estimate that nationally 50,000 people with traumatic brain injury (TBI) die each year; three times as many are hospitalized and more than twenty times as many are released from emergency room departments (ED) (CDC, 2008)¹.

The purpose of this report is to describe the epidemiology of TBI in Iowa to help guide policy and programming. TBI is a result of an external force which transfers energy to the brain. Stroke is caused by a disruption of blood flow in the brain that leads to brain injury. Though stroke is recognized as the 3rd leading cause of death nationally², and is an injury that affects the brain it does not meet the definition a traumatic brain injury and is not included in this report.

Methods

Data Sources:

In Iowa TBI data are collected from the following data sources: the TBI registry, death certificates, hospital inpatient data and hospital outpatient data. Inpatient and outpatient hospital data are managed by the Iowa Hospital Association (IHA); IHA provides the data without personal identifiers. However for this report, only deaths, hospitalizations and emergency department (ED) visits from 2006 to 2008 are presented.

Census population data estimates from 2007-2008 were used to compute rates; and age-adjustment when presented was based on the 2000 US census population.

Analysis:

Individuals diagnosed with TBI were selected from the inpatient and outpatient hospital record database using the ICD9 codes identified by the Iowa Legislature as defining brain injuries. In the Iowa Code 641 chapter 21, brain injury means “any clinically evident brain damage resulting from trauma or anoxia which temporarily or permanently impairs a person’s physical or cognitive functions.” Individuals diagnosed with TBI were selected from the inpatient and outpatient hospital database using these codes (Table 1).

Following the “Burden of Injury Report in Iowa”³, this report needed to be consistent with the Center of Disease Control and Prevention recommendations on how to analyze vital records and hospital discharge data. The cause and type of injury was determined by the external causes of injury or E codes. Deaths were selected from vital records data using ICD 10 codes as recommended by the State Injury Prevention Department Agency guide to injury surveillance (STIPDA, 2004). In cases where injury was identified as the primary cause of death, hospitalization or ED visit; ICD9 codes for traumatic brain injury were searched in all diagnostic fields. In this report, non-Iowa residents were excluded from the analysis (in previous reports,

2004-2005; 2005-2006, non-Iowa residents were included). The analysis in this report was limited to “first encounter” cases, meaning a patient that transferred from one hospital to another or who were admitted from an emergency department to the hospital were excluded. In past reports, a single incident of TBI in a single person would have been counted several times. For example, a person seen in the ED for a TBI would have been counted and if that same person was admitted to the hospital because of that injury they would be counted a second time; if they were transferred to another hospital the incident would have been counted a third time. The change in methodology from previous reports and the subsequent reduction of duplicate cases has decreased the incidence rate of TBI in Iowa; however the rates in this report should be a closer estimate of the true incidence rate of TBI in Iowa.

Trends of TBI deaths, hospitalizations and ED visits from 2002 to 2008 are provided. However, demographic characteristics and other indicators, such as causes, length of stay, discharge disposition and charges, are assessed using three-year averages (2006 to 2008). Following the analysis guidelines, the intent (unintentional, suicide, homicide) was presented but the analysis of cause (based on E codes) was lumped independently of intent. Causes reflect the source of the injury, such as falls, motor vehicle crashes (MVC), firearms, suffocation (strangulation/hanging), burning/fire, and other specified or no otherwise specified. Whenever adequate the leading causes of TBI were ranked and shown when the magnitude was high enough. A category of causes labeled “Other”, which combined several causes with smaller numbers along with the unknown causes, was created. However, since this category did not represent a homogenous group, it was not used as in the comparison or ranking. Because of Iowa rural character, counties were stratified into the following categories: less than 10,000, 10 to 20,000, 20 to 50,000 and greater than 50,000 residents.

The Statistical Analysis System (SAS version 9.1, Cary North Carolina) software was used for data management and analysis. Numbers were generated with SAS software; Rates were calculated using Iowa census population estimates. All age-adjusting was done using the direct method (see definition) with the Excel tools provided by the CDC. The average annual crude rates were calculated by averaging the frequencies and dividing by the average populations.

Limitations:

Limitations in this report pertain to the nature of the inpatient and outpatient hospital data. The purpose of hospital discharge data is primarily for patient or insurance billing and secondarily for surveillance. In many cases, key information is missing from the discharge data; this includes race information and external cause of the injury. For example an injury to the head may be coded but the discharge data lacks the cause of the injury. The magnitude of missing E-code data and race information is such that the impact and mechanism of injury by race may be underestimated or misleading.

Table 1: International classification of disease codes ninth and tenth revision for TBI

ICD 9	Label from IAC 641,21	ICD 10	Label from CDC
348.1	Resulting from physical agents	S01.0–S01.9	Open wound of head
800.00–800.99	Fracture of vault of skull.	S02.0, S02.1, S02.3, S02.7–S02.9	Fracture of skull and facial bones
801.00–801.99	Fracture of base of skull.	S04.0	Injury of optic nerve and pathways
803.00–803.99	Other and unqualified skull fractures.	S06.0–S06.9	Intracranial injury
804.00–804.99	Multiple fractures involving skull or face with other bones.	S07.0, S07.1, S07.8, S07.9	Crushing injury of head
850.00–850.99	Concussion.	S09.7–S09.9	Other and unspecified injuries of head
851.00–851.99	Cerebral laceration and contusion.	T01.0	Open wounds involving head with neck
852.00–852.59	Subarachnoid, subdural, and extradural hemorrhage, following injury.	T02.0	Fractures involving head with neck
853.00–853.19	Other and unspecified intracranial hemorrhage following injury.	T04.0	Crushing injuries involving head with neck
854.00–854.19	Intracranial injury of other and unspecified nature.	T06.0	Injuries of brain and cranial nerves with injuries of nerves and spinal cord at neck level
994.1	Drowning and other nonfatal submersion.	T90.1, T90.2, T90.4, T90.5, T90.8, T90.9	Sequelae of injuries of head
994.7	Asphyxiation and strangulation		

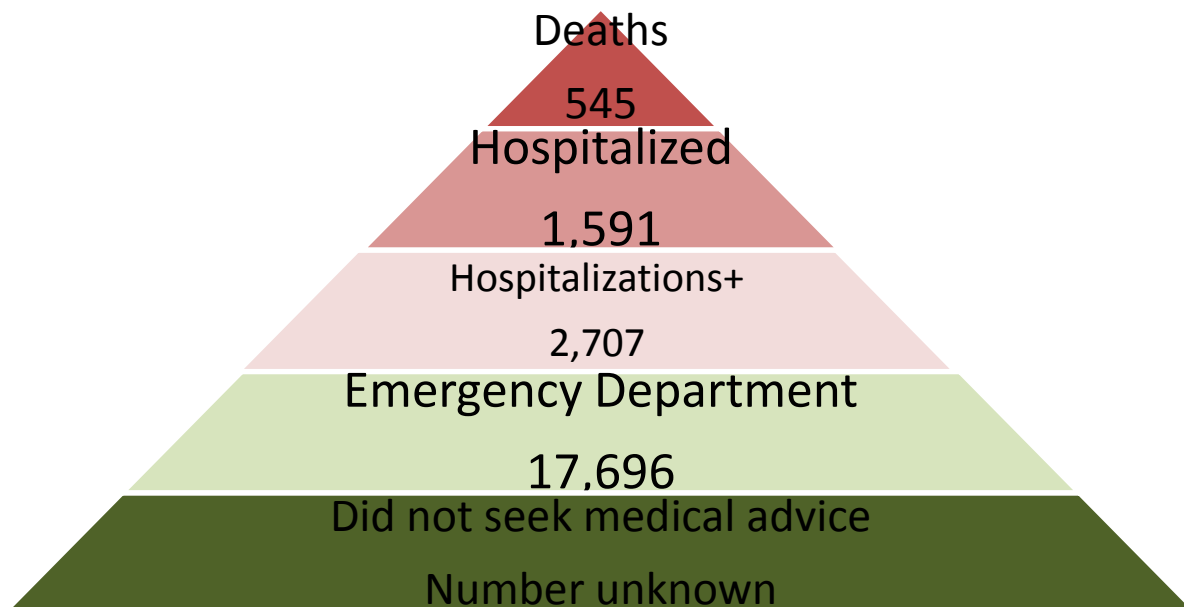
Results

The Injury Pyramid

From 2006 to 2008, traumatic brain injury caused, on average, 545 deaths per year, 1,591 people hospitalized, and 17,696 ED visitors per year in Iowa. On average, there were 2,707 hospital admissions, which indicate that 41% of those cases were readmissions or transfers. The overall burden of TBI in Iowa is certainly underestimated as some authors reported that 25% of mild concussions may not seek treatment or use other sources of medical care, such as doctor's office, outpatient setting and other health centers.⁴

Compared to all other injuries, traumatic brain injury (TBI) was the cause of 30% of injury deaths, 10% of injury hospitalizations and 7% of all emergency department (ED) visits. TBI deaths account for only a small percentage of TBI cases. For every Iowan who died from TBI, three were hospitalized and 32 visited the ED.

Figure 1: Traumatic Brain Injury Pyramid (3-Year average), 2006-2008



Notes: + old calculation method counting events, which include readmissions or transfers

Demographics

TBI Deaths, Hospitalizations and ED Visit Rates by Year and County Size

Except for ED visits, mortality and morbidity rates in Iowa were stable from 2006 to 2008 (Table 2). The mortality rate stayed close to 18 per 100,000 Iowans with an age-adjusted rate of 17 per 100,000. Iowans residing in counties with a population of less than 50,000 were more likely to die from TBI than individuals living in a county with a population over 50,000. The mortality rate

for counties with less than 10,000 was 33 per 100,000 and was 2.3 times higher than in counties with more than 50,000 people.

The overall rate of lowans who were hospitalized for TBI mirrored the mortality rates. Hospitalization rates adjusted to the 2000 census from 2006 to 2008 remained stable at 46.9 and 47.6 hospitalizations per 100,000. Counties with less than 50,000 people had greater rates of hospitalizations than those with more than 50,000 people.

The rates per 100,000 people for ED visits increased 14% from 2006 to 2008. Counties with a population less than 50,000 people had lower rates than counties with population size greater than 50,000 people. The county distribution of lowans with TBI who were hospitalized shows a slight clustering near the interstate system (central areas) and the state north-western regions. The mapping of the county specific rates shows, 12 counties presented rates significantly greater than the state average of 53.2 per 100,000.

Table 2: TBI mortality, hospitalization and ED visit rates per 100,000, 2006-2008

Characteristics	Deaths		Hospitalized		Visited the ED	
	N	Rate (Adj.)	N	Rate (Adj.)	N	Rate (Adj.)
Year						
2006	553	18.6 (17.0)	1,524	51.4 (46.9)	16,188	545.5 (543.2)
2007	528	17.7 (16.2)	1,675	56.1 (51.4)	18,242	611.4 (607.8)
2008	554	18.4 (17.0)	1,574	52.4 (47.6)	18,658	621.4 (618.3)
Location*						
>50,000	208	14.3	757	52.0	9,604	659.2
20-50,000	159	22.2	391	54.8	4,304	602.4
10-20,000	137	19.9	372	54.1	3,179	462.2
<10,000	41	33.0	71	56.5	609	486.8

Notes: *Crude rates are reported here; population estimates are three-year census averages. N= total number; Adj.= Adjusted rate; county >50,000 (bolded values) are used as reference;

Figure 2: Number of TBI Deaths by County

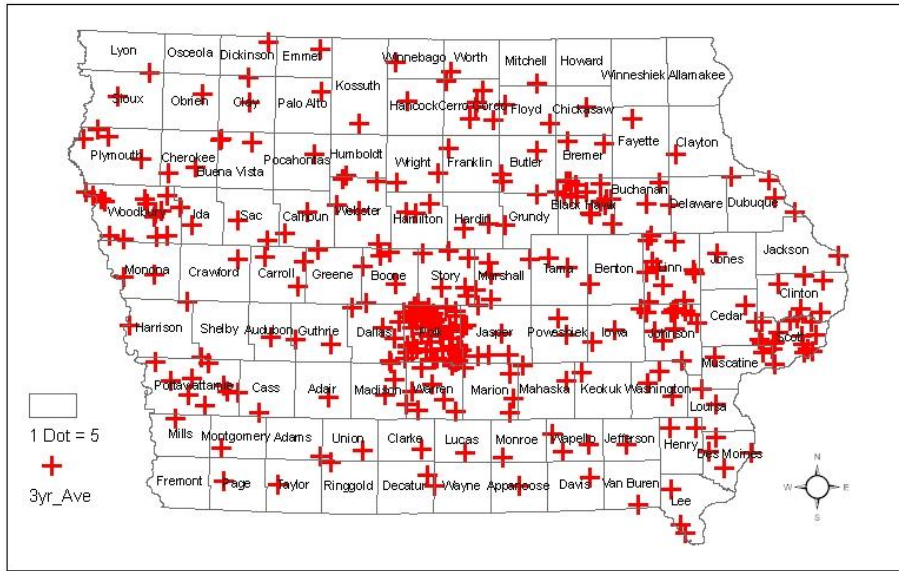
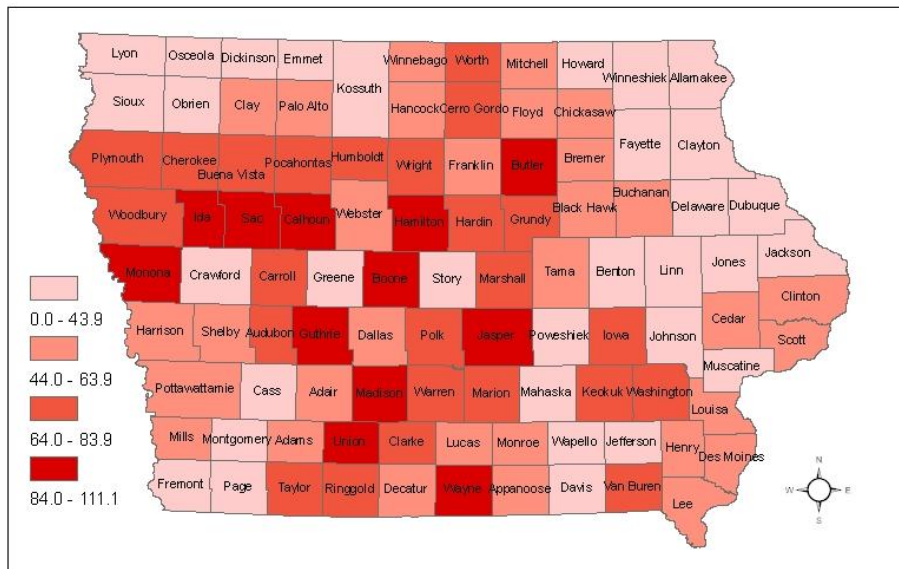


Figure 3: TBI Hospitalization Rate (per 10,000) by County



Note: Note: Counties with less than 5 cases are not shown;

Distribution of TBI Deaths, Hospitalizations and ED Visits by Race, Gender and Age Group
 The majority of TBI mortality cases were Whites (93%) and males (71%). The average age of TBI deaths was 53 years, ranging from less than one year to over 100 years. The age distribution of TBI deaths showed a greater proportion of people less than 25 years of age (18%) and people more than 65 years of age (39%). The proportion of TBI deaths between the age of 25 and 64 years ranged from 8% to 13%.

Since seventeen percent of hospital and ED visit cases did not have race information, the reported percent comparing the burden of TBI by race should be used with caution. The misclassification of race may artificially overburden one compared to the other races. The

average age of TBI hospitalization was also 53 years and the age range spanned from less than one year to over 100 years old. The TBI hospitalizations were evenly distributed across the age groups (8-14%), except for those less than 15 years (4%) and those over 65 years of age (38%). Iowans age 65 and older were also more likely to be hospitalized for TBI. Emergency department patients had an average age of 35 years. Individuals younger than 25 years of age represented 53 percent of all ED visits (Table 3).

Table 3: Demographic Distribution of TBI hospitalization and ED visits

Characteristics	Deaths		Hospitalizations		ED Visits	
	N	%	N	%	N	%
Race						
Whites	509	93.2	1,257	79.0	13,749	77.7
Blacks	13	2.4	41	2.6	746	4.2
Other Races	15	2.7	13	0.8	144	0.8
Unknown	9	1.6	280	17.6	3,057	17.3
Gender						
Male	389	71.4	943	59.2	10,000	56.5
Female	156	28.6	648	40.7	7,694	43.5
Age Groups						
<15	23	4.2	123	7.7	5,764	32.6
15 to 24	77	14.2	236	14.8	3,679	20.8
25 to 34	45	8.3	126	7.9	1,710	9.7
35 to 44	58	10.6	137	8.6	1,340	7.6
45 to 54	73	13.4	166	10.4	1,347	7.6
55 to 64	56	10.3	144	9.1	967	5.5
Over 65	212	38.9	659	41.4	2,889	16.3

Notes: Race information in Hospital Discharge Data was lacking in 17% of the cases;

Severity, Mechanism and Causes of TBI

Information on external causes of injury was filled out in all cases of deaths; 20 percent of hospitalizations for TBI lacked an E Code and nearly 50 percent of ED visits were missing this information. The lack of E Code information made the calculation of exact rates of TBI by causes impossible. This report includes percent distribution only.

TBI Severity among Hospitalized and Emergency Department Cases

The TBI severity distribution showed that 80 percent of hospitalizations were severe (60%) to moderate (22%) TBI cases, while mild TBI or potential concussion consisted of 18 percent of cases. Emergency department cases were made up of mostly potential TBI diagnosis (73%); with less than 25 percent being diagnosed as moderate to severe TBI (Figure 4).

Nearly 80 percent or more of hospitalizations and ED visits that resulted in a TBI diagnosis were due to unintentional injuries. Assaults (homicide) constituted six percent of TBI related hospitalizations and nine percent of TBI related ED visits (Table 4).

Figure 4: TBI Severity Distribution, Hospitalizations vs. ED visits

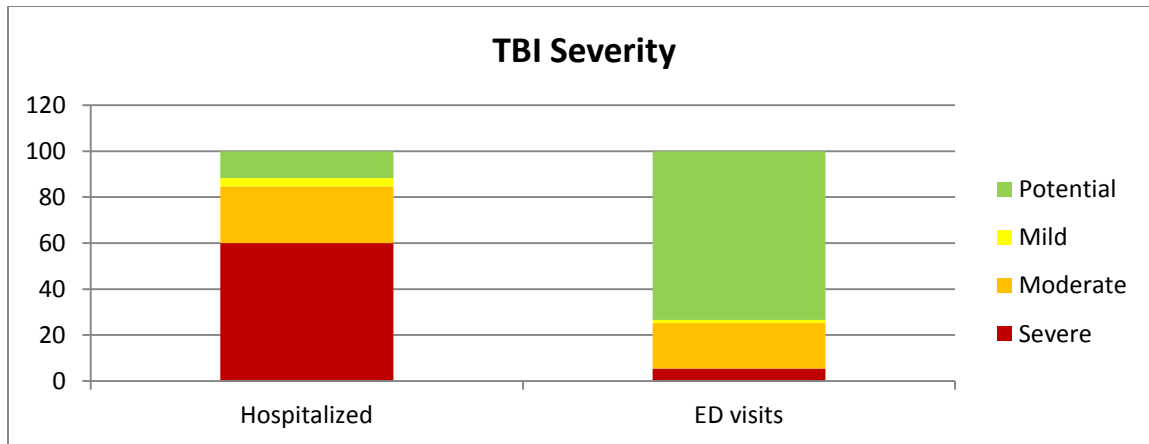


Table 4: Distribution of TBI Deaths, Hospitalizations and ED visits by Intent

INTENT	Deaths		Hospitalizations		ED Visits	
	N	%	N	%	N	%
Unintentional	371	68.1	1,257	79.1	15,055	85.1
Suicide	123	22.6	10	0.6	21	0.1
Homicide	29	5.3	79	5.0	1,632	9.2
Other/Undetermined	22	4.0	245	15.4	988	5.6

TBI Causes in Iowa

Leading Causes of TBI Deaths, Hospitalizations and Emergency Department Visits

The three leading causes of TBI deaths for this reporting period were MVC (163), falls (153) and firearms (138). The leading causes of hospitalizations were falls (686), motor vehicle crashes (396) and struck by/against (100). The leading causes of ED visits were falls (8,207), struck by/against (4,439) and MVC (2,703). For clarity of the report an “other” category of causes, which combined all other causes including poisoning, suffocation, causes not specified, unknown and missing, was created (Table 5).

Table 5: Leading cause of TBI Deaths, Hospitalizations and ED Visits, 2006-2008

Causes	Deaths	Hospitalizations	ED Visits
MVC	163	396	2,073
FALL	153	686	8,207
FIREARM	138	12	14
STRUCK BY/AGAINST	6	100	4,439
OTHER	85	402	2,963
Total	545	1,596	17696

Notes: ED= emergency department visits; MVC= motor vehicle crashes; Others = CUT/PIERCE, DROWNING, FIRE/FLAME, MACHINERY, NATURAL/ENVIR, NEC, NOT SPECIFIED, OTHER LAND TRANSPORT, OTHER PEDAL CYC, OTHER PEDESTRIAN, OTHER SPEC, OTHER TRANSPORT, POISONING, SUFFOCATION;

Percent Distribution of TBI Causes by Age

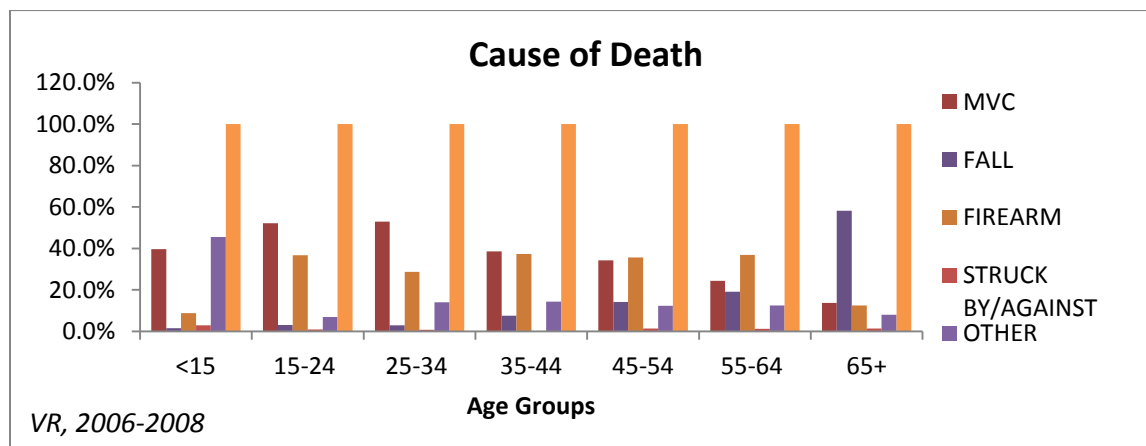
The three leading causes of TBI deaths in Iowa were MVC (30%) followed by falls (28%) and firearms (25%). These percents reported are column percents, meaning the comparison is specific to the corresponding age group and the sum should total 100% approximately, accounting for rounding errors.

Among Iowans under the age of 35, the main cause of TBI related deaths were MVC (50%) followed by firearm deaths (30%). The proportion of deaths due to MVC equaled that of firearms (36%) in Iowans between the ages of 35 and 54. Among the 55-64 years of age, firearms were the leading cause of TBI deaths (37%) followed by MVC (24%). Among Iowans older than 65 years of age, the leading cause of deaths was fall (58%) followed by MVC (18%) and firearms (12%), (Figure 5).

For hospitalizations, MVC are highest among the 15-44 years old, ranging from 40 to 50 percent. "Struck-by or against" was the second leading cause among young adults 18-24 and was tied to falls among the 25-34 years age group. The percent of TBI related falls ranked second in magnitude among the 35-44 (22%) to become the leading cause of hospitalizations starting with the 45-54 age groups (35%) and among the older age groups. Among the 65 years and older, fall constituted 68% of TBI hospitalizations (Figure 6). Furthermore, fall was the leading cause of TBI (30%) among youth less than 25 years of age. It is important to note, unknown causes and others combination of causes (poisoning, suffocation, etc.) represented 25 percent of TBI hospitalizations.

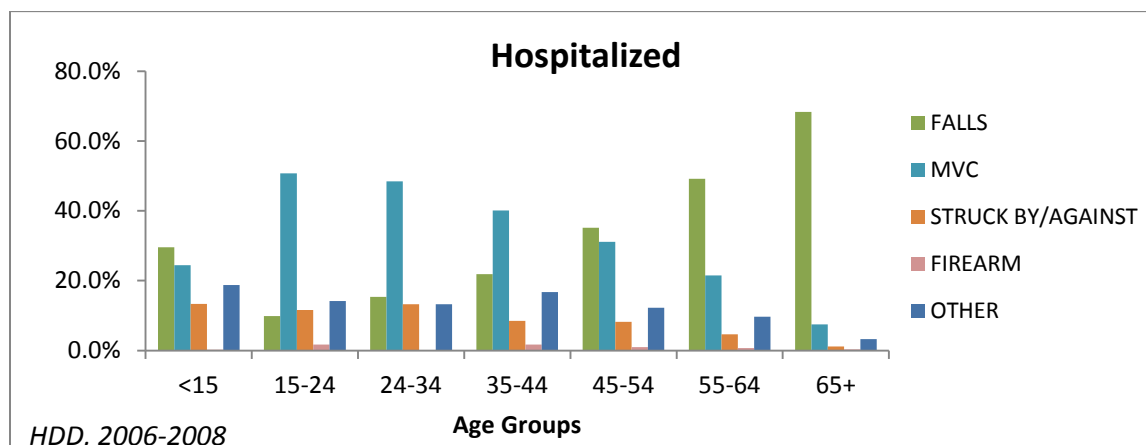
The Emergency department visits presented a different picture (Figure 7). ED visits categorized as "Other" for cause, which represents the combination of all causes including unknown causes-except falls, MVC, struck-by/against and firearm - made up 50% of all ED visits for all age groups during the surveillance period. Excluding "Other" from the ranking, fall was the leading cause of ED visits in Iowans less than 15 years of age (31%) and those over the age of 45. The percent distribution of falls by age followed a bimodal V-like shape with higher percent on the external age groups, the less than 15 years of age and the 55 and older age groups. "Struck-by or against" was the first leading cause of TBI in the 15 to 34 age groups. The MVC were more important among the young adults 15-24 (13%) and the 25-34 age groups (12%).

Figure 5: Percent Distribution of Causes of TBI Deaths by Age



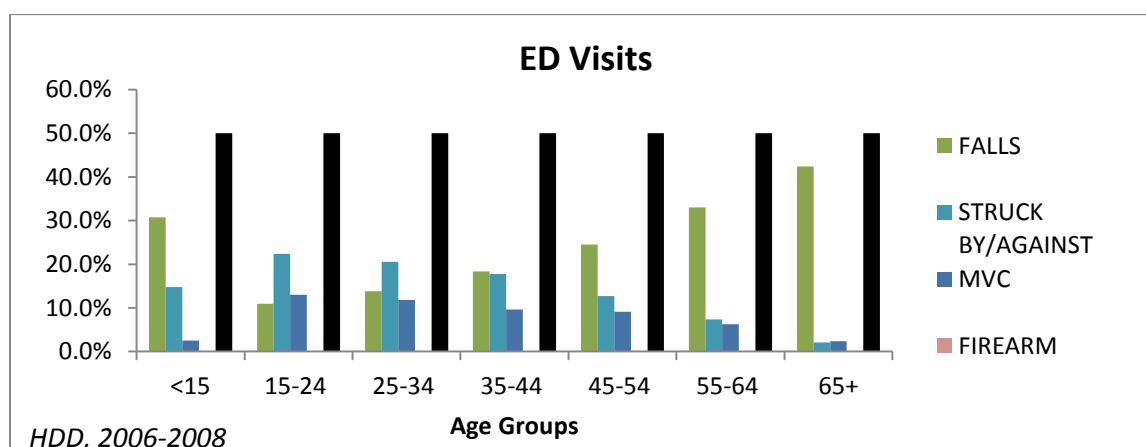
Notes: VR= IDPH vital Records

Figure 6: Percent Distribution of Causes of TBI Hospitalizations by Age



Notes: HDD: Hospital discharge data

Figure 7: Percent Distribution of Causes of TBI ED Visits by Age



Notes: HDD= hospital discharge database;

Percent Distribution of TBI Causes by Race

Among Whites, the leading cause of TBI death was MVC (31%) followed by falls (30%) and firearms (26%); whereas in Blacks, 42% of all deaths were due to firearms followed by “MVC (18%) and falls (10%), (Figure 8).

The category of causes labeled “Other” represents the combination of all other causes, such as poisoning, suffocation, machinery, etc. and unknown causes, such as not specified or missing, and therefore is excluded from the comparison with other causes. For people in the “others” racial category, more people died from MVC (41%). Firearm and fall followed with a respective proportion of 23 percent and 12 percent of TBI deaths.

The hospital distribution showed Whites suffered more from falls than MVC; while MVC were the leading cause of hospitalizations among Blacks and “Other” racial groups. “Struck-by and

against” was the third leading cause of hospitalizations in Blacks (16%) and other racial groups (9%), (Figure 9).

For ED visits (Figure 10), fall was the leading cause of TBI among all racial groups followed by “Struck by and against.” MVC was the third leading cause and emerging from the lot were bicycle injuries, which constituted around two percent of TBI related ED visits.

Figure 8: Percent Distribution of Causes of TBI Deaths by Race

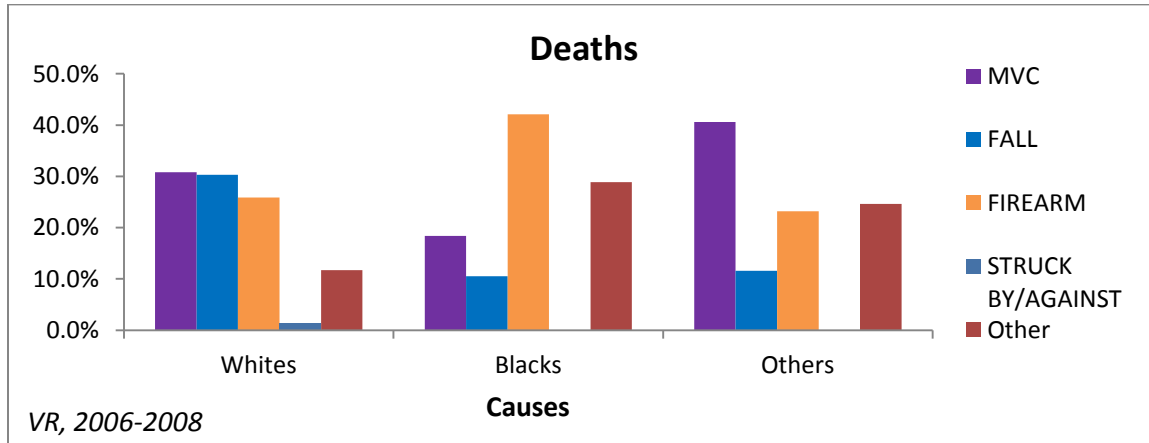


Figure 9: Percent Distribution of Causes of TBI Hospitalizations by Race

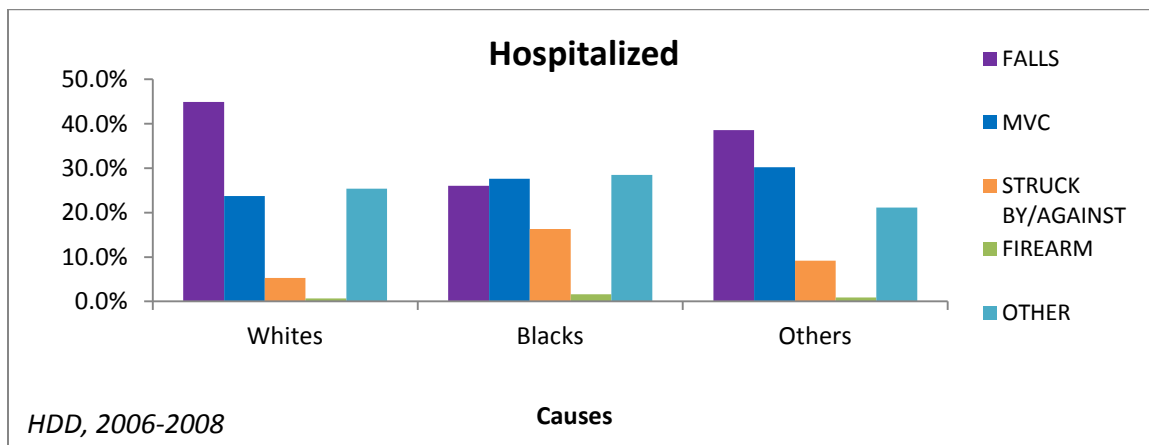
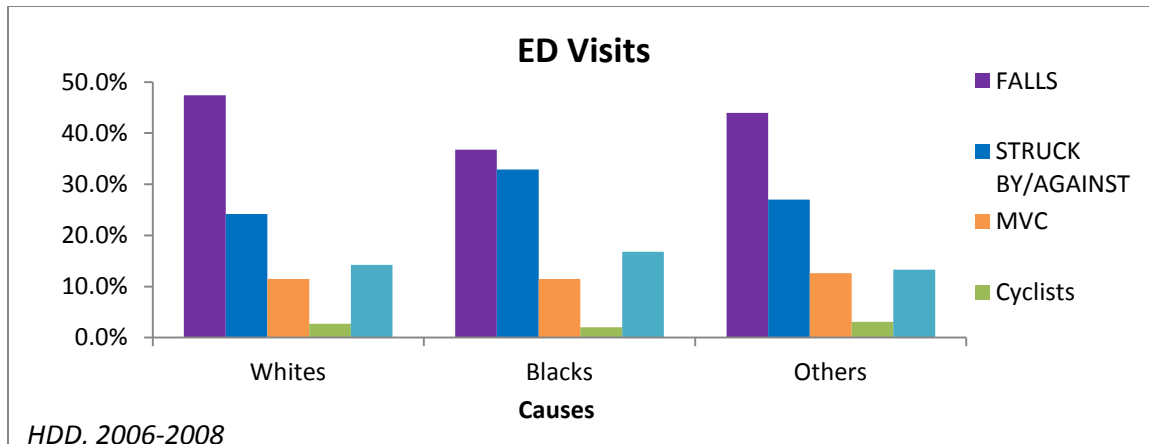


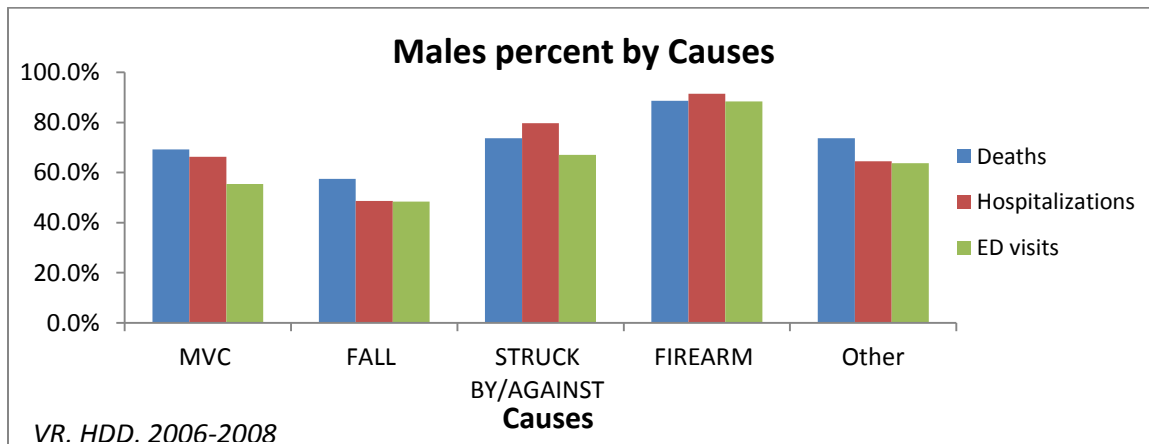
Figure 10: Percent Distribution of Causes of TBI ED visits by Race



Distribution of TBI Hospitalizations by Gender

Males were more likely than females to die, be hospitalized or visit the ED because of motor vehicle crashes, firearms and “being struck by or against”(Figure 11). Males constituted most of firearm deaths (89%), hospitalizations (91%) and ED visits (88%). Although most fall-related TBI deaths were males (58%), there was no difference in the proportion of males and females hospitalized or visiting the ED because of fall-related TBI (52%).

Figure 11: Proportion of Male TBI deaths, hospitalizations and ED visits by Causes



Notes: VR= Vital Records, HDD: hospital discharge data; IP= hospitalizations, OP= emergency department visits;

TBI Death, hospitalization, ED Visits Rates by Causes and County Size

Since the percent distribution of TBI deaths, hospitalization and ED visits was not meaningful without adjusting for county size; rates per 100,000 were calculated to assess the magnitude of the problem. Counties were categorized into four groups depending on their size. A three-year average population from the census estimates was computed and used to calculate the specific rates by county category.

As shown earlier, the three leading causes of TBI deaths in Iowa were in order of magnitude: MVC, falls and firearms. When stratified by county size, the leading cause of death in counties with a population greater than 50,000 was falls followed by MVC and firearms (data not shown).

In terms of rates, counties with less than 50,000 people presented higher rates of MVC, firearm related deaths and, to a smaller degree, fall related deaths (Figure 12). Compared to counties with population greater than 50,000 (reference group), the relative risk for dying from MVC was two times higher for counties with a population between 20 to 50,000, 90 percent higher for counties with population of 10 to 20,000, and almost four times higher for counties with population of less than 10,000 people. In addition, counties with population less than 50,000 had a higher relative risk of dying from falls than counties with population greater than 50,000. The relative risk was 60 percent higher in counties with population between 20-50,000, forty percent higher in those with population of 10 to 20,000, and two times higher in those with population of less than 10,000 people. Furthermore, firearms related death rates were higher in counties with less than 50,000 people.

Hospitalization rates for TBI related falls were consistently higher than any other causes across all county groups (Figure 13). There were no differences in the rates of TI related hospitalizations due to falls or MVC. Counties with population greater than 50,000 had a higher rate of firearm hospitalizations for the other county categories, except for those with less than 10,000 people. The rate of TBI hospitalizations for “Struck by/against” was twice higher in counties with population greater than 50,000 than in those between 20 to 50,000 and 10 to 20,000, and was 70 percent higher than among those less than 10,000. There were no significant differences in the rate of TBI ED visit rates by county size. Counties with less than 10,000 people seem to have 20% higher rate than counties with less than 50,000. The rates of TBI related ED visits for falls were higher with increasing population size (Figure 14).

Figure 12: TBI Mortality Rates per 10,000 by Causes and County Size

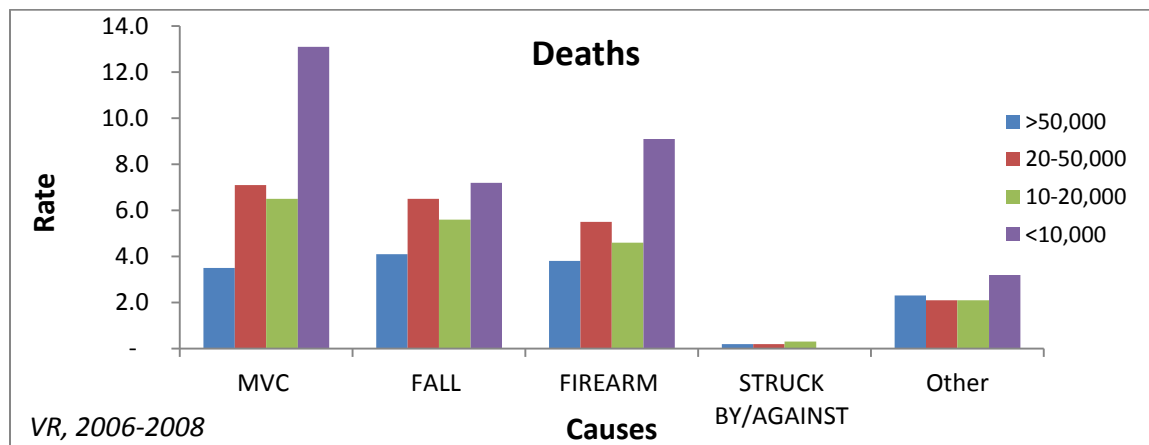


Figure 13: TBI Hospitalization Rates per 10,000 by Causes and County Size

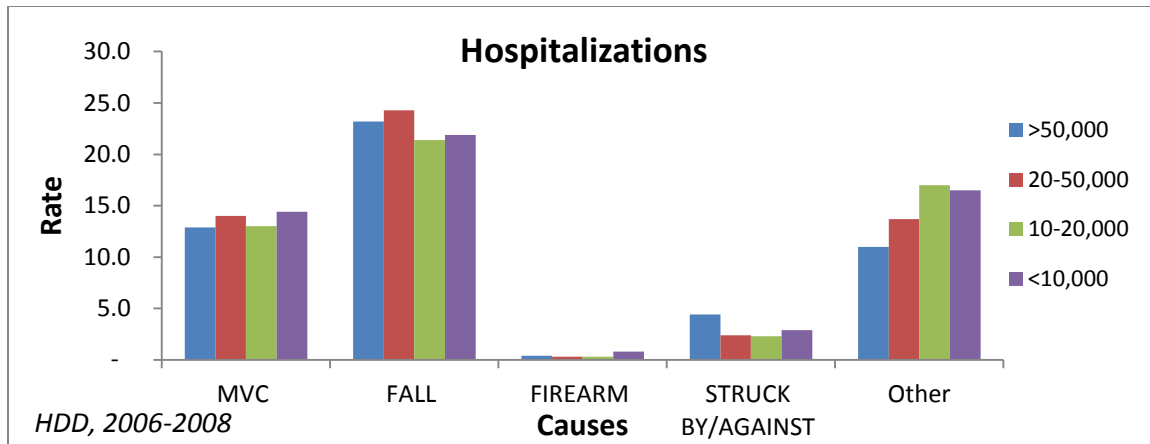
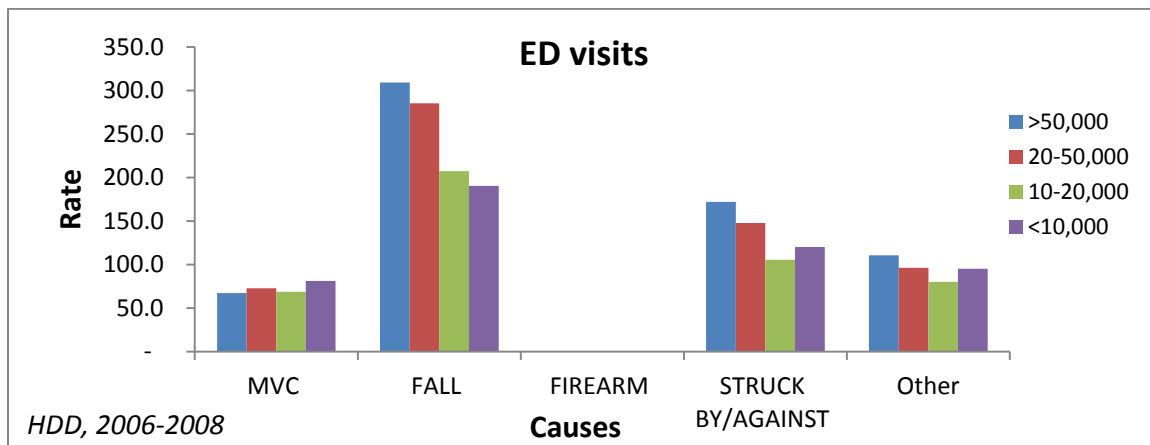


Figure 14: TBI ED Visit Rates per 10,000 by Causes and County Size



Leading Causes of TBI mortality and morbidity, MVC and Falls

The major causes of TBI deaths, hospitalizations and ED visits were mostly MVC and falls. Whereas MVC were the leading cause of TBI deaths, falls contributed the most to the burden of TBI hospitalization and ED visits. The third leading cause of TBI mortality and morbidity was different whether deaths, hospitalizations or ED visits were assessed. Firearm was the third leading cause of deaths, while “Struck by and against” ranked third in TBI hospitalizations and second in ED visits. This section will address specifically the two leading causes of TBI deaths (MVC), hospitalization and ED visits (falls).

Motor Vehicle Crashes

Every year, MVC result in an average of 98 TBI deaths, 237 people hospitalized, and 2072 people visiting the emergency departments.

Persons injured by Age

Consistently across all ages, car occupants or drivers constituted the highest proportion of traffic related TBI deaths (71%), hospitalizations (67%) and ED visits (82%). The majority of occupant deaths were 15 to 24 years old (29%), 25 to 34 years old (16%) and 35 to 44 years old (12%), (Figure 15). Occupant hospitalizations occurred mostly among the 15 to 24 years old (35%), 25 to 34 years old (16%) and 35 to 44 years old (11%), (Figure 16). Occupant ED visits were mostly 15 to 24 years old (42%) and 25 to 34 years old (16%), (Figure 17).

Motorcycle injuries represented 19 percent of all TBI related traffic deaths and TBI hospitalizations, and eight percent of ED visits. Pedestrians and bicyclists consisted of seven percent of the traffic related TBI deaths, 11 percent of TBI hospitalizations, and six percent of ED visits.

On average, there were seven pedestrian and bicyclist deaths, 23 hospitalized and 82 admitted to ED from traffic related TBI. About 46 percent of the cases were 5 to 24 years old.

Figure 15: Percent Distribution of TBI Deaths in MVC by Causes and Age

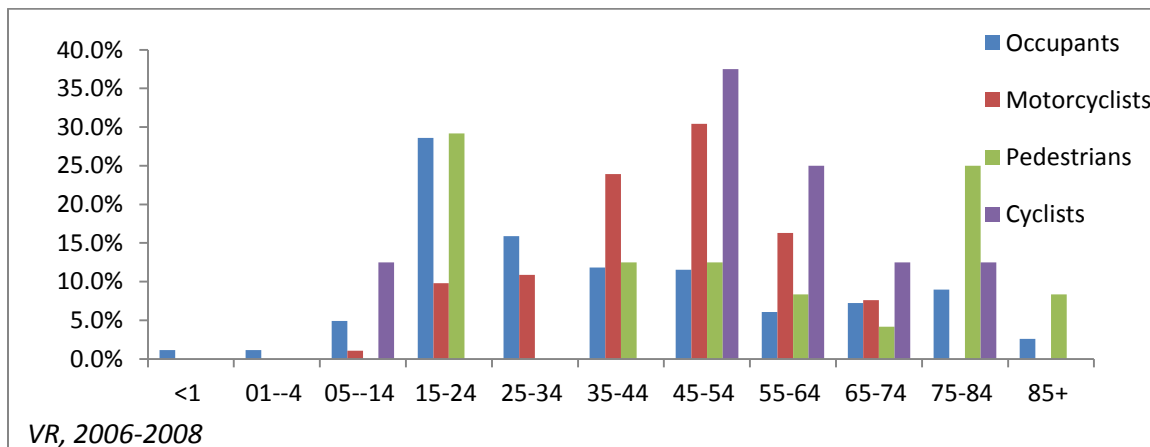


Figure 16: Percent Distribution of TBI Hospitalizations in MVC by Causes and Age

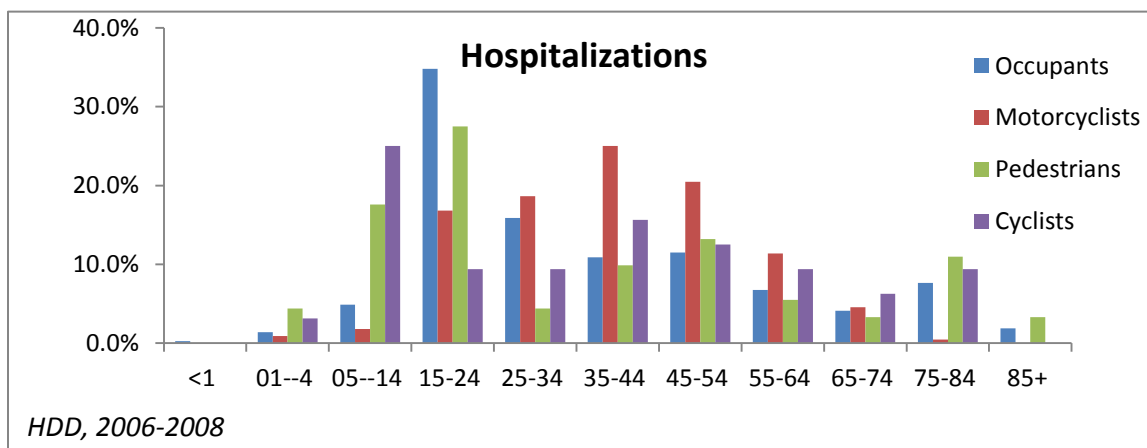
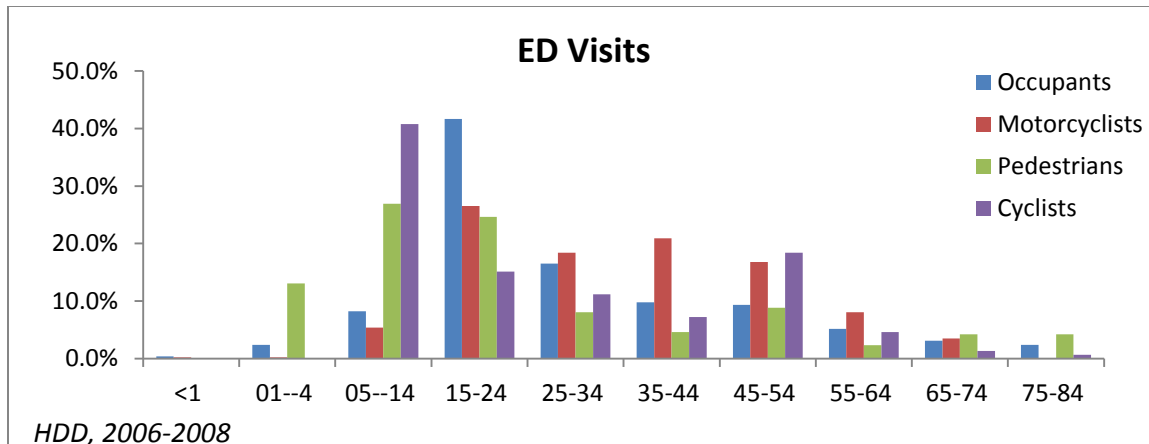


Figure 17: Percent Distribution of TBU ED Visits by Causes and Age



Persons injured by Gender and Race

Table 4 shows the mortality and morbidity distribution of MVC by gender and race. The majority of females who died from MVC (77%), or were hospitalized (78%) or visited ED (88%) were drivers or occupants of personal car crashes. Males, who died (68%) or were hospitalized (62%) or visited ED (76%), were mostly drivers or occupants in personal car crashes. In terms of race, the proportion of occupants and drivers in personal car crashes among Blacks (85%) and other racial group (90%) was higher than among Whites (69%).

While the proportion of males in motorcycle TBI deaths was two times higher, the difference was 3 times higher for hospitalizations and 6 times higher for ED visits. All motorcycle related TBI deaths were white; representing 20% percent of TBI related traffic fatalities. However, in terms of hospitalization, there was a significant proportion of minorities with 18 percent of TBI related MVC among Blacks and 13 percent among other racial group were due to motorcycle. Blacks and Other races (including Hispanics) had a higher proportion of pedestrian and pedal cycle deaths.

The proportion pedestrians who died from TBI related MVC or were hospitalized was greater among females than males. The proportion of pedestrian deaths was higher among Blacks than among Whites or other racial group. Other racial group had a greater proportion of pedestrian visiting the ED for MVC related TBI. Bicycle mortality and morbidity demonstrated a higher proportion among other racial groups.

Table 6: MVC deaths-hospital-ED by Gender and Race

Demographics	Persons Injured	Death	Hospitalized	Visited ED
GENDER				
Female	Occupants	77.5%	78.3%	88.3%
Male		67.6%	61.8%	76.1%
Female	Motorcyclists	11.3%	7.0%	2.5%
Male		22.1%	24.4%	12.0%

Female	Pedestrians	6.0%	11.0%	3.9%
Male		4.4%	6.0%	4.4%
Female	Cyclists	2.0%	1.0%	1.2%
Male		1.5%	3.6%	3.5%
RACE				
Whites	Occupants	69.5%	67.2%	81.5%
Blacks		85.7%	73.5%	81.6%
Others		90.0%	60.0%	83.0%
Whites	Motorcyclists	20.0%	19.2%	8.5%
Blacks		0.0%	17.6%	2.0%
Others		0.0%	13.3%	3.8%
Whites	Pedestrians	4.6%	7.3%	3.7%
Blacks		14.3%	8.8%	7.4%
Others		5.0%	20.0%	1.9%
Whites	Cyclists	1.5%	2.6%	2.2%
Blacks		0.0%	0.0%	5.1%
Others		5.0%	6.7%	3.8%

Note: percent does not add up to 100% because unknown causes of MVC are not shown

Falls

There were on average 153 fall-related TBI deaths, 686 hospitalizations and 8207 ED visits. Across the gender strata, the proportion of fall-related TBI deaths, hospitalizations and ED visits increased with age.

The percent distribution by age was different when comparing males and females. The proportion of fall related TBI deaths was higher among males age 45 to 74 than among females in the same age range; while it was higher among females age 75+ compare to males (Figure 18). Hospitalizations for fall related TBI followed the same trend as deaths. The proportion of fall related TBI leading to emergency department visits was higher among lowans under age 25 (Figure 19). ED visits for fall related TBI followed a “V” distribution with increased visits for individuals aged 0-24 and 45-85+. The proportion was higher among males under the age of 24 than among females; while it was higher among females over the age of 45 compared to males in the same age category (Figure 20).

Figure 18: Percent Distribution of TBI Deaths due to Fall by Gender and Age

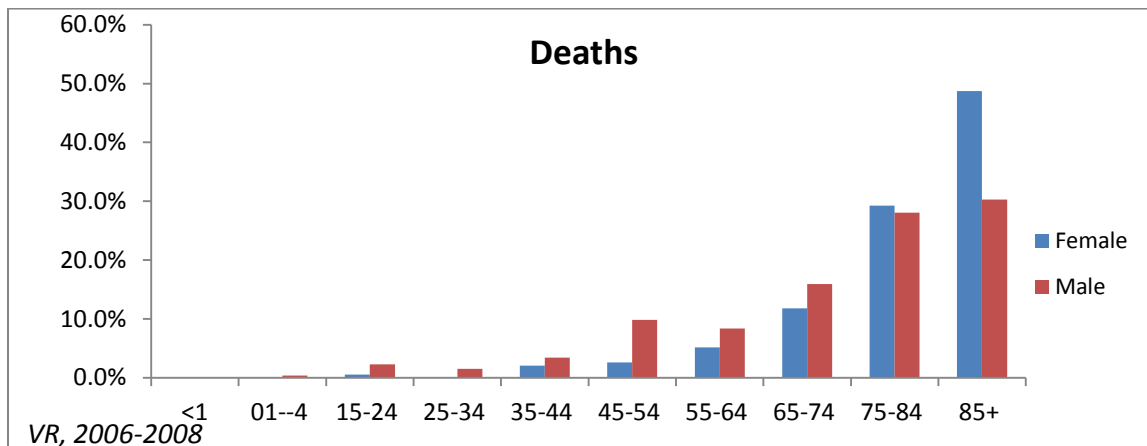


Figure 19: Percent Distribution of TBI Hospitalization due to Fall by Gender and Age

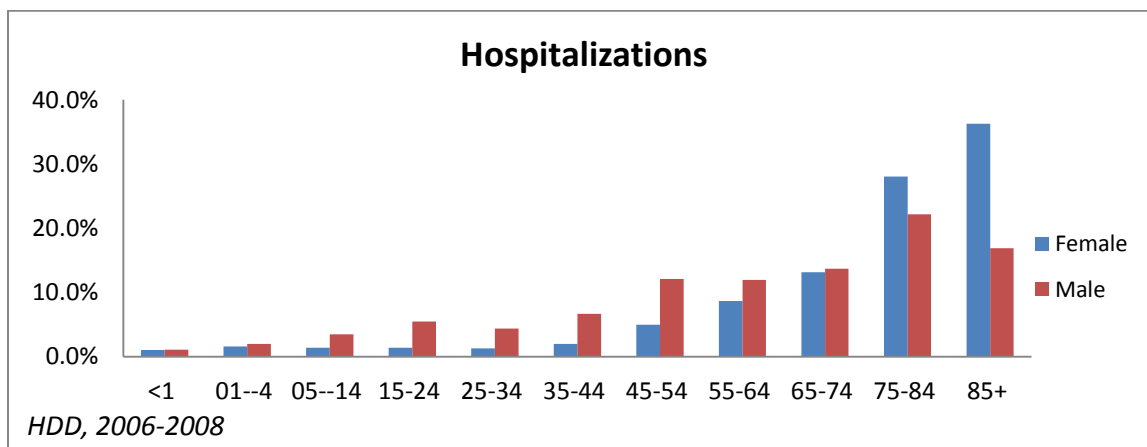
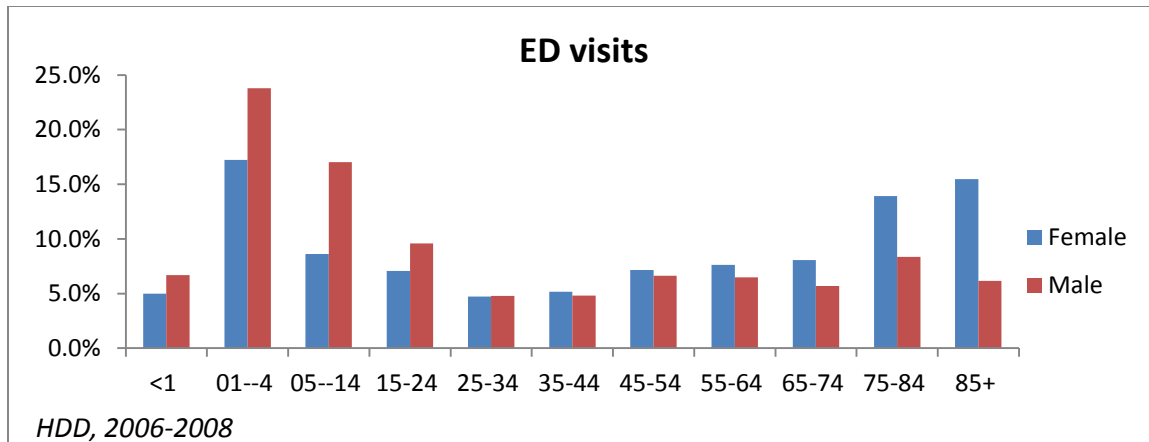


Figure 20: Percent Distribution of TBI ED visits due to Fall by Gender and age



Hospital Discharge Prognosis

Discharge location

Figure 21 depicts the discharge location of TBI patients that were hospitalized or visited the emergency department. From 2006 to 2008, 60 percent of hospitalized TBI cases were discharged home, 16 percent to long term care facilities, seven percent to rehabilitation services and eight percent were transferred to another inpatient hospital. About seven percent died during hospitalization. The cases discharged to long term care and rehab (25%) bring to focus the issue of disability post-TBI. TBI cases discharged from the emergency department had better discharge outcomes than hospitalized cases, with 90 percent of ED cases discharged home and only seven percent transferred to inpatient services. The proportion of cases that died on arrival at the ED was insignificant, less than 0.2 percent.

Table 5 describes the discharge location of TBI patients from hospitals and emergency departments by causes. Although not in the top three causes for hospitalization, firearm related TBI hospitalizations had the worst outcomes of all causes with 74 percent of cases resulting in death, nine percent discharged to rehabilitation services, three percent to long term care and six percent transferred to other hospitals. Patient hospitalized because of falls had better individual outcomes with 52% of cases discharged home, 27 percent to long term care, five percent to rehabilitation services, nine percent to another hospital. For patients received at the emergency department, firearms related TBI had also the worst outcome with 37 percent dead on arrival and 44 percent transferred to another hospital. As for other causes of ED visits, such as falls, MVC and “Struck by and against”, the proportion of patient who died was 0.1, one and less than two percent, respectively. About seven percent of TBI related ED visits, except for firerams, were transferred to another hospital.

Figure 21: Percent Distribution of TBI Discharge Type after Hospitalization or ED Visits

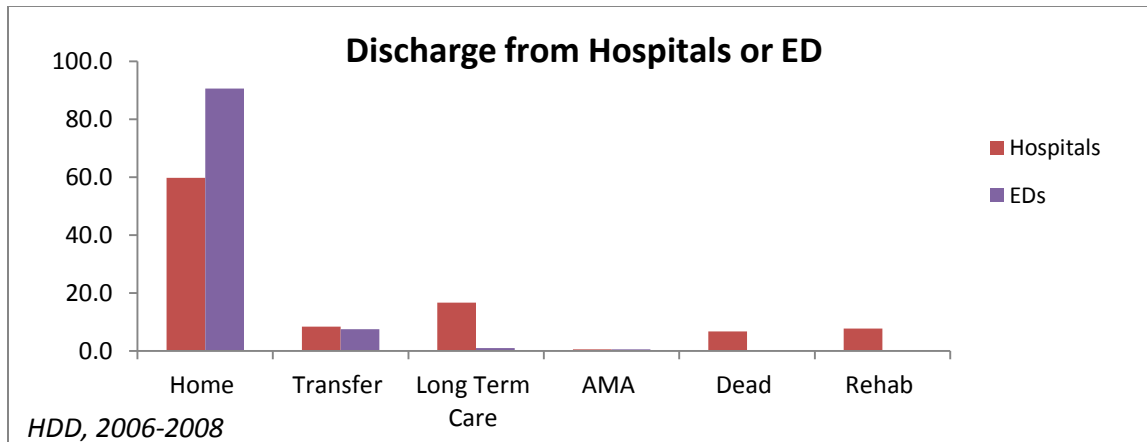


Table 7: Patient Discharge Type after TBI hospitalizations and ED visits by Causes

CAUSE	Location	Average Number of Cases	Home	Transfer	Long Term Care	Rehab	Dead
FALLS	Hospitalized	682	51.7%	8.9%	27.5%	5.2%	6.7%
	Visited ED	8,182	91.1%	6.9%	2.0%	0.0%	0.1%
MVC	Hospitalized	394	67.5%	7.9%	5.7%	12.8%	6.0%
	Visited ED	2,062	82.2%	16.6%	0.2%	0.0%	1.0%
STRUCK BY/AGAINST	Hospitalized	99	87.6%	4.4%	2.7%	3.7%	1.7%
	Visited ED	4,414	96.8%	3.1%	0.1%	0.0%	0.0%
FIREARM	Hospitalized	12	8.6%	5.7%	2.9%	8.6%	74.3%
	Visited ED	14	18.6%	44.2%	0.0%	0.0%	37.2%
ALL CAUSES *	Hospitalized	1,337	61.6%	8.1%	16.5%	7.4%	6.5%
	Visited ED	16,660	91.3%	7.4%	1.0%	0.0%	0.2%

Note: *The numbers do not add to the total number of TBI cases because of missing E-codes and missing disposition.

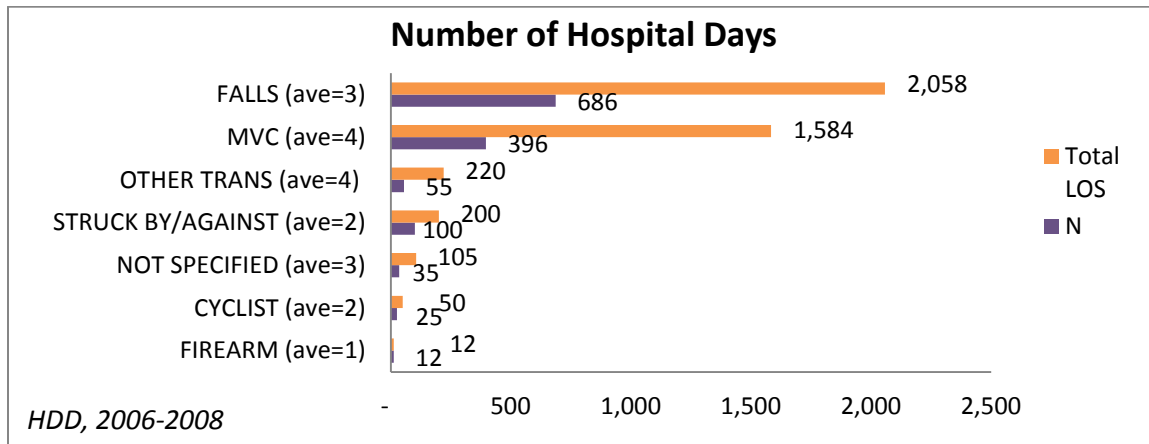
Length of Stay (LOS)

The length of stay (LOS) had a wide range, from 1 day to up to 72 days with a mean of 3.0 days. Although there were only five TBI hospitalizations due to burning/fire and suffocation (strangulation/hanging) over the three year period, these causes had the greatest mean LOS compared to all other causes. Burning/fire related TBI had a mean LOS of 44 days, while suffocation had a mean LOS of 23 days. The mean LOS for MVC was four days, compared to falls with a mean LOS of three days.

Falls were responsible for the highest average number of people hospitalized (686 per year) and the higher total number of hospital stay days (2,058 per year). MVC had the second highest

average number of hospitalizations (396 per year) with and average of 1,584 hospitalized days annually. (Figure 22).

Figure 22: TBI hospitalization Burden: Total LOS per year by Causes



Note: *The numbers may not correspond to number of TBI cases because of missing E-codes, missing disposition and missing los.

Hospital Charges

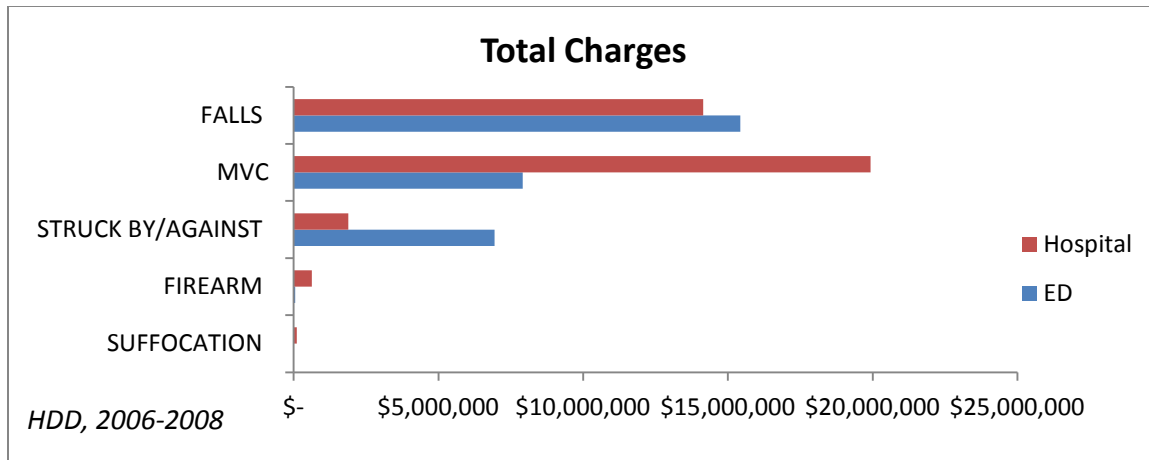
Average Charges by Causes of TBI:

The three-year average total TBI related hospital charges for the individual cases (limited to first encounters) totaled nearly \$40 million for hospitalizations and \$35 million for ED visits, for a respective mean charge (per individual) of \$14,000 and \$1,600.

The mean charge for a hospitalized MVC related TBI was a little over \$23,000. The mean charge for a MVC related ED visit was \$2,600. The total charges per year for MVC related TBI hospitalization and ED visit totaled \$27 million.

TBI hospitalizations due to falls were charged on average \$12,000 and ED visits were charged an average of \$1,500. Firearm treatment charges following a hospitalization reached the bar of \$19,000 per case per year, for an average total of \$620,000, just for a three-year average number of 12 cases per year.

Figure 23: Average Total Hospital Charges by Causes of TBI



Source of Pay Information

Figure 23 and figure 24 show the distribution of the expected payment sources and total amounts charged (three-year average), respectively for hospitalizations and ED visits. Private insurance were charged about 52 percent of hospitalizations and 48 percent of ED visits. Hospitalizations charges to private payers totaled, on average, over \$25 million per year. Emergency Department visits charges to private payers totaled nearly \$18 million per year.

The federal government, including Medicaid and Medicare, was charged, on average, \$18 million annually, which corresponded to 37 percent of the total charges for the hospitalized cases. For Emergency department visits, the annual average charges amounted to \$13 million, corresponding to 34 percent of the total charges. State and local funds including worker’s compensation were expected to be responsible for five percent of charges for hospitalized cases and ED visits, which amounted respectively to over three and two million dollars. Individuals (Out of pocket) were responsible for six percent of hospitalization and 13 percent of ED visit charges. These charges respectively amounted to three and five million dollars.

Motor vehicle crashes comprised the highest amount of hospital charges and ED visits as well, despite some differences. Regarding ED visits, MVC related TBI were generally charged to the private sector while falls were almost equally billed to private and federal payers. Many reasons may be given to explain the differences in charge methods. The data showed that most of private payers are related to motor vehicle crashes, which present a greater LOS and worse debilitating outcomes. Another reason is that Medicare and Medicaid are differently charged than private insurers. Federal sources were mostly charged for falls related hospitalizations.

Figure 24: Total Charges for TBI Hospitalizations by Expected Source of Pay

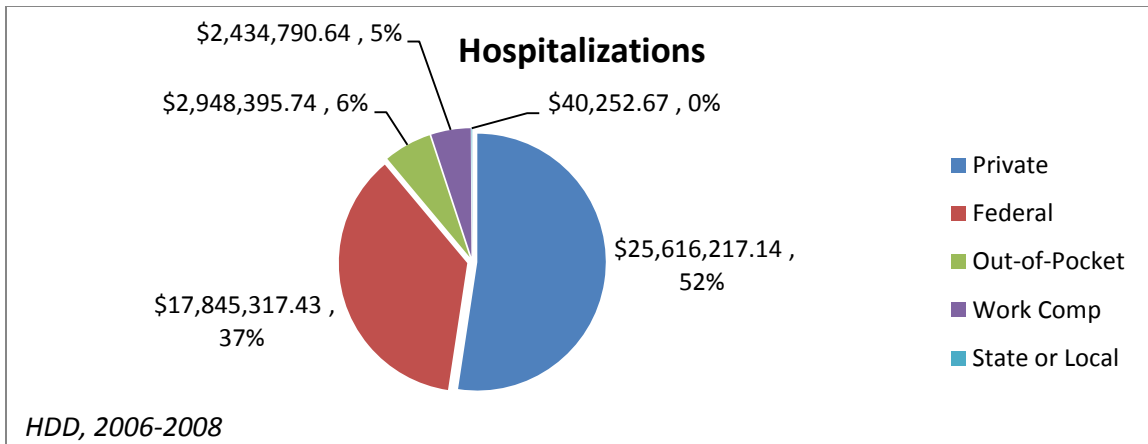


Figure 25: Total Charges for TBI Hospitalizations by Expected Source of Pay

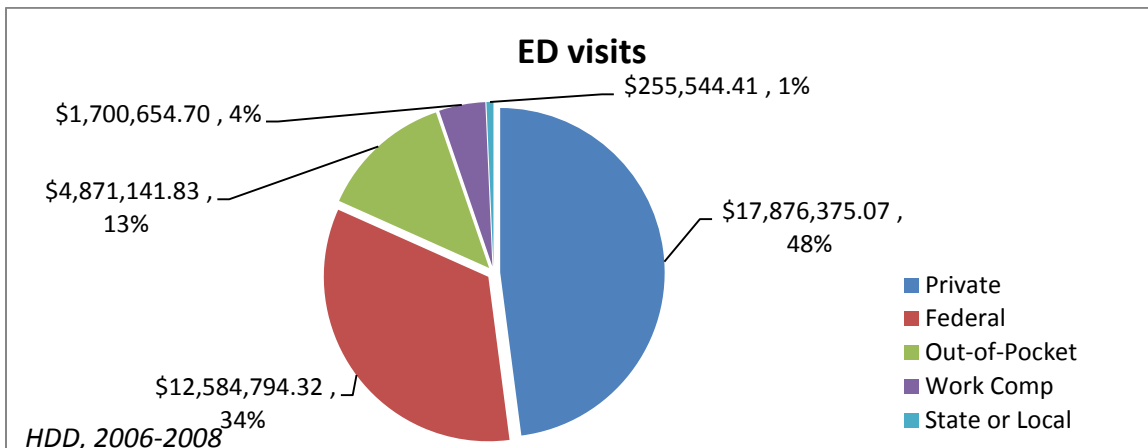


Table 8: Total Hospital Charges by Causes and Expected Source (Dollars)

CAUSE	Federal	Private	State or Local	Work Comp	Out-of-Pocket	Average Total
MVC	3,037,124	14,407,104	11,949	782,758	1,686,456	19,925,391
FALLS	9,425,206	3,327,230	8,327	918,995	461,565	14,141,323
STRUCK BY/AGAINST	625,022	865,885	13,381	188,926	190,599	1,883,814
OTHER TRANS	395,341	1,133,687	1,910	8,541	72,826	1,612,304
NOT SPECIFIED	582,156	346,896	1,659	-	79,265	1,009,976
FIREARM	315,094	274,552	-	-	34,244	623,889
BICYCLE	143,429	254,518	-	4,760	93,995	496,702
MACHINERY	152,705	114,861	1,240	38,767	-	307,572
NATURAL/ENVIR	79,835	109,856	-	77,880	4,379	271,949
OTHER SPEC	179,315	49,449	-	22,579	4,354	255,696
CUT/PIERCE	157,957	1,447	-	-	22,934	182,337
FIRE/BURN	-	121,312	-	-	-	121,312
SUFFOCATION	70,332	42,411	-	-	-	112,743
OTHER PEDESTRIAN	34,942	60,639	-	-	7,988	103,569
NEC	42,139	21,330	-	-	21,683	85,152
POISONING	11,474	22,394	-	-	5,520	39,388
OVEREXERTION	24,235	-	-	-	-	24,235
Grand Total	15,276,305	21,153,571	38,466	2,043,205	2,685,807	1,197,353

Notes: MVC= motor vehicle crashes; TRANS= other transportation, SPEC= specified, ENVIR= environment, NEC= not expressly coded;

Conclusions

Despite the change in methodology, death, inpatient and outpatient data from 2006 to 2008 illustrate a stable trend of Traumatic Brain Injury (TBI) rates in Iowa. TBI remains a source of great concern in Iowa and continues to impact the lives of thousands of Iowans every year. Demographic distributions show an increased burden of TBI in males and older adults over the report time period. Although there was not any increase in the rate of TBI among youths, it is important to keep in mind the impact of TBI on any person, especially youth.

County size classification showed the overall rates of TBI were different across the county sizes. Smaller counties, considered more rural, had greater rates of MVC related TBI hospitalizations than more populated counties.

Inpatient data shows that falls are the leading cause of TBI in adults over the age of 45 years. Motor vehicle crashes are prevalent in younger adults between the ages of 15 and 45, and are associated with acute medical costs.

Private insurance companies were more likely to be charged MVC compared to governmental entities, which are charged with fall related TBI. Though, it is important to note that different payers are billed different rates depending on their business status (e.g., private payers vs. governmental).

Families of individuals with brain injury face overwhelming challenges not only in dealing with their loved one's injury, in finding adequate services in a confusing and frustrating delivery system. Under the leadership of the Advisory Council on Brain Injuries (ACBI), the department partners with the Brain Injury Association of Iowa (BIAIA) to create a better future for survivors through brain injury prevention, education, advocacy and support.

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