# TRAUMATIC BRAIN INJURIES in Missouri

## The Public Health Burden


Missouri Department of Health and Senior Services
Office of Epidemiology



Governor Matt Blunt
Jane Drummond, Director
March 2007

# The Public Health Burden of
# Traumatic Brain Injuries
# in Missouri

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## REPORT INFORMATION

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**Description:** Utilizing the surveillance systems that are in place in Missouri, a vast perspective of the traumatic brain injury (TBI ) burden is provided. This report contains information on morbidity (i.e., hospitalizations and emergency department visits), mortality, safety issues, and economic cost of TBI in Missouri.

**Audience:** This report provides a foundation for defining and monitoring the burden of TBI in Missouri and is offered as a resource to an array of professionals, including public health professionals, health providers, advisory boards, coalitions, and others designing interventions and taking action to prevent and reduce the burden of traumatic brain injuries.



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# EXECUTIVE SUMMARY

Missouri has seen a troubling increase of 15.6% in the annual combined emergency department (ED) visits and hospitalizations related to traumatic brain injury (TBI). The rate of combined ED visits and hospitalizations increased from 213.3 per 100,000 in 1999 to 246.6 per 100,000 in 2003. TBI is an insult to the brain that can result in multiple impairments and disabilities often leading to considerable loss of independence, productivity, and income potential.

Although there is no estimate for the number of people that experience a TBI and receive some other type of medical care other than visiting an ED or being admitted to a hospital or who receive no care at all, there were still over 14,000 TBI events each year in Missouri between 1999-2003 with an average 1,320 deaths, 3,660 hospitalizations, and 9,082 individuals treated and released from the ED.

The leading causes of TBI in Missouri are falls/jumps, motor vehicle traffic crashes, being struck by a blunt object or by a person, and motor vehicle non-traffic crashes occurring off major roadways. All four mechanisms experienced a statistically significant increase during 1999-2003, falls/jumps increased 22.7%, motor vehicle traffic crashes increased 12.9%, struck by or against an object or person increased 16.1%, and motor vehicle non-traffic crashes increased 26.1%. These four causes account for over 90% of all TBI-related injuries in Missouri. Falls/jumps and motor vehicle traffic crashes each accounted for approximately 37% of all TBI-related hospitalizations. The majority of TBI-related ED visits were from falls/jumps, motor vehicle traffic crashes, and being struck by or against a person or object and Missouri experienced greater combined percentage of ED visits and hospitalizations related to these mechanisms than the U.S.

The populations at highest risk for TBI in Missouri were males in the age groups of 0-4 years, 15-24 years, and 85 years and older.

> Missouri has seen a troubling increase in the annual combined emergency department visits and hospitalizations related to traumatic brain injury.

Males are more than 1.5 times as likely as females to sustain a TBI. African-American men are also more likely to experience TBI than females or white males. The overall age groups in Missouri demonstrating the highest combined ED visits and hospitalization rates for TBI from falls/jumps were those aged 0-4 and 85 and older. Motor vehicle traffic crashes related to TBI were highest among individuals 15-17 for females, 18-19 for males, and followed by individuals 20-24. TBI ED visits and hospitalization combined rates for being struck by or against an object or person were highest among individuals aged 15-17. TBI-related to being struck by or against an object or person showed a statistically significant increase of 35.4% between the years 1999-2003. The 10-14 years of age group is most likely to go to the ED or be hospitalized for a TBI caused by a motor vehicle non-traffic crash. In addition, the overall trend in ED visits and hospitalizations separately and combined related to TBI in Missouri are increasing.

There are several Missouri counties that demonstrated higher combined rates of TBI-related ED visits and hospitalizations compared to the state average (226.5 per 100,000) based on the county of residence of the person seeking care for TBI. The six Missouri counties identified with the highest reported annual TBI combined rates during 1999-2003 were Harrison (565.7), Ray (475.1), Clinton (443.3), Clay (420.3), Daviess (349.2), and Jackson (343.4).

The economic burden from medical care, disability, and death related to TBI is considerable. The total annual direct medical cost of TBI in Missouri was an estimated $67 million. Indirect costs such as lost productivity due to TBI-related mortality was an estimated $795 million annually in Missouri. The state's Medicaid program bears substantial costs related to TBI. For the four-year period, 1999-2002, Medicaid net payments in the fee-for-service portion of the program paid over $22.5 million related to TBI.

Implementing evidence-based and promising strategies offers key opportunities for reducing traumatic brain injury in Missouri.

TBI creates a significant public health burden, both nationally and within the state of Missouri when the number of events, short- and long-term consequences, and costs are considered. Implementing evidence-based and promising strategies offers key opportunities for reducing TBI in Missouri. Interventions that are most likely to reduce the burden of TBI in Missouri include risk assessment and measures to reduce the risk of falls particularly in children and the elderly; use of safety equipment (e.g., child seats, seat belts, and helmets); reducing alcohol impaired driving; and behavioral interventions to reduce violence such as therapeutic foster care, early childhood home visitation programs, and limiting accessibility to firearms.

# INTRODUCTION 1

Many individuals who experience a traumatic brain injury (TBI) experience long-term or lifelong disabilities.[1] Individuals with TBI often experience multiple impairments (e.g., physical, cognitive, behavioral, emotional) that subsequently impact their self-concept, family and social relations, as well as education and learning performance.[2, 3] In turn, these secondary disabilities can cause significant long-term problems in independent living, community integration, employment and financial stability. The short- and long-term consequences of TBI create a significant public health burden, both nationally and within the state of Missouri.

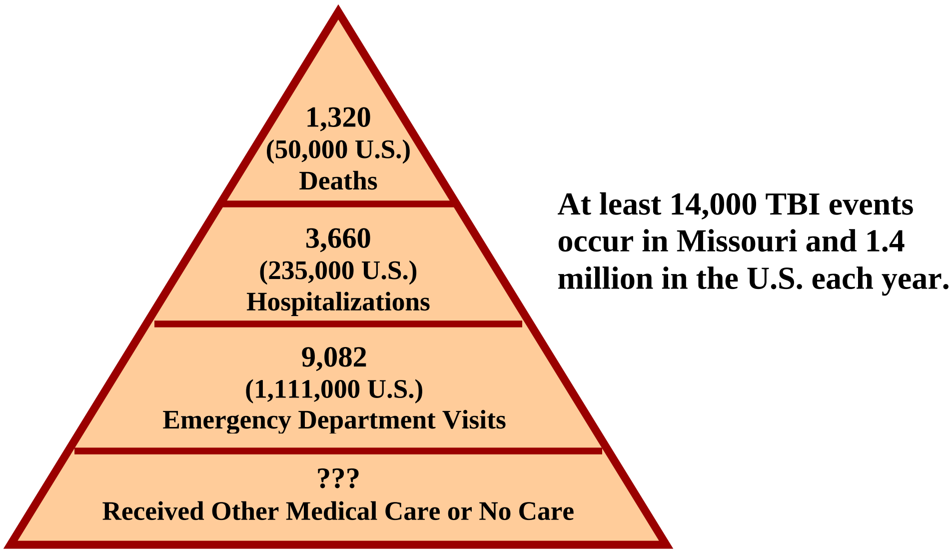
## Purpose of Report

Population-based information on TBIs in Missouri and the U.S. is crucial for understanding the impact, documenting the need for prevention, identifying priorities and supporting service needs among those living with TBI-related disabilities. The purpose of this report is to define and present basic epidemiological information on TBIs in Missouri, including the number of emergency department (ED) visits, hospitalizations and deaths related to TBI; identification of those affected; causes or mechanisms of these TBIs; and the resulting economic impact. Also, information on TBI morbidity trends statewide, for Missouri counties (where sufficient data exist), and for specific mechanisms is presented. In addition, evidence-based safety measures from selected sources are identified and discussed. Based on this information, opportunities, challenges and policy implications to decrease TBI events are included.

## Overview

In the United States, an estimated 1.4 million people sustain a TBI each year; 50,000 die, 235,000 are hospitalized and 1.1 million are treated and released from an ED.[4, 5] In Missouri, for all ages combined, from 1999-2003, there was an annual average of over 12,700 TBIs reported ED visits and hospitalizations, plus 1,320 deaths for the period 2001-2004 (Figure 1), for a total of over 14,000 events annually.[6, 7]

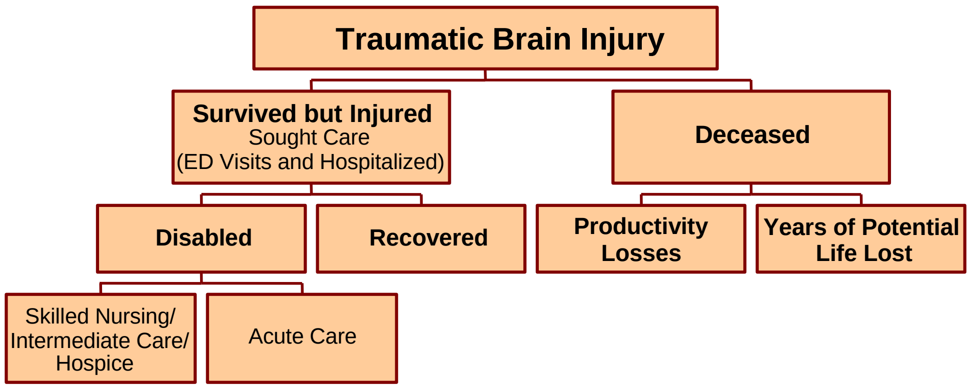
**Figure 1. Average Annual Number of Traumatic Brain Injury-Related Emergency Department Visits and Hospitalizations (1999-2003)[6] and Deaths (2001-2004)[7] in Missouri Compared to the United States (1995-2001)[5]**




While there are a small number of re-encounters included in these annual Missouri numbers, the true significance of the problem is likely to be underestimated. Many individuals with mild TBI are seen by private healthcare providers or do not seek care at all. Therefore, the number of individuals experiencing TBIs who are not hospitalized or seen in an ED is unknown. Nevertheless, TBI is the cause of substantial burden and costs (see Chapter 7) in Missouri.

This report examines the burden of TBI in terms of etiology, morbidity (i.e., ED visits and hospitalizations), mortality (i.e., deaths), and costs. Risk factors and selected preventive practices are reviewed for consideration in developing and enhancing head injury programs in Missouri. Figure 2 outlines the framework for the burden of traumatic brain injury in this report.

**Figure 2. Framework for the Burden of Traumatic Brain Injury in Missouri**




TBI-related ED visits and hospitalizations in Missouri and for the counties of Missouri are presented by demographics, cause of injury or mechanism, intent of injury, and the final disposition of the individuals. The data provided for traumatic brain injuries, are by county of residence rather than geographic location where the injury occurred, which is not available through this data source.

There are several components of cost associated with TBIs. Like other injuries TBIs also have several impacts on human life. TBIs may result in termination of life (mortality), which results in social cost measured by years of potential life lost (YPLL) and indirect cost measured by productivity loss. In many more cases, the person recovers, but there are short-term direct costs involved in terms of ED visits, hospital charges, and in-home care. In some cases, the person becomes disabled, leading to long-term acute care, hospice and other required special services costs. This report reviews the costs of TBIs in terms of ED visits, hospitalizations, YPLL, and productivity loss. The total costs associated with TBI disabilities are beyond the scope of this report, but are important areas to explore in the future to understand the full scope of the burden in Missouri.

# METHODS 2

## Definition of Traumatic Brain Injury (TBI)

A TBI is defined as a blow or jolt to the head or a penetrating head injury that disrupts the function of the brain. Not all blows or jolts to the head result in a TBI. The severity of such an injury may range from 'mild,' i.e., a brief change in mental status or consciousness to 'severe,' i.e., an extended period of unconsciousness or amnesia after the injury. A TBI can result in short- or long-term problems with independent function."[8] In addition, a similar definition exists in Missouri Revised Statutes (RSMo 192.735). For surveillance purposes nationally and for this report, traumatic brain injuries are defined using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic codes and are described in Appendix 1.[9] Since 1999, Missouri has used ICD-10 codes to classify mortality data (Appendix 1). Mechanism or external cause of injury consists of a number of categories identified by ICD-9-E codes for TBI and are shown in Appendix 2.

## Data Sources

TBI surveillance in Missouri provides a wealth of information. The data presented in this report are from many different sources. The Missouri Department of Health and Senior Services (DHSS), Bureau of Health Informatics manages large databases of health-related morbidity and mortality data. Vast amounts of health data are available through an interactive system known as the Missouri Information for Community Assessment (MICA). These databases include the Injury MICA and the HSCR used to describe TBIs for this report.[6, 9] The Injury MICA provides data on all injuries and permits cross-tabulations with demographic and other related factors. The Barell Matrix method of classifying injuries by body region and nature of injury was used for the design of the Injury MICA.[10, 11] The HSCR MICA was used to provide additional information on the mechanisms, locations and severity of head injuries in Missouri.

Charges incurred from hospitalizations and ED visits are available and obtained from the DHSS patient abstract system (PAS) database (i.e., ED visits and hospital discharge records)[12] compiled from data provided to DHSS by the Missouri Hospital Association. Mortality data were abstracted from the MICA system and special data requests based on death vital records.[7] Information from the Behavioral Risk Factor Surveillance System (BRFSS), a random-digit-dialed telephone survey of adult (18 years of age and older) residents of the state, was used to assess risk behaviors that often lead to TBI.[13] The Motor Vehicle Crash Variables and Outcomes for Drivers MICA from the Crash Outcome Data Evaluation System (CODES) is based on motor vehicle crash records provided by the Missouri Highway Patrol, and was used to explore the impact of safety belt, alcohol and helmet use during motor vehicle and bicycle crashes.[14] In addition, Missouri Department of Transportation (MoDOT) maps on motor vehicle crashes were examined and are included.[15] Medicaid data were made available from the Missouri Department of Social Services, Division of Medical Services.[16] These sources are presented in greater detail in Appendix 3.

Confidentiality rules have been developed to protect the privacy of individuals. Therefore, the data described in this report are in aggregate. The ED and hospitalization data are from 1999-2003, the mortality data are from 2001-2004, and all other data are as cited. All incidence rates presented for morbidity, hospitalizations, and ED visits are age adjusted, using the 2000

U.S. standard population. Data presented by age groups are crude rates, meaning the rates have not been adjusted for some characteristic such as age.

## Statistical Analysis

A trend analysis of TBI ED visits and hospitalizations combined rates in Missouri was performed in order to determine if there were significant changes in incidence rates during the period 1999-2003, both at the State and county level. This time period was selected because after 1998 the ICD-9 method of coding used to classify TBI was revised, making it difficult to compare pre-revision TBI event rates with post-revision rates.

Univariate logistic regression analysis was used to determine the significant increasing or decreasing trends for crude TBIs for the State overall and for each county, with a sufficient number of events to calculate a stable rate, in Missouri for 1999-2003. A logistic regression is more appropriate to perform the trend analysis rather than a linear regression, because TBI rates represent a proportion of the population. The logistic regression required the use of crude rates rather than age-adjusted rates. A *p*-value is the probability of obtaining a result from a sample that is as extreme or more extreme than the one observed. A significant decline or increase in incidence rates was determined by a $p$-value $< .05$. The counties were then ranked. The top 10 counties showing significant trends were identified, as well as those with the highest aggregate TBI ED visits and hospitalizations combined rates.

Measures of association are used to assess whether a relationship exists between a particular risk factor and health status, disease state or outcome. The most commonly used measure of association for population-based surveillance data is the relative risk (RR).[17] The RR is a ratio of the health outcome in a subgroup with the risk factor present and in a subgroup without the factor. A RR of “1” indicates that the rates are the same in the two groups. However, a RR above "1" indicates that those with the risk factor present are more likely to have the outcome. In contrast, a RR below "1" indicates that the group without the risk factor is more likely to experience the outcome; thus the presence of the factor is protective. To examine the effects of various risk factors (e.g., lack of seatbelt, drinking and driving, etc.) on TBI and survival, RR were calculated and reported.

## Cost Analysis

The lifetime cost of injury includes the amounts spent for medical care and non-medical services for persons injured, as well as the value of losses to society due to premature death or inability to work or to maintain a household. Cost analysis was conducted for estimating the economic burden of TBIs in Missouri including direct care (i.e., TBI-related ED visits combined with hospitalizations), YPLL and productivity losses. The Consumer Price Index for medical care produced by the U.S. Department of Labor which provides changes in the prices paid by urban consumers for health care services or goods by U.S. region, was used to adjust annual TBI-related charges for inflation.[18] Annual average ED visit and hospital combined charges by Missouri counties were used to estimate the direct cost of TBIs by applying a cost-to-charge ratio of 0.442.[19] While acknowledged in the model (Figure 2), disability and long-term care costs are beyond the scope of this report and are only included as part of the Medicaid cost.

## Data Limitations

There are some very important limitations to the data provided in this report. The data on TBI events is only available for county of residence and **not county of injury**. This becomes a challenge in identifying the exact location of an injury and what policies or infrastructure can be put into place to prevent such injuries from occurring. However, the MoDOT maps on motor vehicle crashes resulting in disabling injuries and fatalities do show the location of the crash.

Although there is no information on the extent to which these fatalities or disabilities relate to TBIs, data from the Injury MICA indicate that 4.7% of all motor vehicle crashes result in TBI.

A large portion of the data contained in this report is from the Injury MICA that is based on PAS data. Although the ED records and inpatient hospital records are designed to be mutually exclusive in the PAS system, a small number of patients will have both an ED and inpatient record for the same hospital stay. Additionally, patients who return to the hospital for follow-up treatment will also have more than one ED or inpatient record for an injury episode. Therefore, the number of injury records is somewhat more numerous than the number of injury episodes and patients, and as such, does not represent true incidence, but is close. An examination of the 1999 data revealed that the number of patients was approximately 10% less than the number of records for the combined ED and inpatient hospitalization records.[20]

Several of the variables reported from the Head and Spinal Cord Registry MICA show missing data. This is the result of supplementing this data system from other systems not containing all of the same information or variables. Therefore, the majority of the missing data arises from these data system linkages, as well as under-reporting of information.

Some categories of TBI causes can be both under-reported, as well as under-coded, and therefore, results in lower documented frequencies than are actually occurring. A prime example is with the Abuse/Neglect/Rape category. A record may fall into more than one category of abuse depending on the patient’s age and the E-codes and diagnosis codes on the record. For example, some records had both an E-code for spouse abuse and a diagnosis code for sexual abuse. These records, with multiple codes, are categorized according to a priority scheme and therefore, may be under represented in certain categories, as well as under reported. Another example, shaken baby, has to be multi-coded to be captured in the TBI data. It is most often coded as an assault, but also may be coded as abuse. However, if the head injury nature of injury code is missing, it is not captured in the TBI data and therefore, under-reported.

The TBI surveillance coding scheme used in this report for ED visits and hospitalizations is consistent with the Centers for Disease Control and Prevention's (CDC) definition with the exception of ICD-9-CM code 959.01 (head injury, unspecified), which is not included in the Injury MICA. The exclusion of 959.01 could lead to an underestimation in the number of TBI events but this is likely to be small. However, this code is included in the costs data.

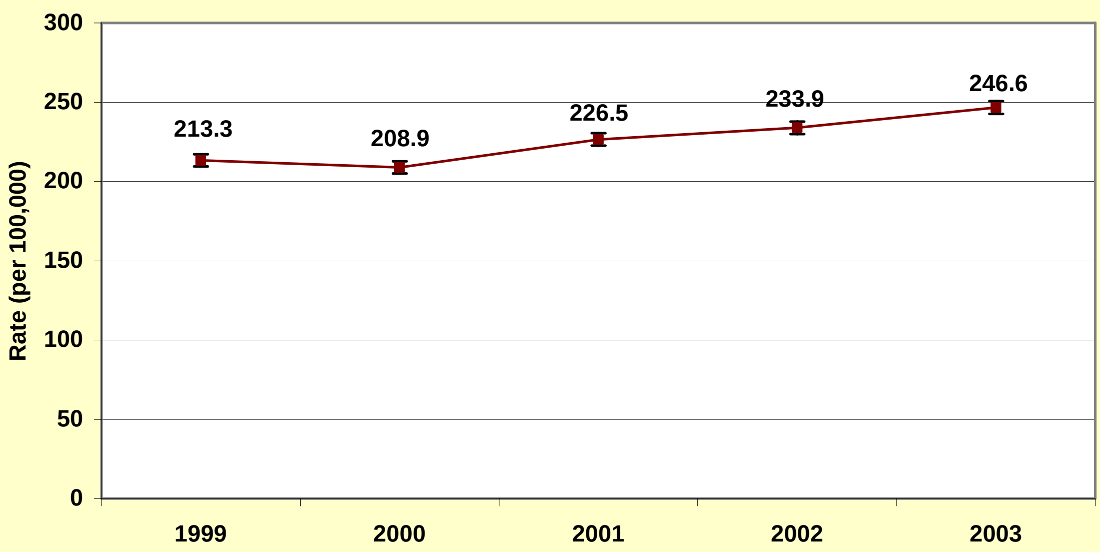
When conducting the TBI cost analysis, specific Missouri estimates of Present Discounted Value of Future Earnings (PDVFE) were not available; therefore, national estimates computed by Max et. al. for 2000 were used to estimate the PDVFE for Missouri for the year 2004.[21]

Annual TBI ED visits and hospitalizations combined rates are not available for many Missouri counties, because the TBI events were too low (<20 cases) to produce a stable rate. Therefore, conclusions about TBI trends could not be determined for less populous counties.

# TBI ED VISITS & HOSPITALIZATIONS 3

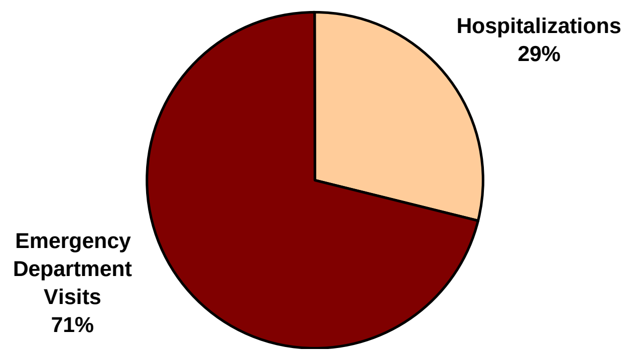
Missouri has seen a 15.6% increase, a statistically significant rise ($p$ = .0001), in crude TBI ED visits combined with hospitalizations from 1999-2003 from 213.3 per 100,000 in 1999 to 246.6 per 100,000 in 2003 (Figure 3)[6]. The Missouri annual combined TBI ED visits and hospitalization rate for 1999-2003 was 226.3 per 100,000.

**Figure 3. TBI ED Visits and Hospitalizations Combined Crude Rates and 95% Confidence Intervals, Missouri, 1999-2003**

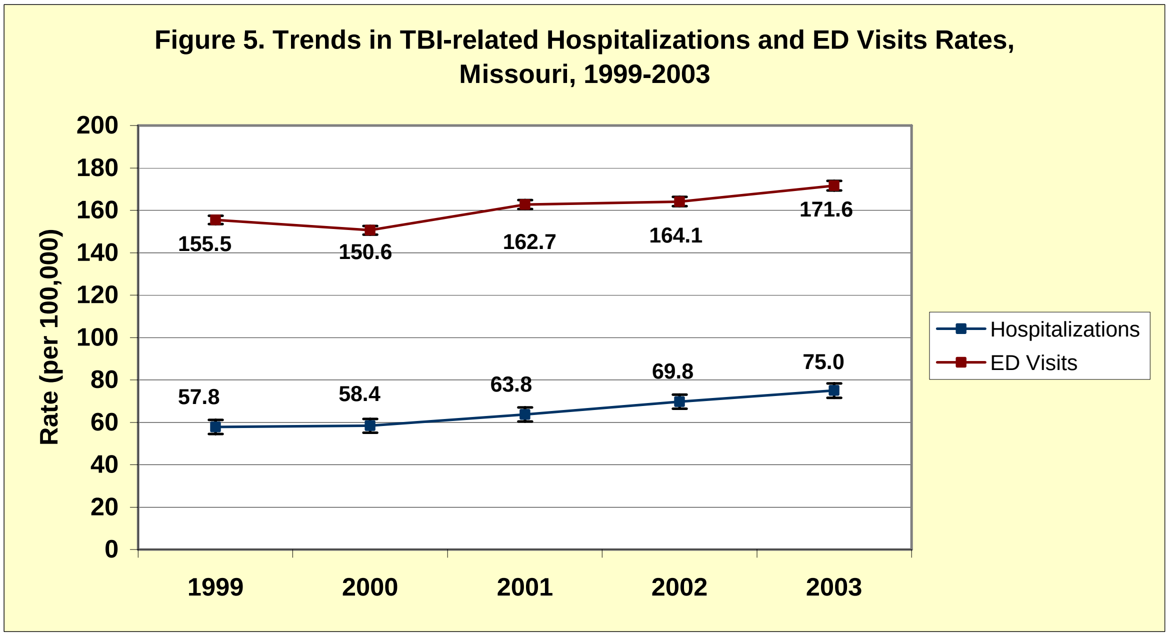


In 2003, nearly 4,300 hospitalizations and 9,800 ED visits were attributable to TBI, with an increasing rate over a five-year period. From 1999-2003, ED visits represented over 70% of TBI care sought (Figure 4)[6]. Maps 1 and 2 (Appendix 4) show the rate and number of ED visits related to TBI by Missouri counties for the period 1999-2003. Maps 3 and 4 (Appendix 4) show the rate and number of inpatient hospitalizations for traumatic brain injuries by Missouri counties for the same period.

**Figure 4. Average Annual Percent of TBI-Related ED Visits and Hospitalizations, Missouri 1999-2003[6]**




The five-year trend for rates of hospitalizations and ED visits separately related to TBI each showed an increasing trend (Figure 5)[6] and were statistically significant (*p*-value = .0046 and *p*-value = .0344, respectively). The hospitalization rate grew 29.8%, from 57.8 per 100,000 to 75.0 per 100,000, during 1999-2003. The ED visits rate grew 10.4%, from 155.5 per 100,000 to 171.6 per 100,000, during 1999-2003. Over the five-year period, ED visits were much greater than inpatient hospitalizations.

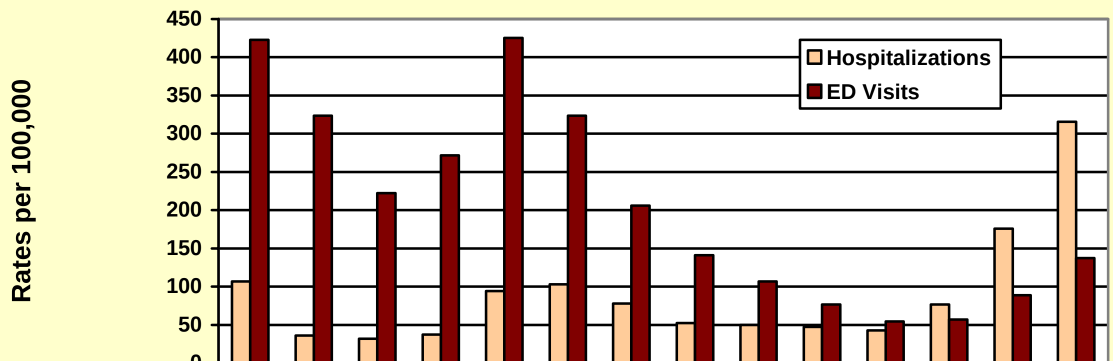



Of the 114 Missouri counties and the City of St. Louis, from 1999-2003 almost one-fifth (19.1%) demonstrated relatively high rates (≥ 256 per 100,000) of TBI-related ED visits and hospitalizations combined based on the county of residence of the person seeking care (Map 5, Appendix 4). Some of the counties with the highest combined TBI ED visits and hospitalization rates in alpha order were Caldwell, Clay, Clinton, Daviess, Harrison, Jackson, Marion, Polk, Randolph, Ray and Warren. Map 6 (Appendix 4) shows the number of TBI ED visits and hospitalizations combined by county.

## Demographics

Adolescents aged 15-17 years followed by very young children aged 0-4 years had the highest rates of TBI-related ED visits compared with other age groups (Figure 6)[6]. Hospitalizations were greatest among those age 85 years and older. Overall, ED visits were higher in the younger age groups while hospitalizations occur more frequently in older age groups as a result of TBI.

**Figure 6. Average Annual TBI Rates for Hospitalizations and ED Visits by Age Groups, Missouri, 1999-2003**

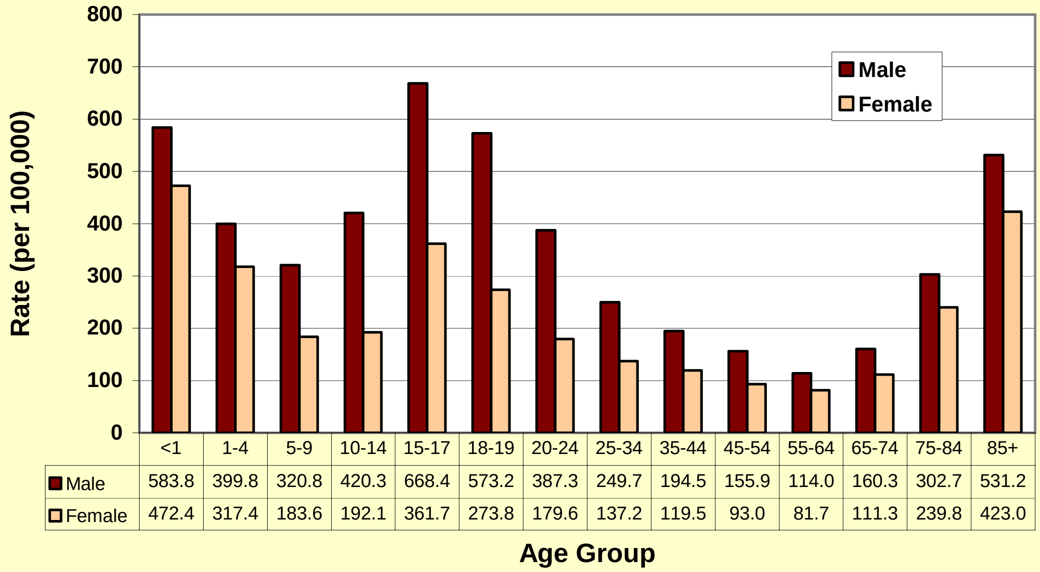



| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 106.6 | 36.1 | 31.7 | 37.1 | 94.1 | 102.8 | 78 | 52.2 | 50 | 47.2 | 42.8 | 76.5 | 175.8 | 315.6 |
| ED Visits | 422.8 | 323.5 | 222.1 | 271.8 | 425.3 | 323.5 | 205.9 | 141.1 | 106.7 | 76.5 | 54.4 | 57.1 | 88.6 | 137.5 |

Age Group

ED visits and hospitalizations combined rates by age and gender demonstrated a similar pattern across the age groups for males and females (Figure 7)[6]. Males, however, exhibited a much higher TBI event rate compared to females. Both genders showed a spike in TBI events in the youngest age group of children under 1, adolescents 15-17 years old, and those 85 years of age and older. Maps 7 and 8 (Appendix 4) show the rate and number of ED visits and hospitalizations combined for TBIs by county, respectively, for Missouri males and Maps 9 and 10 (Appendix 4) show the same information for females.

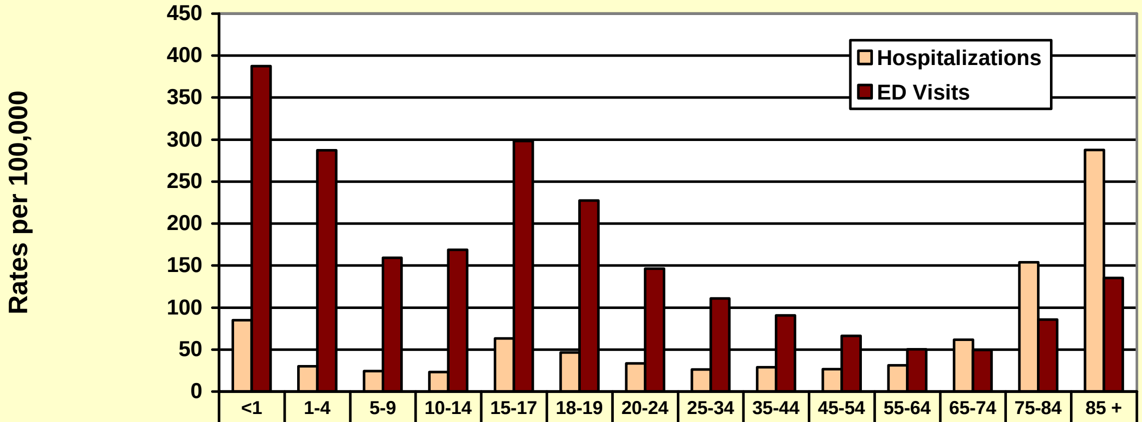
**Figure 7. Average Annual TBI ED Visits and Hospitalizations Combined Rates by Age Groups and Gender, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 583.8 | 399.8 | 320.8 | 420.3 | 668.4 | 573.2 | 387.3 | 249.7 | 194.5 | 155.9 | 114.0 | 160.3 | 302.7 | 531.2 |
| Female | 472.4 | 317.4 | 183.6 | 192.1 | 361.7 | 273.8 | 179.6 | 137.2 | 119.5 | 93.0 | 81.7 | 111.3 | 239.8 | 423.0 |

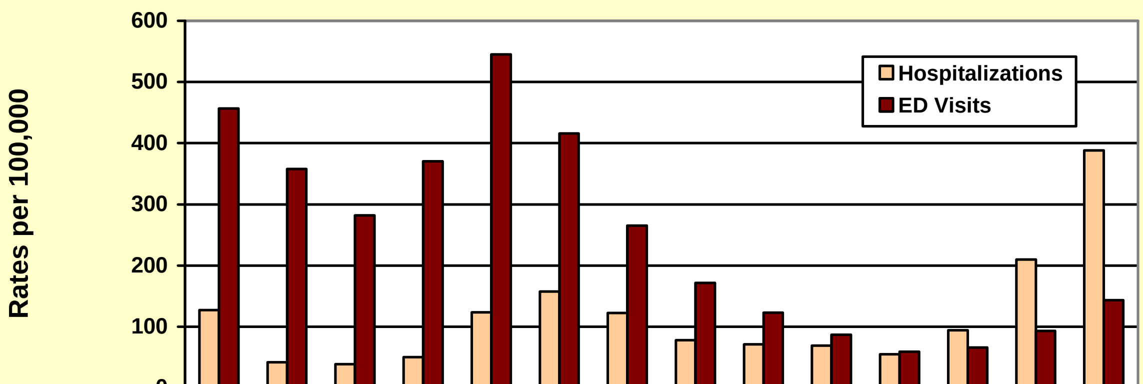
Figures 8 and 9 show the rates of hospitalization and ED visits separately related to TBI for males and females by age group.[6] Comparing males and females, the distribution by age group was very similar. A notable difference was the overall rates for both genders. The ED visits for males was much higher than for females. For females, the highest TBI-related ED visits was 387.5 per 100,000 for the age group less than one year. Males in the age group 15-17 had a rate of ED visits for TBI at 545.3 per 100,000 compared to 298.4 per 100,000 for females. Males in the age group 18-19 had a TBI-related hospitalization rate of 157.2 per 100,000 compared to 46.3 per 100,000 for females. However, TBI-related hospitalizations were highest for both males and females for the age group 85+. Among males age 85+, the hospitalization rate was 388.0 per 100,000 compared to 287.6 for females.

**Figure 8. Average Annual TBI Rates for Hospitalizations and Emergency Department Visits by Age Groups for Females, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 84.9 | 30 | 24.4 | 23.4 | 63.3 | 46.3 | 33.4 | 26.4 | 28.9 | 26.6 | 31.4 | 61.7 | 154.1 | 287.6 |
| ED Visits | 387.5 | 287.4 | 159.2 | 168.7 | 298.4 | 227.5 | 146.2 | 110.8 | 90.6 | 66.4 | 50.2 | 49.6 | 85.7 | 135.4 |

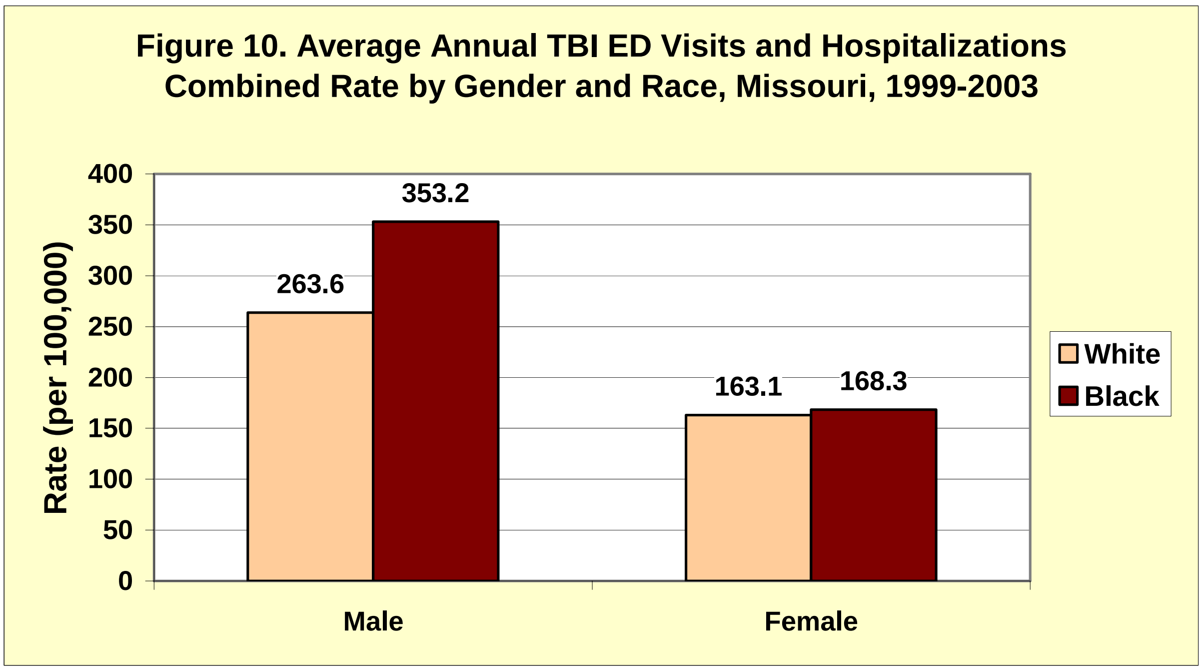
**Figure 9. Average Annual TBI Rates for Hospitalizations and Emergency Department Visits by Age Groups for Males, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 127.3 | 41.9 | 38.7 | 50.2 | 123.2 | 157.2 | 122.3 | 78.1 | 71.4 | 68.9 | 55.1 | 94.2 | 209.7 | 388.0 |
| ED Visits | 456.5 | 357.9 | 282.1 | 370.1 | 545.3 | 416.0 | 265.0 | 171.5 | 123.1 | 87.0 | 58.9 | 66.1 | 93.0 | 143.1 |

## Disparities

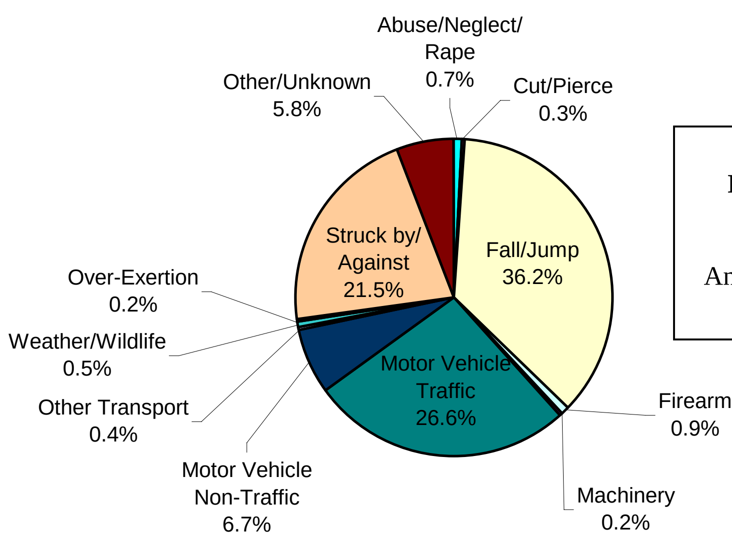
Map 11 (Appendix 4) depicts the rate of ED visits and hospitalizations combined for TBI by county for African-Americans/Blacks in Missouri and Map 12 (Appendix 4) depicts the same information for the White population. Distribution by gender and race demonstrated that African-American/Black males in Missouri had a statistically significant higher combined TBI ED visits and hospitalizations rate (353.3 per 100,000) compared to White males (263.6 per 100,000) (Figure 10)[6]. There is no significant racial disparity noted among females.



# ETIOLOGY OF TBI IN MISSOURI 4

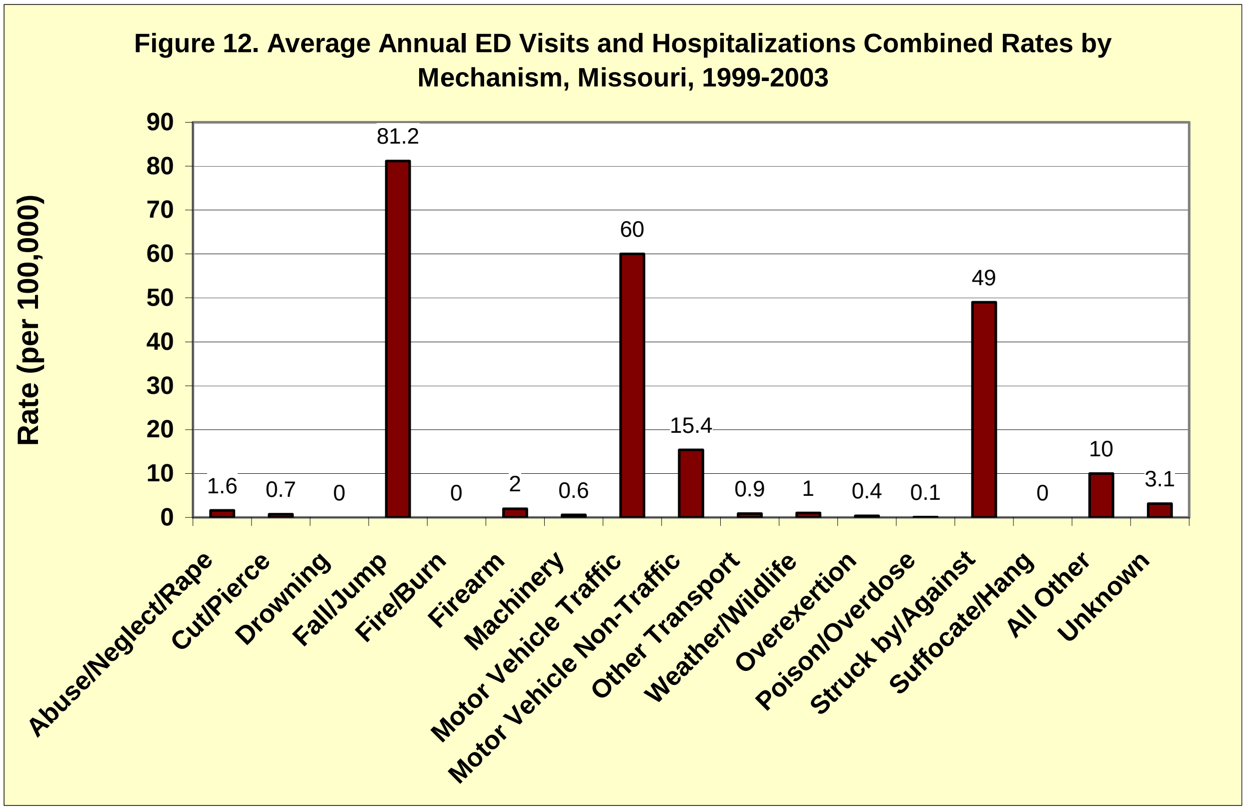
To determine the causes of TBIs in Missouri, ED visits and hospitalizations matching the surveillance definition were analyzed for 1999-2003. Combined, there were 63,724 TBI-related ED visits and hospitalizations in Missouri for the 5-year period. As shown in Figure 11, the four leading causes were falls and jumps (36.2%), motor vehicle traffic crashes (26.6%), being struck by or against an object or person (21.5%) and non-traffic crashes involving motor vehicles off a main roadway, such as occurring in a parking lot or driveway (6.7%). These four causes represented over 90% of all ED visits and hospitalizations related to TBI.

**Figure 11. TBI ED Visits and Hospitalizations by Cause of Injury in Missouri, 1999-2003**[6]



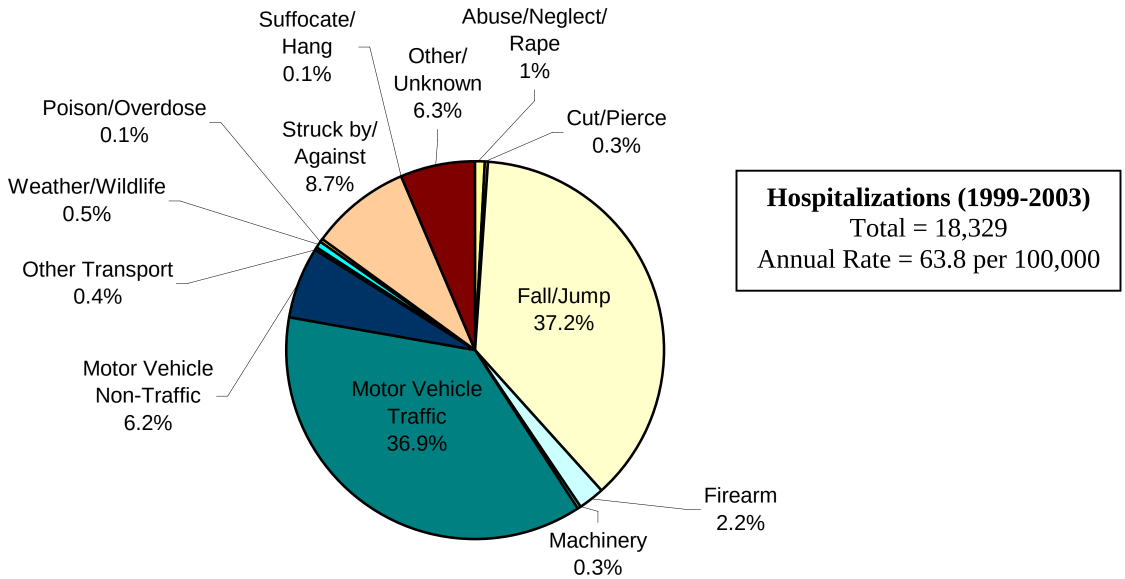

**TBI ED Visits and Hospitalizations Combined (1999-2003)**
Total = 63,724
Annual Rate = 226.3 per 100,000

The rates for the causes of TBI in Missouri are shown in Figure 12. The rates for the four leading causes were falls and jumps (81.2 per 100,000), motor vehicle traffic crashes (60.0 per 100,000), struck by a blunt object or another person (49.0 per 100,000), and motor vehicle non-traffic crashes (15.4 per 100,000).[6]



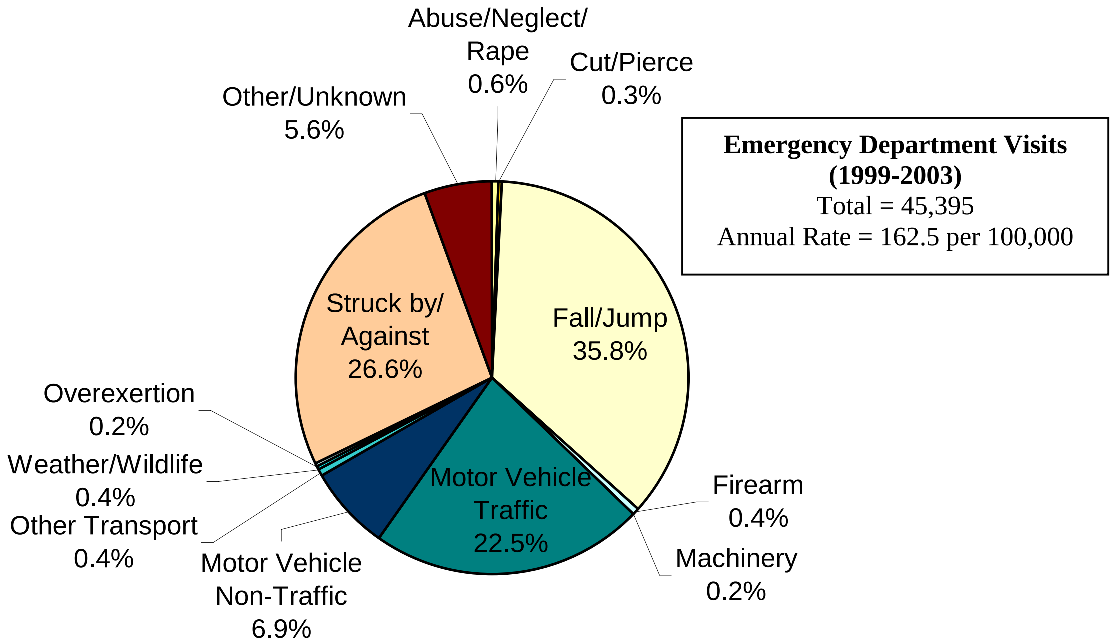
When examining hospitalizations separately from ED visits related to TBI in Missouri, the four leading causes remained the same. However, Figure 13 shows that falls/jumps combined with motor vehicle traffic crashes represented almost three of every four TBI-related hospitalizations (74.1%).

**Figure 13. TBI Hospitalizations by Cause of Injury in Missouri, 1999-2003[6]**



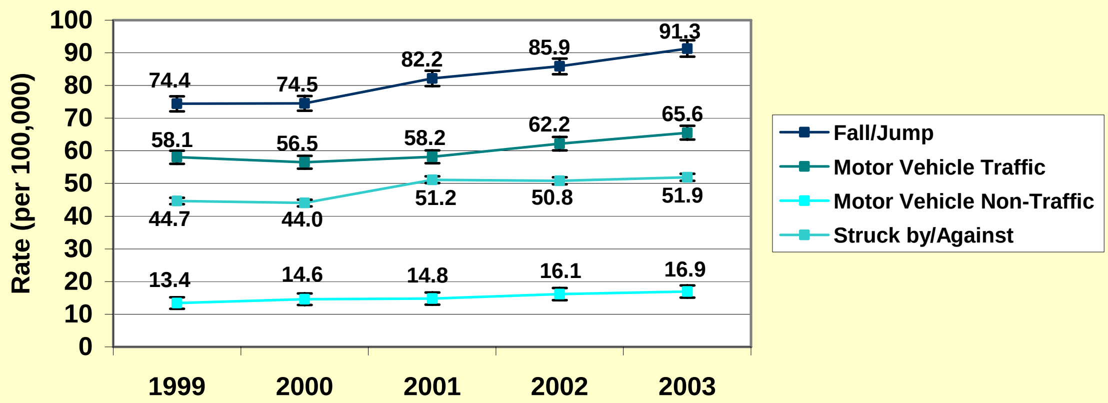
When ED visits related to TBI alone are reviewed, the two leading causes become falls and jumps, and being struck by or against an object (Figure 14). These two causes represented 62.4% of the ED visits. When motor vehicle crashes were added, these three causes represented 85% of the ED visits related to TBI during this time period.

**Figure 14. TBI-related Emergency Department Visits by Cause of Injury in Missouri, 1999-2003[6]**



When the rates of TBI ED visits combined with hospitalizations were plotted by mechanism for Missouri during 1999-2003 (Figure 15)[6], the four main causes showed similar growth trends. The four main causes were falls/jumps (+22.7%, $p < .0001$), motor vehicle traffic (+12.9%, $p < .0001$), motor vehicle non-traffic (+26.1%, $p = .0001$), and struck by or against an object or person (+16.1%, $p < .0001$). All four mechanisms have experienced statistically significant increases during this time period.

**Figure 15. Average Annual TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals by Mechansim, Missouri, 1999-2003**




The TBI ED visit and hospitalization rates for males and females exhibited increasing trends during 1999-2003 in Missouri (Figures 16 and 17)[6]. Males showed significantly higher TBI event rates than females for TBIs caused by falls or jumps, motor vehicle traffic crashes, motor vehicle non-traffic crashes, and being struck by or against a person or object. Male TBI ED visit and hospitalization rates have increased at a statistically significant rate ($p < .05$) during 1999-2003 for injuries caused by these four mechanisms. Female TBI ED visit and hospitalization combined rates showed a significant increase ($p < .05$) for injuries caused only by falls/jumps during 1999-2003. Female TBIs caused by motor vehicle traffic crashes, motor vehicle non-traffic crashes, and being struck by or against an object or person remained relatively steady during 1999-2003 with no detectable trend ($p > .05$).

**Figure 16. Average Annual TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals for Males by Mechansim, Missouri, 1999-2003**

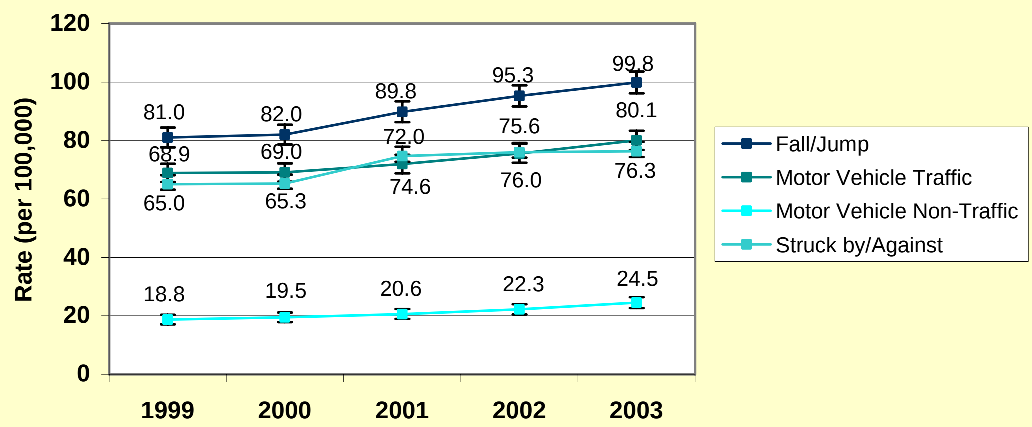
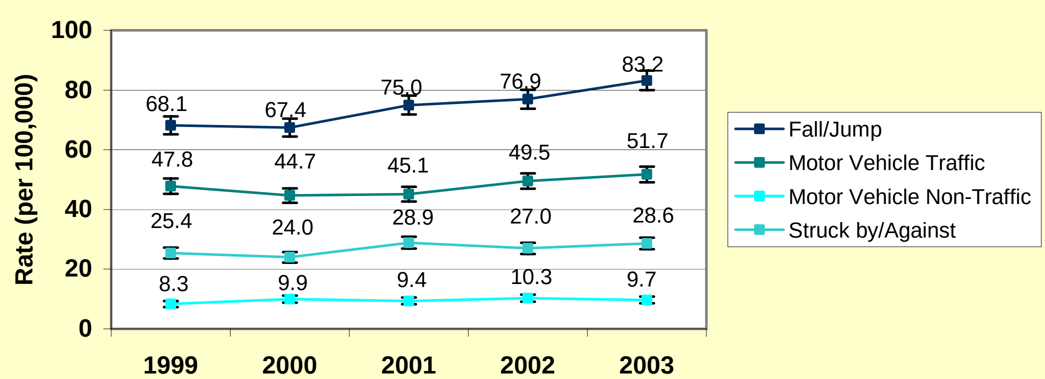



**Figure 17. Average Annual TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals for Females by Mechansim, Missouri, 1999-2003**



## Falls and Jumps

The ED visit and hospitalization combined rate for TBIs caused by falls/jumps revealed significantly higher rates among infants and children less than 5 years of age and among individuals 85 years of age and older (Figure 18)[6]. There did not appear to be any substantial changes in TBIs caused by falls/jumps among the different age groups during the period 1999-2003.

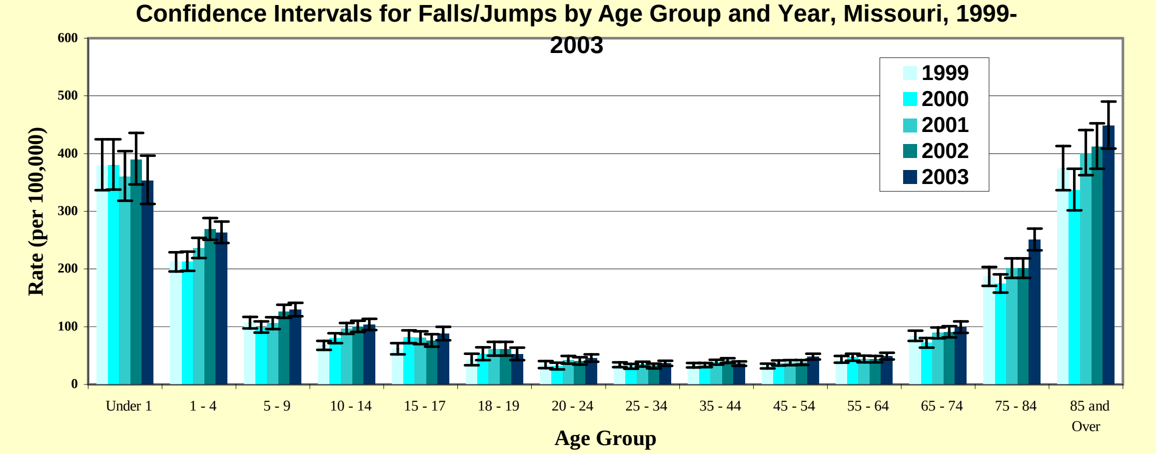


**Figure 18. TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals for Falls/Jumps by Age Group and Year, Missouri, 1999-2003**

TBI ED visit and hospitalization combined rates by gender for 1999-2003 revealed a similar pattern for both males and females by age group (Figure 19)[6].

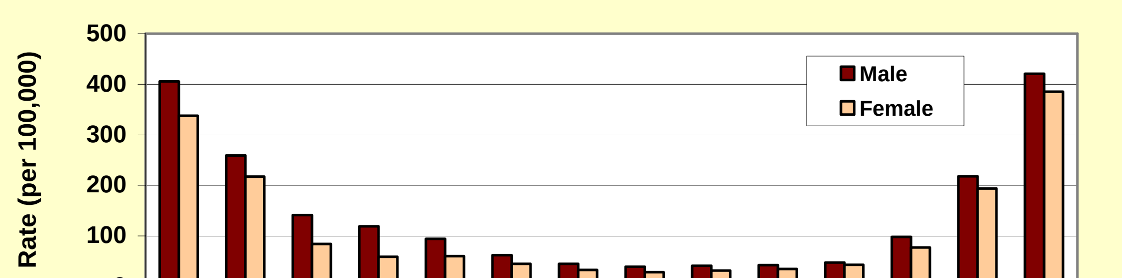
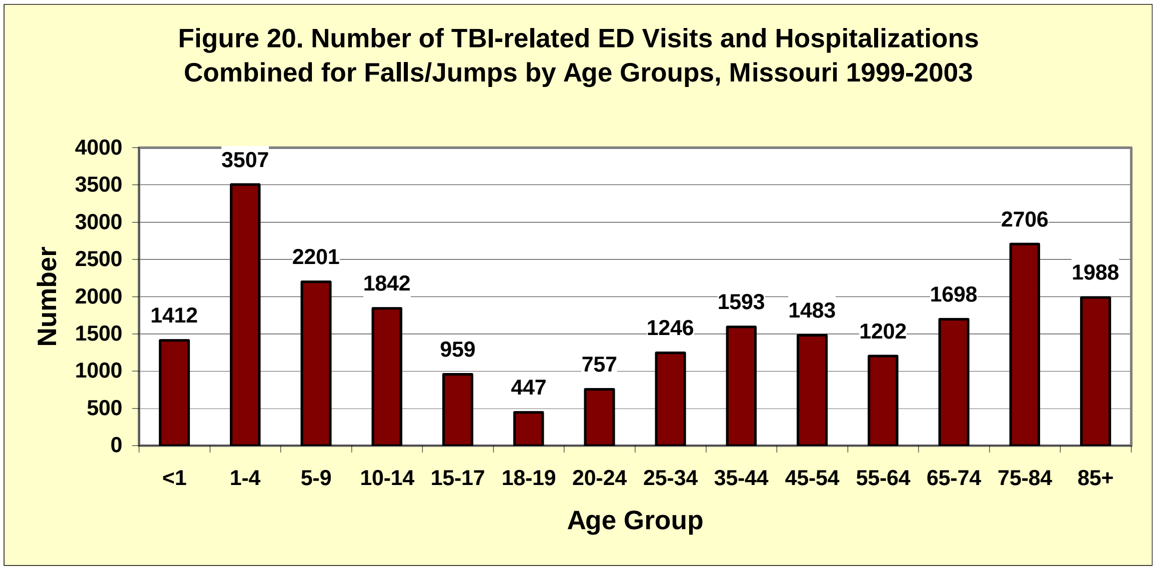


**Figure 19. Average Annual TBI ED Visits and Hospitalizations Combined Rates for Falls/Jumps by Age Group and Gender, Missouri, 1999-2003**

| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 405.5 | 259.4 | 141.5 | 118.9 | 94.2 | 62.4 | 45.3 | 39.1 | 41.3 | 42.7 | 47.8 | 98.5 | 217.8 | 420.8 |
| Female | 337.8 | 217.3 | 84 | 59.1 | 60.1 | 45.3 | 32.7 | 28.4 | 31.7 | 34.9 | 43.3 | 77.5 | 193.9 | 385.2 |

Age Group

Figures 20 and 21 represent the number and combined rates of ED visits and hospitalizations related to TBI from falls/jumps.[6] County comparisons of these data are shown in Maps 13 and 14 (Appendix 4) with Clay, Clinton, Harrison, and Ray counties demonstrating high rates.



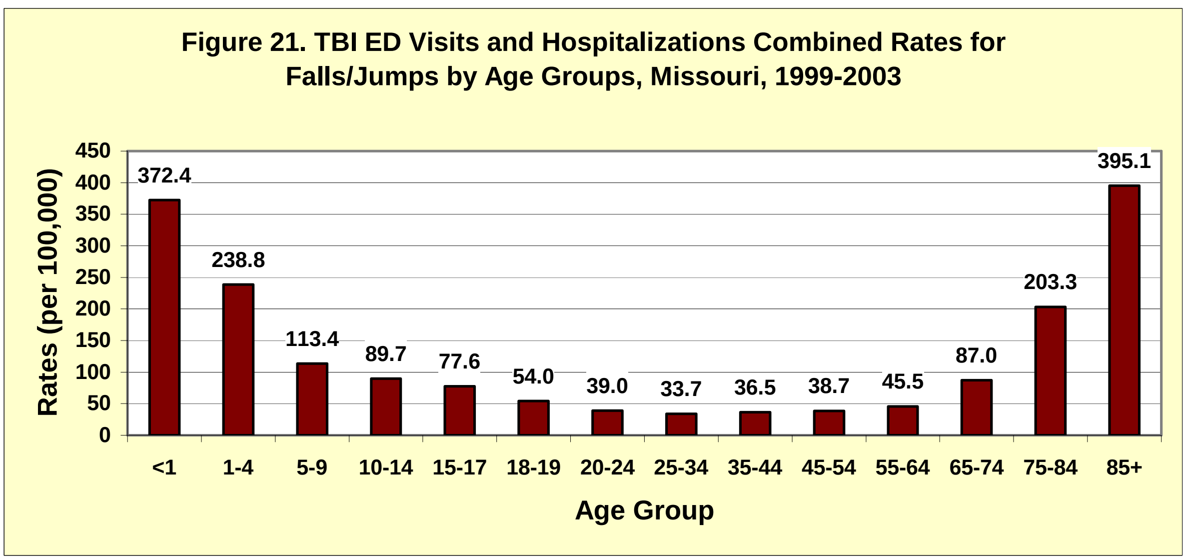
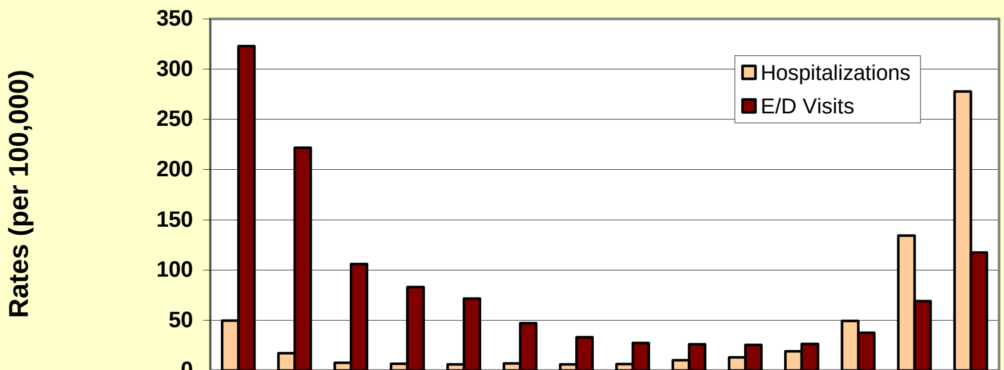



Figure 22 shows high average annual rates of ED visits in the younger age groups compared to higher hospitalizations among the older age groups.[6] Comparing the rates by gender (Figures 23 and 24)[6] demonstrates a similar pattern of rates by age for both females and males.

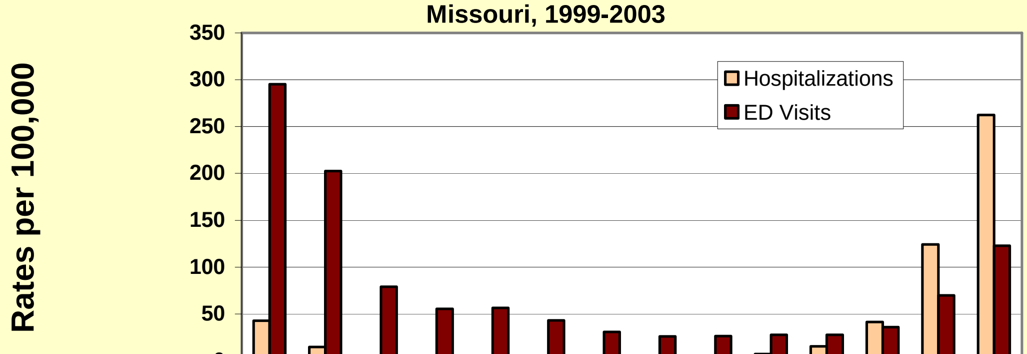
**Figure 22. Average Annual TBI Rates for Hospitalizations and ED Visits Rates for Falls/Jumps by Age Groups, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 49.6 | 17.1 | 7.6 | 6.8 | 6.0 | 7.0 | 6.1 | 6.4 | 10.3 | 13.1 | 19.0 | 49.3 | 134.2 | 277.9 |
| E/D Visits | 322.9 | 221.8 | 105.9 | 82.9 | 71.6 | 47.0 | 33 | 27.3 | 26.2 | 25.6 | 26.4 | 37.7 | 69.1 | 117.3 |

**Age Group**

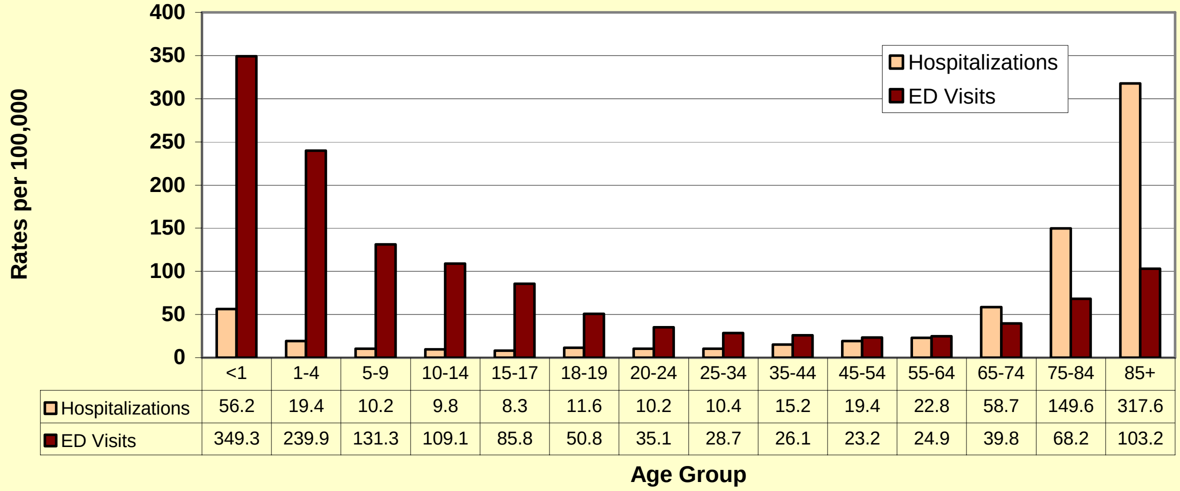
**Figure 23. Average Annual TBI Rates for Hospitalizations and ED Visits for Falls/Jumps by Age Groups for Females, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 42.7 | 14.7 | 4.9 | 3.6 | 3.5 | 2.2 | 2.0 | 2.4 | 5.4 | 7.1 | 15.5 | 41.5 | 124 | 263 |
| ED Visits | 295 | 203 | 79.1 | 55.5 | 56.6 | 43.1 | 30.8 | 26.0 | 26.3 | 27.8 | 27.8 | 36.0 | 69.7 | 123 |

**Age Group**

**Figure 24. Average Annual TBI Rates for Hospitalizations and ED Visits for Falls/Jumps by Age Groups for Males, Missouri, 1999-2003**

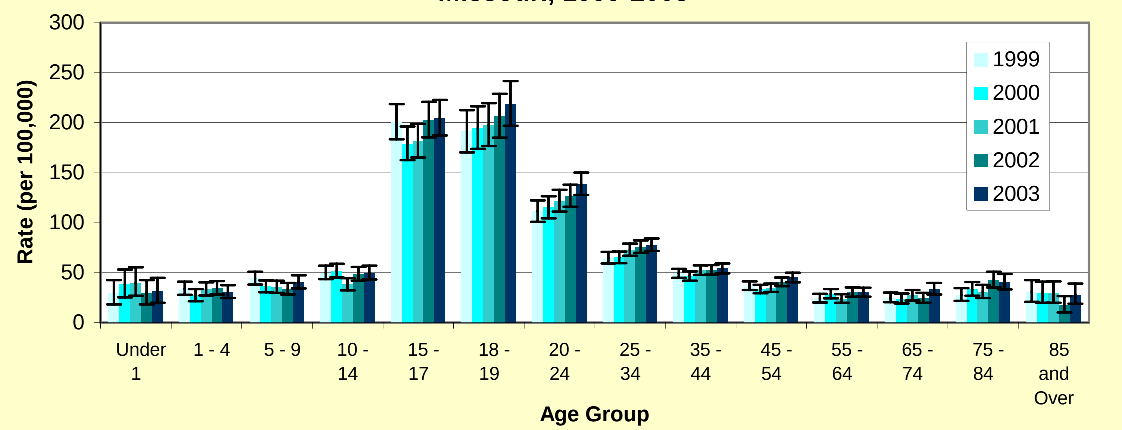



| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 56.2 | 19.4 | 10.2 | 9.8 | 8.3 | 11.6 | 10.2 | 10.4 | 15.2 | 19.4 | 22.8 | 58.7 | 149.6 | 317.6 |
| ED Visits | 349.3 | 239.9 | 131.3 | 109.1 | 85.8 | 50.8 | 35.1 | 28.7 | 26.1 | 23.2 | 24.9 | 39.8 | 68.2 | 103.2 |

## Motor Vehicle Traffic Crashes

The combined ED visit and hospitalization rates for TBIs caused by motor vehicle crashes showed a clear spike among individuals in the 15-17 and 18-19 age categories (Figure 25)[6].

**Figure 25. TBI ED Related Visits and Hospitalizations Combined Rates for Motor Vehicle Traffic Crashes by Age Groups and Year, Missouri, 1999-2003**

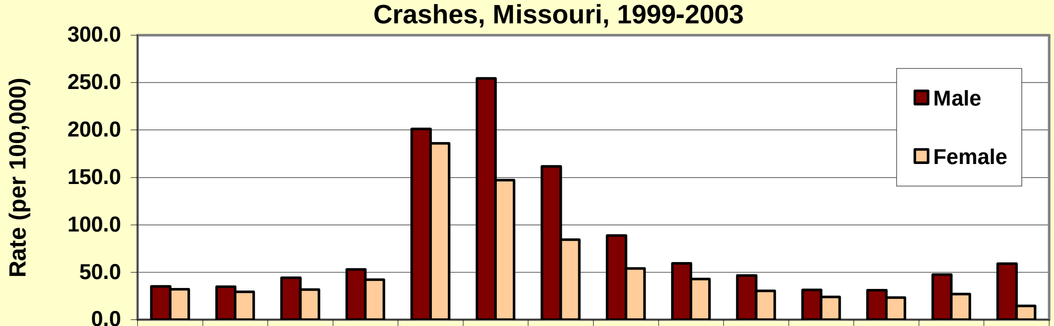



There appears to be an increasing trend in the number of TBIs caused by motor vehicle crashes during the period 1999-2003 among individuals in the 20-24 age group (increasing from

111.3 to 137.6 or +23.6%, $p$ = .0003), and the 25-34 age group (increasing from 64.7 to 77.3 or +19.5%, $p$ = .0003).

Figure 26 shows that males have higher combined ED visit and hospitalization rates of TBIs due to motor vehicle traffic crashes compared to females. Male TBI events spiked around 18-19 years of age, while the peak age for females was 15-17 years of age.[6] Maps 15 and 16 (Appendix 4) depict this information by Missouri counties.

**Figure 26. Average Annual ED Visits and Hospitalizations Combined Rates for TBI by Age Groups and Gender for Motor Vehicle Traffic Crashes, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | 35.0 | 34.7 | 44.3 | 53.0 | 201.1 | 254.3 | 161.6 | 88.7 | 59.3 | 46.5 | 31.5 | 31.2 | 47.6 | 59.1 |
| Female | 31.9 | 29.2 | 31.6 | 42.1 | 186.0 | 147.0 | 84.4 | 54.0 | 42.8 | 30.5 | 24.0 | 23.2 | 27.1 | 14.6 |

Age Group

When looking more closely at TBIs caused by motor vehicle traffic crashes by type of vehicle (Figures 27 and 28)[6], it is noted that the majority of these occurred to occupants in a car, truck, or some other vehicle and according to the HSCR, occurred most often to the driver (56%) followed by a passenger (26%). TBIs resulting from pedestrian or bicyclist traffic crashes were highest among those under the age of 15 years. TBIs caused by motorcycle traffic crashes were fairly low compared to car, truck, etc., but showed the highest rates among those 15-44 years of age.

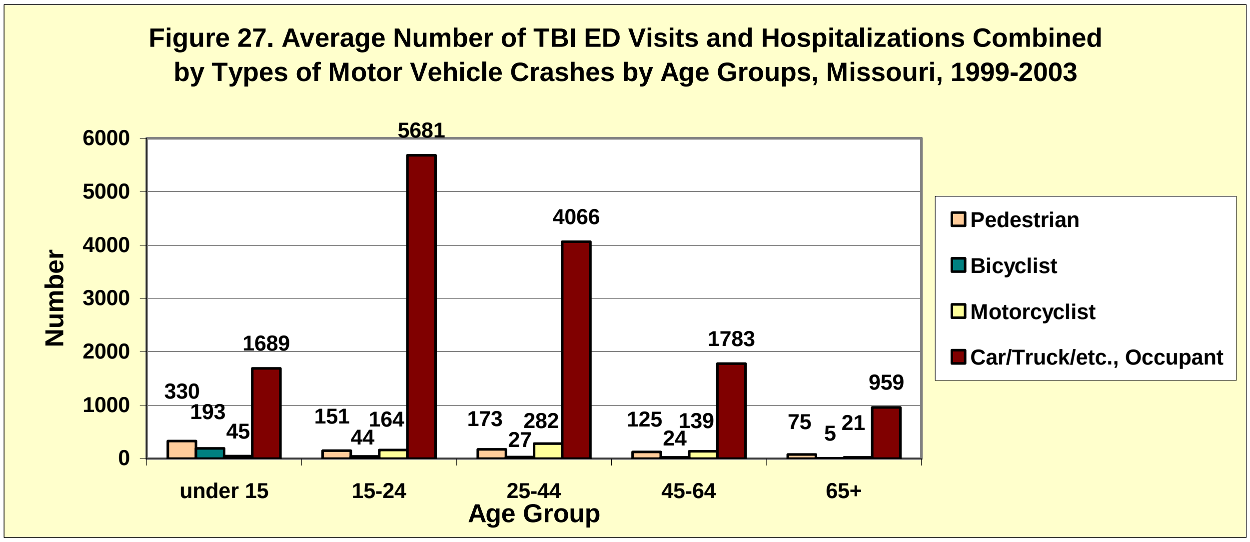


Figure 27. Average Number of TBI ED Visits and Hospitalizations Combined by Types of Motor Vehicle Crashes by Age Groups, Missouri, 1999-2003
Number
Age Group
under 15
15-24
25-44
45-64
65+
Pedestrian
Bicyclist
Motorcyclist
Car/Truck/etc., Occupant
330
193
45
1689
151
44
164
5681
173
27
282
4066
125
24
139
1783
75
5
21
959

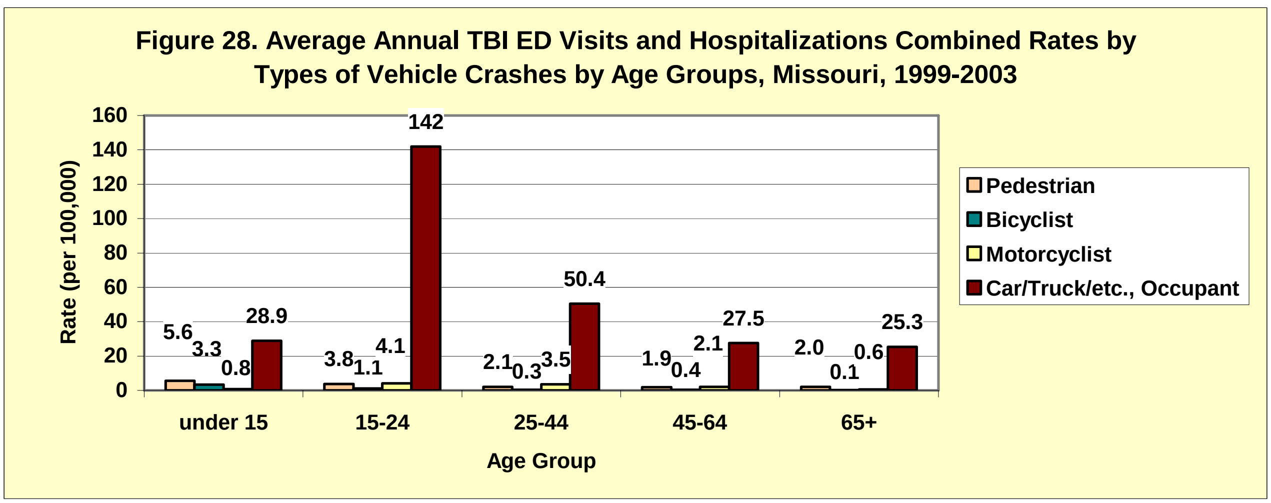
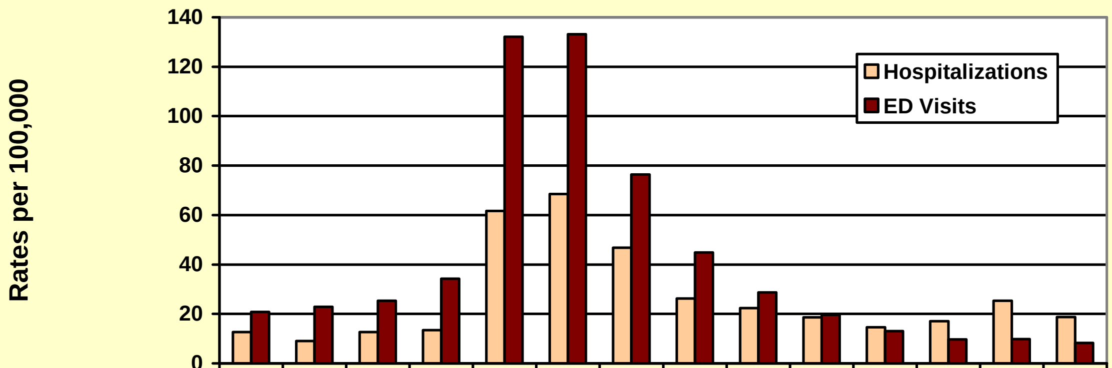


Figure 28. Average Annual TBI ED Visits and Hospitalizations Combined Rates by Types of Vehicle Crashes by Age Groups, Missouri, 1999-2003
Rate (per 100,000)
Age Group
under 15
15-24
25-44
45-64
65+
Pedestrian
Bicyclist
Motorcyclist
Car/Truck/etc., Occupant
5.6
3.3
0.8
28.9
3.8
1.1
4.1
142
2.1
0.3
3.5
50.4
1.9
0.4
2.1
27.5
2.0
0.1
0.6
25.3

TBI-related rates for hospitalizations and ED visits due to motor vehicle traffic crashes were highest among the 15-19 year olds (Figure 29)[6] and were more likely to result in an ED visit than a hospitalization.

**Figure 29. Average Annual TBI Hospitalizations and ED Visits Combined Rates by Motor Vehicle Crashes by Age Groups, Missouri, 1999-2003**

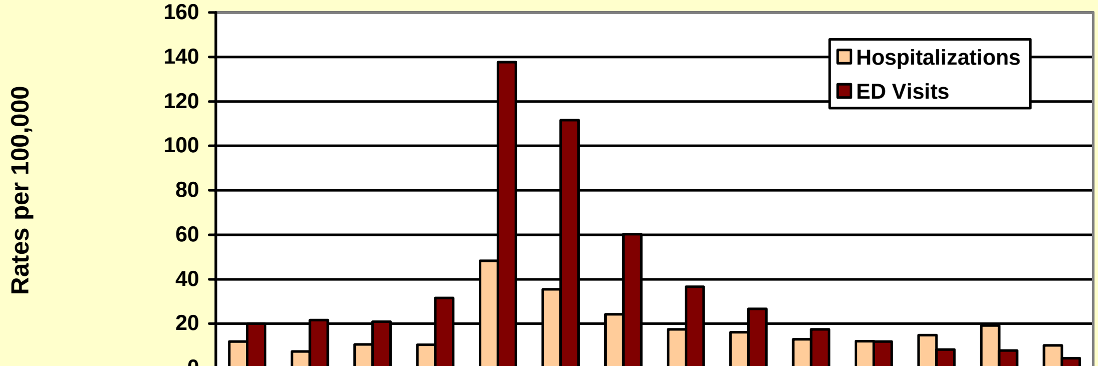



| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 12.7 | 9.1 | 12.7 | 13.4 | 61.7 | 68.5 | 46.8 | 26.3 | 22.3 | 18.6 | 14.6 | 17.1 | 25.4 | 18.7 |
| ED Visits | 20.8 | 22.9 | 25.4 | 34.3 | 132.1 | 133.1 | 76.4 | 44.9 | 28.7 | 19.7 | 13.0 | 9.7 | 9.8 | 8.3 |

**Age Group**

When comparing females and males (Figures 30 and 31)[6], the age distribution for both hospitalizations and ED visits are similar. Males showed higher rates than females. For females, the highest rates for both hospitalizations and ED visits occurred in the 15-17 year age group, while the highest for males occurred in the 18-19 year age group.

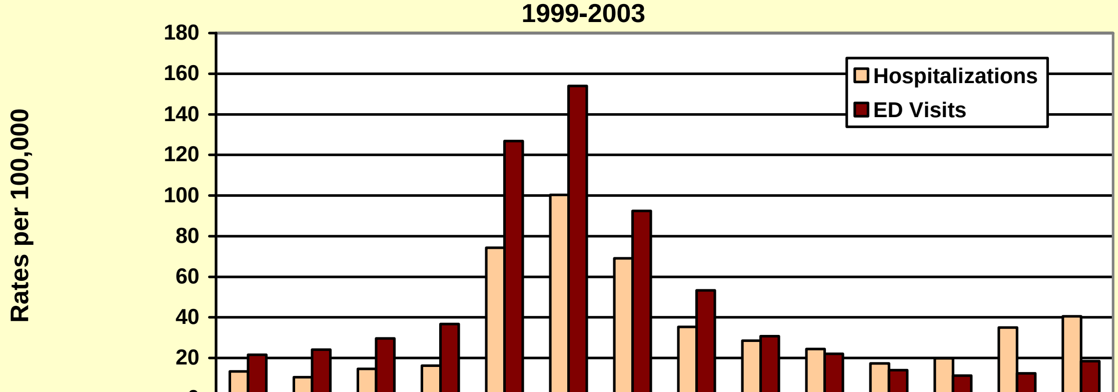
**Figure 30. Average Annual TBI Hospitalizations and ED Visits Combined Rates for Motor Vehicle Crashes by Age Groups for Females, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 11.9 | 7.5 | 10.7 | 10.5 | 48.3 | 35.5 | 24.2 | 17.4 | 16.2 | 13.0 | 12.1 | 14.8 | 19.1 | 10.2 |
| ED Visits | 20.0 | 21.6 | 20.9 | 31.6 | 137.7 | 111.6 | 60.2 | 36.6 | 26.6 | 17.5 | 12.0 | 8.4 | 8.0 | 4.4 |

Age Group

**Figure 31. Average Annual TBI Hospitalizations and ED Visits Combined Rates for Motor Vehicle Traffic Crashes by Age Groups for Males, Missouri, 1999-2003**



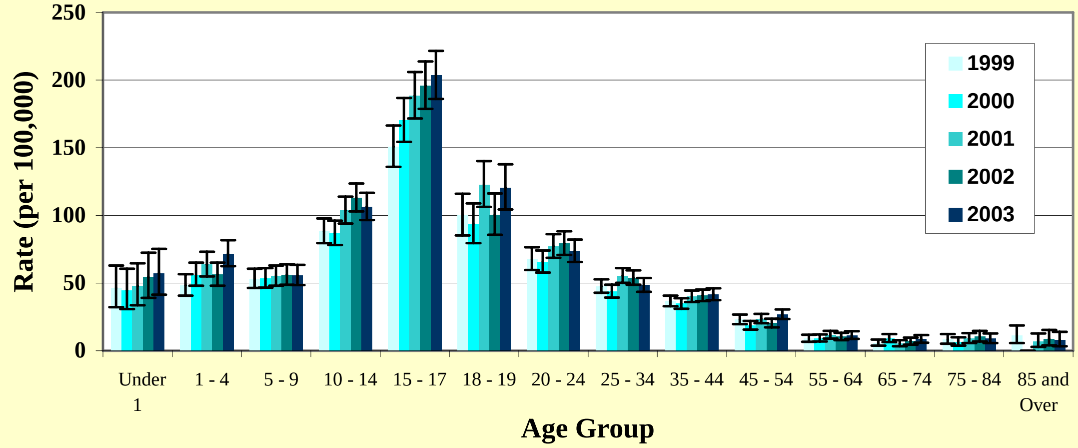

| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85 + |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 13.4 | 10.6 | 14.6 | 16.2 | 74.3 | 100.4 | 69.1 | 35.4 | 28.5 | 24.5 | 17.4 | 19.9 | 35.1 | 40.6 |
| ED Visits | 21.6 | 24.1 | 29.7 | 36.8 | 126.8 | 153.9 | 92.5 | 53.3 | 30.8 | 22.1 | 14.1 | 11.4 | 12.5 | 18.5 |

Age Group

## Struck By or Against a Person or Object

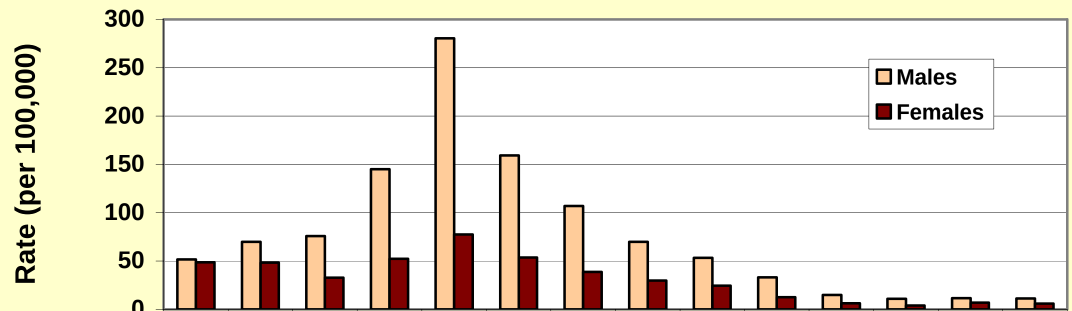
The risk for TBIs caused by being struck by or against a blunt object or person was much higher among individuals in the younger age categories, especially for youth 15-17 year of age (Figure 32)[6]. TBI ED visit and hospitalization combined rates among those 15-17 years of age showed an increase by a significant degree during 1999-2003 (rising from 150.7 to 204.0 or 35.4%, $p < .0001$).

**Figure 32. TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals for Struck by/Against by Age Groups and Year, Missouri 1999-2003**




Males represent much higher ED visit and hospitalization combined rates for TBIs caused by struck by or against an object or person compared to females, primarily in 15-17 years of age group where it spiked for males (Figure 33)[6]. The rate of TBI ED visits and hospitalizations combined also spiked for females in this age group, but not to the extent experienced by males.

**Figure 33. Average Annual TBI ED Visits and Hospitalizations Combined Rates for Struck by/Against by Age Groups and Gender, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | 51.5 | 69.8 | 75.7 | 145.0 | 280.3 | 159.3 | 106.8 | 70.0 | 53.3 | 33.1 | 14.9 | 10.9 | 11.5 | 11.4 |
| Females | 48.6 | 48.2 | 32.8 | 52.2 | 77.4 | 53.7 | 38.8 | 29.8 | 24.6 | 12.6 | 6.2 | 4.0 | 6.8 | 6.1 |

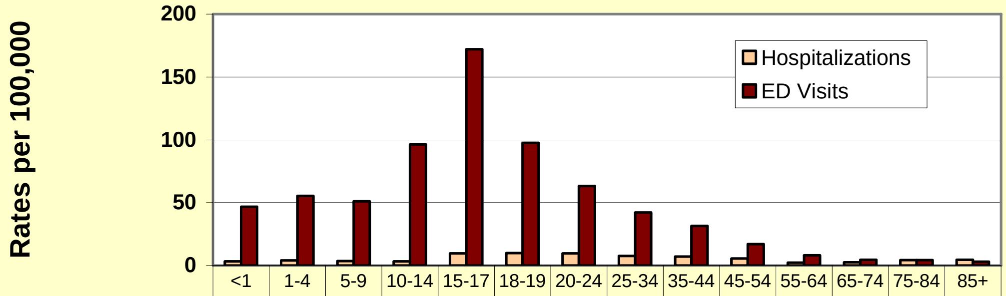
Age Group

TBI ED visit and hospitalization combined rates for being struck by or against an object or person by Missouri counties are shown in Map 17 (Appendix 4). To explore whether the counties with the higher rates of TBIs from this mechanism were also the counties with correctional facilities, Map 18 (Appendix 4) shows the geographic locations of Missouri correctional facilities. Of the four Missouri counties with the highest ED visit and hospitalization combined rates from being struck by or against an object or person (Clinton, Clay, Harrison and Ray), Clay County has three youth correctional facilities and Clinton County has one adult correctional facility that could possibly contribute to these higher rates in these counties. However, many of the counties with correctional facilities did not exhibit the highest rates from this mechanism. Nevertheless, a special study would be needed to determine the extent of the relationship, if any, between TBIs resulting from this mechanism and the correctional facilities taking into consideration the level of facilities (i.e., minimum to maximum security), facility size, and populations being served.

Map 19 (Appendix 4) provides a comparison of Missouri counties in the number of ED visits and hospitalizations combined for TBIs related to being struck. Jackson and St. Louis counties had the highest numbers of TBIs related to being struck by or against an object or person followed by Clay County, St. Louis City and St. Charles County.

TBIs that were caused by being struck by or against a blunt object or by another person resulted primarily in ED visits (Figure 34)[6]. The rate is highest in the 15-17 year age group.

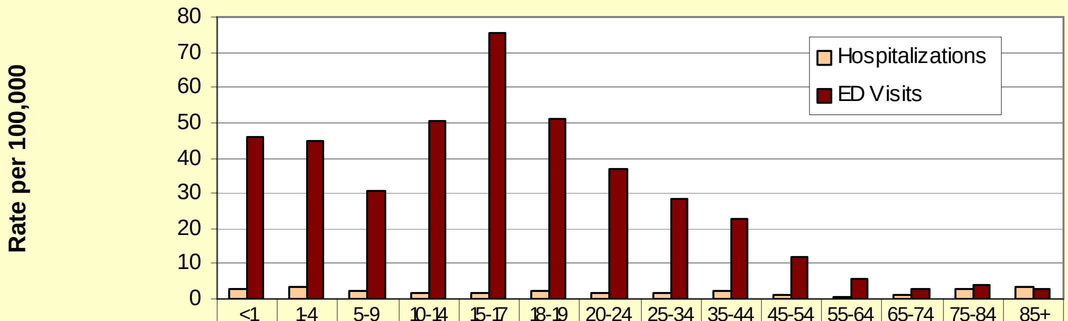
**Figure 34. Average Annual TBI ED Visits and Hospitalizations Rates for Struck by/Against by Age Groups, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 3.4 | 4.0 | 3.6 | 3.4 | 9.7 | 9.8 | 9.7 | 7.6 | 7.2 | 5.5 | 2.3 | 2.6 | 4.4 | 4.6 |
| ED Visits | 46.7 | 55.3 | 51.2 | 96.3 | 172.0 | 97.7 | 63.2 | 42.2 | 31.6 | 17.1 | 8.1 | 4.6 | 4.3 | 3.0 |

Males show a much higher rate of TBI-related ED visits from this mechanism than females (Figures 35 and 36)[6]. The rate for males is 263.2 per 100,000 compared to 75.6 per 100,000 for females. In addition, the hospitalization rate related to this mechanism for males substantially increases in the age group 15-17 and continues being at a higher rate than females throughout age 85+ when the hospitalization rate for males (7.8 per 100,000) remains over twice that of females (3.3 per 100,000).

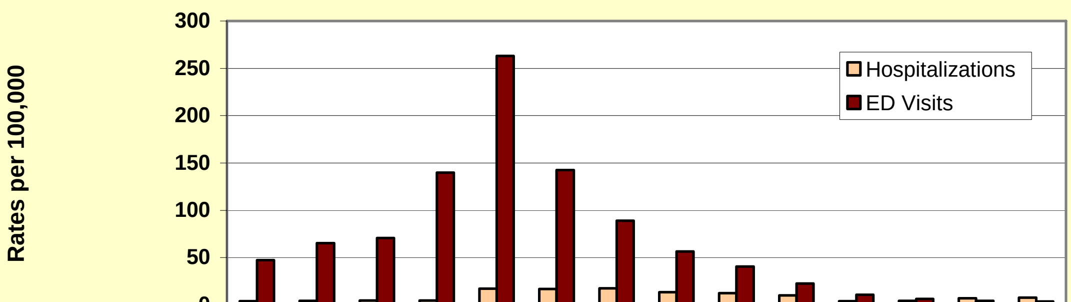
**Figure 35. Average Annual TBI ED Visits and Hospitalizations Rates for Struck by/Against by Age Groups, Females, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 2.7 | 3.3 | 2.2 | 18 | 18 | 2.5 | 19 | 17 | 2.0 | 10 | 0.6 | 10 | 2.6 | 3.3 |
| ED Visits | 45.9 | 44.8 | 30.6 | 50.4 | 75.6 | 512 | 37.0 | 28.2 | 22.6 | 117 | 5.7 | 3.0 | 4.2 | 2.8 |

Age Group

**Figure 36. Average Annual TBI ED Visits and Hospitalizations Rates for Struck by/Against by Age Groups, Males, Missouri, 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 4.1 | 4.5 | 4.9 | 4.9 | 17.2 | 16.9 | 17.6 | 13.6 | 12.5 | 10.3 | 4.2 | 4.5 | 7.1 | 7.8 |
| ED Visits | 47.4 | 65.3 | 70.8 | 140.0 | 263 | 143 | 89.2 | 56.4 | 40.8 | 22.8 | 10.7 | 6.4 | 4.4 | 3.6 |

Age Group

## Motor Vehicle Non-Traffic Crashes (off Major Roadway)

The rates of TBIs caused by motor vehicle non-traffic crashes (meaning the crash occurs in a parking lot, driveway or somewhere else away from a major roadway) showed high rates among younger age groups (Figure 37)[6]. Children in the 10-14 age categories were at a higher risk for TBI-related ED visits and hospitalizations from this mechanism than other age groups during 1999-2003. There are no clear trends in TBI rates for motor vehicle non-traffic crashes during this period. Males represent a much higher incidence of TBI combined ED visits and hospitalizations caused by motor vehicle non-traffic crashes compared to females, primarily in 10-14 years of age group (Figure 38)[6].

**Figure 37. TBI ED Visits and Hospitalizations Combined Rates and 95% Confidence Intervals for Motor Vehicle Non-Traffic Crashes by Age Groups and Year, Missouri, 1999-2003**

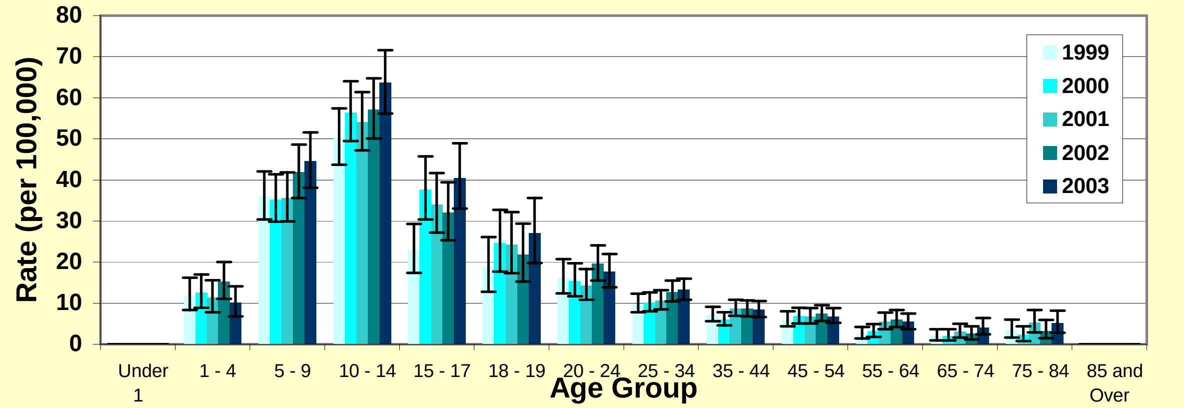
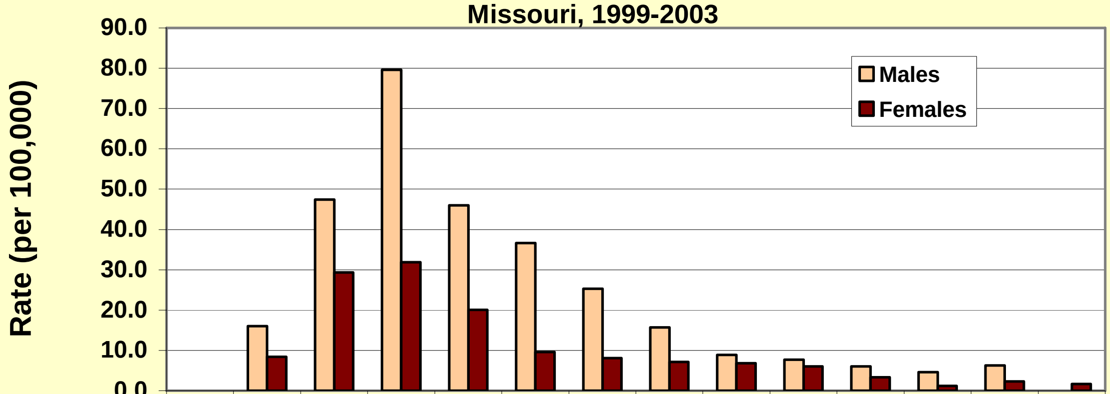


**Figure 38. Average Annual TBI ED Visits and Hospitalizations Combined Rates for Motor Vehicle Non-Traffic Crashes by Age Groups and Gender, Missouri, 1999-2003**

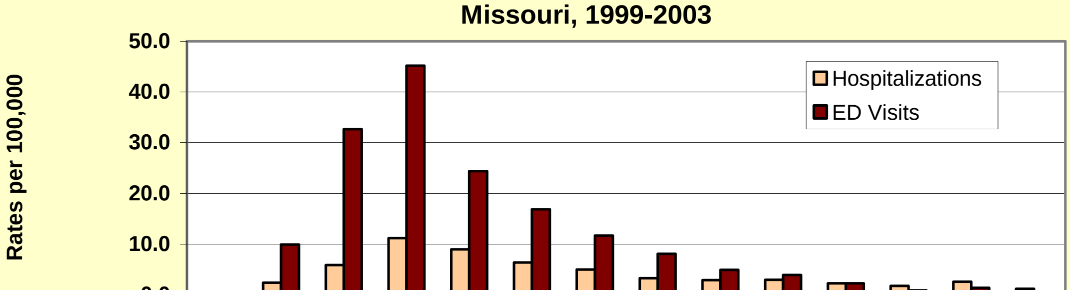



| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | 0.0 | 16.0 | 47.4 | 79.6 | 46.0 | 36.6 | 25.3 | 15.7 | 8.9 | 7.7 | 6.0 | 4.6 | 6.3 | 0.0 |
| Females | 0.0 | 8.4 | 29.3 | 31.9 | 20.1 | 9.6 | 8.1 | 7.1 | 6.8 | 6.0 | 3.3 | 1.2 | 2.3 | 1.7 |

**Age Group**

Motor vehicle non-traffic crashes resulted in a higher rate of ED visits compared to hospitalizations (Figure 39)[6]. The 10-14 year age group is most likely to go to the ED or be hospitalized for a TBI caused by a motor vehicle non-traffic crash.

**Figure 39. Average Annual Rates for TBI ED Visits and Hospitalizations Rates for Motor Vehicle Non-Traffic Crashes by Age Groups, Missouri, 1999-2003**



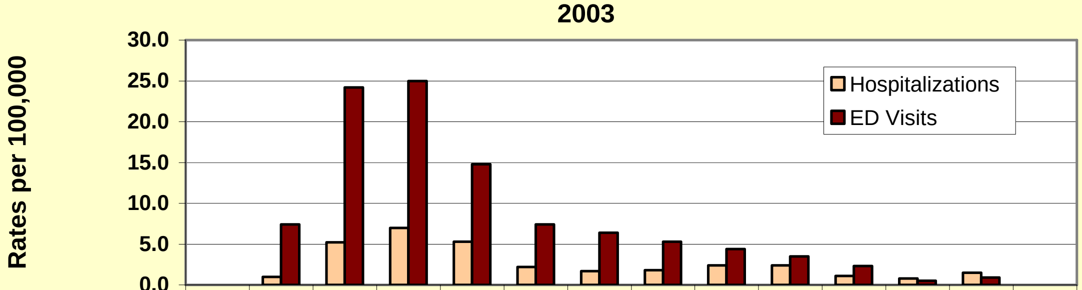

| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 0.0 | 2.4 | 5.9 | 11.2 | 9.0 | 6.4 | 5.0 | 3.3 | 2.9 | 3.0 | 2.3 | 1.8 | 2.6 | 1.2 |
| ED Visits | 0.0 | 9.9 | 32.7 | 45.2 | 24.4 | 16.9 | 11.7 | 8.1 | 4.9 | 3.9 | 2.3 | 0.9 | 1.4 | 0.0 |

**Age Group**

Males exhibited twice as many hospitalizations than females in the 10-14 years of age group (15.1 per 100,000 compared to 7.0 per 100,000) and 2.5 times more ED visits (64.5 per 100,000 compared to 25.0 per 100,000) respectively (Figures 40 and 41)[6], related to motor vehicle non-traffic crashes.

Map 20 (Appendix 4) shows a comparison of Missouri counties for the rates of TBI-related ED visits and hospitalizations combined for motor vehicle non-traffic crashes. Seven counties exhibit rates twice (> 30.0 per 100,000) that of the Missouri average (15.4 per 100,000) for this mechanism – Polk, Ray, Clinton, Vernon, Lawrence, Perry, and Washington. Map 21 (Appendix 4) provides the same comparison regarding the number of combined ED visits and hospitalizations for this mechanism by Missouri counties. Approximately 60% of Missouri counties had less than 20 events (i.e., number of ED visits and hospitalizations combined) from 1999-2003 for motor vehicle non-traffic crashes.

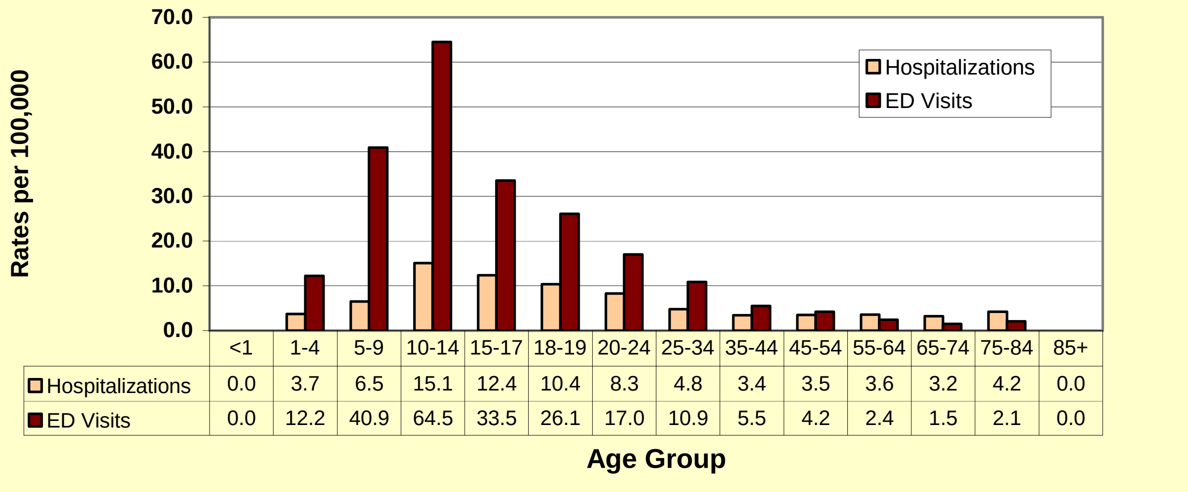
**Figure 40. Average Annual TBI ED Visits and Hospitalizations Rates for Motor Vehicle Non-Traffic Crashes by Age Groups, Females, Missouri 1999-2003**




| | <1 | 1-4 | 5-9 | 10-14 | 15-17 | 18-19 | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 | 65-74 | 75-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hospitalizations | 0.0 | 1.0 | 5.2 | 7.0 | 5.3 | 2.2 | 1.7 | 1.8 | 2.4 | 2.4 | 1.1 | 0.8 | 1.5 | 0.0 |
| ED Visits | 0.0 | 7.4 | 24.2 | 25.0 | 14.8 | 7.4 | 6.4 | 5.3 | 4.4 | 3.5 | 2.3 | 0.5 | 0.9 | 0.0 |

Age Group

Figure 41. Average Annual TBI ED Visits and Hospitalization Rates for Motor Vehicle Non-Traffic Crashes by Age Groups, Males, Missouri, 1999-2003




## Missouri Compared to United States TBI Data

Although the data included for Missouri differs from the U.S. data, as the Missouri data includes jumps with falls but does not include deaths except with assaults, a comparison of the data offers insights into the extent of the injuries in the State. As shown in Table 1, even with deaths not included in the Missouri data for falls, motor vehicle traffic crashes and struck by or against an object or person, Missouri is experiencing greater ED visits and hospitalizations related to these causes of TBI compared to the U.S.

**Table 1. Missouri Compared to the U.S. for Proportion of TBI by Selected Mechanisms[5-7]**

| Mechanism | Missouri | U.S. (includes deaths) |
|---|---|---|
| Falls | 36.2% (and jumps) | 28% |
| Motor Vehicle Traffic Crashes | 26.6% | 20% |
| Struck by or Against By Person/Object | 21.5% | 19% |
| Assaults | 10.9% (deaths only) | 11% |

## Other Causes of TBI in Missouri

As shown in Figures 11 and 12, other causes such as assaults, particularly with firearms, also contribute to the overall ED visit and hospitalization rates of TBIs in Missouri.[6] Maps to compare Missouri counties on select causes (assault, abuse/neglect/rape, self-injury, cut/pierce, drowning, and war) and intentions (unintentional injury and unknown intent) are shown in Maps 22–36 (Appendix 4).

Jackson County followed by St. Louis City had the highest rates for assaults resulting in ED visits and hospitalizations for TBI in Missouri. Seventy-five percent of Missouri counties had 25 or less ED visits or hospitalizations for TBI caused by assaults during this five-year time period (1999-2003). The TBI mechanisms of abuse/neglect/rape and cut/pierce represent approximately 1% of all ED visits and hospitalizations in Missouri from 1999-2003 with the majority occurring in Jackson and St. Louis counties. The Missouri counties with the highest numbers of ED visits and hospitalizations for TBIs resulting from self-injury included Jackson, Clay, St. Charles, St. Louis (city and county), Franklin and Greene.

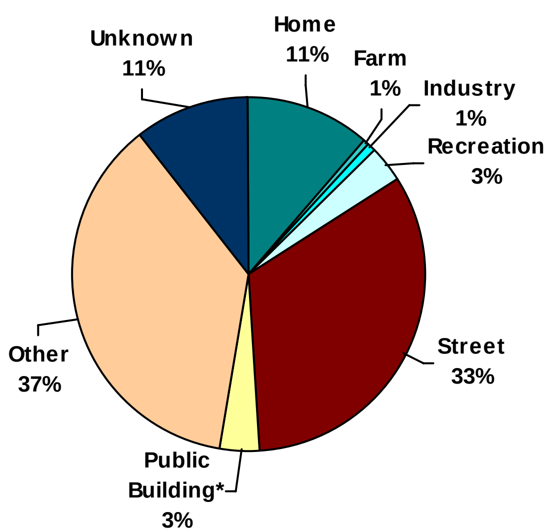
Nine Missouri counties (Jackson, Greene, Cape Girardeau, St. Charles, St. Louis, Franklin, Jefferson, Washington, and Barry) had one to two ED visits or hospitalizations for TBIs as a result of drowning from 1999-2003. Only 18 Missouri counties had ED visits or hospitalizations for TBIs resulting from war with the majority of these counties indicating one to two events. The five Missouri counties with the highest rates ($\geq$326 per 100,000) of unintentional injuries are clustered in the northwest portion of the state and include Ray, Clinton, Clay, Harrison and Daviess. Intentionality of TBIs is further defined in the mortality chapter.

## Place of Injury, Arrival for Care, Severity and Dispositions

The HSCR, established by state statute (RSMo 192.737) along with the Injury MICA, provides important data for needs assessments of head injured persons in Missouri. Among the many data elements collected are information on the place of injury, mode of arrival to the hospital, severity, disposition and disability at discharge.

The place or setting where the head injury occurred is categorized into 10 locations: home, farm, mine, industry, recreation, street, public building, residential institution, other, and unknown. According to the latest HSCR data (Figure 42)[22], 1996-2000, the majority of head injuries occurred in other locations (37.0%) which has no additional information provided or reported for this category, on streets (32.9%) or in homes (11.4%). For this same time period, only 0.7% of the TBI events occurred on a farm and 3.1% occurred in a recreation area. Of the head injuries that resulted from falls that occurred in homes, 23.0% occurred on stairs, 19.8% occurred on the same level, 4.6% occurred as a fall from a ladder, 4.6% occurred from a chair or bed, and 4.2% occurred as a fall from a building.

**Figure 42. Settings Where Traumatic Brain Injuries Occurred in Missouri, 1996-2000[22] (N = 30,521)**



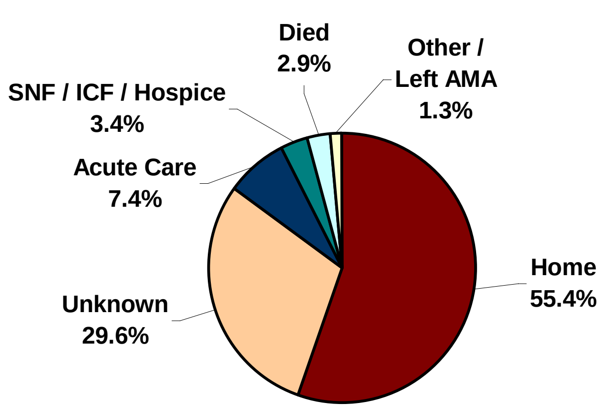

*Also includes residential institutions and mines.

In 2000, a majority of individuals seeking care for a TBI arrived by ground ambulance (39.3%), followed by air ambulance (6.7%) and private vehicle (6.6%).[23] Unfortunately, this information was often (46.9%) omitted in the reporting or missing due to data set linkages; therefore, the data should be interpreted cautiously.

Upon a review of the severity of TBIs from the HSCR for 1996-2000, the majority were classified as mild (39.4%) with moderate to severe combined for a total of 36.0%, the remainder died (24.6%).[22] In 2000, the HSCR showed that when discharged, 3.1% of patients with head injuries were dependent-total help needed; 4.6% were dependent-partial help needed; and 8.7% were independent with a device.[23] From this same database, the remainder of patients at discharge were coded as independent, unknown status, or died.

Based on the Injury MICA 1999-2003 (Figure 43)[6], the majority of the dispositions for TBIs from ED visits and hospitalizations were home (55.4%), followed by transferred to acute care (7.4%); and transferred to skilled nursing facility (SNF), intermediate care facility (ICF) or hospice (3.4%). Of the patients with TBI that were treated in the ED or admitted to the hospital, 2.9% died. However, almost one-third (29.6%) of the dispositions related to TBI from ED visits and hospitalizations were categorized as unknown.

**Figure 43. Missouri Traumatic Brain Injury Dispositions following ED Visit or Hospitalization, 1999-2003**

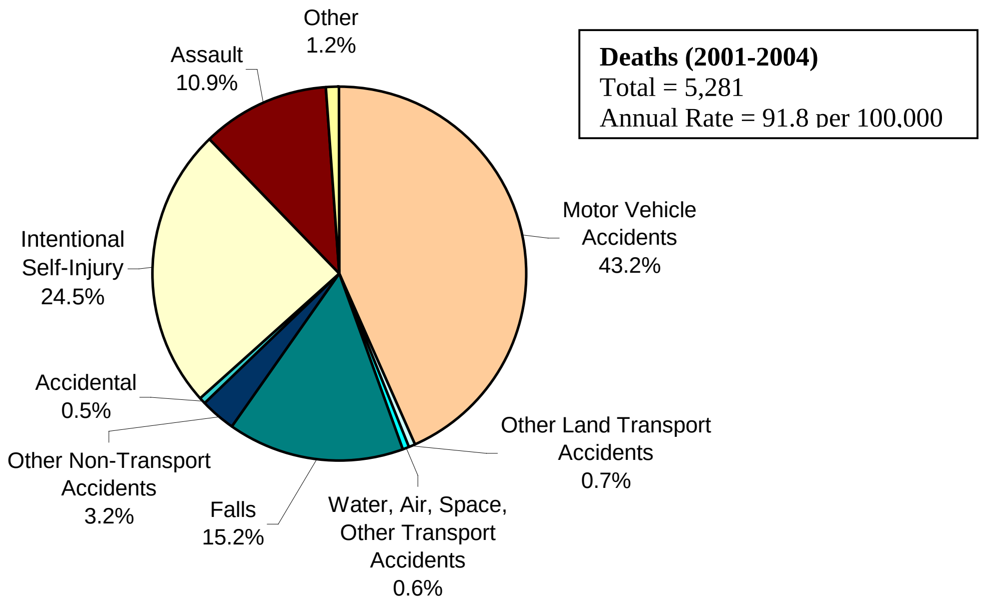


Maps 37-42 (Appendix 4) show a comparison of Missouri counties in TBI-related dispositions for home, acute care, and hospice. Although Harrison County was among the four highest counties (Clinton, Ray, and Clay) with rates of home dispositions following an ED visit or hospitalization for TBI ($\geq$ 202 per 100,000) and also among the four counties (Daviess, Monroe and Dent) with the highest rates for acute care dispositions ($\geq$ 37 per 100,000), Harrison County had the highest rate of dispositions to a skilled nursing facility, intermediate care facility or hospice following a TBI (25 per 100,000).

# TBI MORTALITY IN MISSOURI 5

There were a total of 5,281 TBI-related deaths from 2001-2004 with the majority due to motor vehicle crashes and intentionally self-inflicted injuries (Figure 44)[24]. These include deaths that occurred on the scene, in transport, as well as those that occurred during an ED visit or hospitalization. Maps 43 and 44 (Appendix 4) compare Missouri counties on the annual rates and numbers of TBI-related deaths. Worth, Gentry, Mercer, Carroll, Dade, and Reynolds counties showed relatively high death rates from TBI compared to other Missouri counties. Jackson, St. Louis County and St. Louis City had the highest number of deaths.

**Figure 44. TBI Mortality by Cause of Injury in Missouri, 2001-2004**



Motor vehicle crashes are the largest single contributor to TBI deaths. Annual TBI-related motor vehicle crash fatalities for Missouri counties are shown in Maps 45 and 46 (Appendix 4). All motor vehicle crashes with disabling injuries and fatalities are shown in Maps 47-49 (Appendix 4).[15] Combined, motor vehicle crashes and intentional self-injuries represent 68% of the TBI-related deaths. When TBI deaths from falls are added, these three causes represent over three-fourths (82.9%) of the deaths.

In addition to mechanism of injury, the Injury MICA provides TBI data by intent. Intention of injuries is classified into four categories: (1) assault–intent to injure others; (2) self-injury–intent to injure one's self; (3) unintentional–accidental or no intent to hurt anyone; and (4) intent undetermined–intention cannot be determined. When TBI-related deaths from assaults are added to the three leading causes (i.e., motor vehicle crashes, self-inflicted injuries, and falls), these four mechanisms represent almost 95% of the deaths. Table 2 presents the frequency of TBI-related deaths by individual causes.

| Table 2. Missouri Frequency and Percent of TBI Deaths by Cause, 2001-2004 Combined[24] | | |
|---|---|---|
| **Cause** | **Frequency** | **Percent** |
| Motor Vehicle Accidents | 2281 | 43.19 |
| Intentional Self-Harm (Suicide) by Discharge of Firearms | 1266 | 23.97 |
| Falls (Accidental) | 800 | 15.15 |
| Assault (Homicide) by Discharge of Firearms | 402 | 7.61 |
| Assault (Homicide) by Other/Unspecified Means | 176 | 3.33 |
| Other/Unspecified Non-Transport Accidents | 167 | 3.16 |
| Other Land Transport Accidents | 39 | 0.74 |
| Other/Unspecified Events of Undetermined Intent | 33 | 0.62 |
| Water, Air, Space, Other/Unspecified Transport Accidents | 32 | 0.61 |
| Intentional Self-Harm (Suicide) by Other/Unspecified Means | 29 | 0.55 |
| Discharge of Firearms of Undetermined Intent | 27 | 0.51 |
| Accidental Discharge of Firearms | 16 | 0.30 |
| Accidental Drowning or Submersion | 4 | 0.08 |
| Accidental Poisoning and Exposure to Noxious Substances | 4 | 0.08 |
| Accidental Exposure to Smoke, Fire, or Flames | 2 | 0.04 |
| Legal Intervention | 1 | 0.02 |
| Complications of Medical and Surgical Care | 1 | 0.02 |
| War/Sequelae | 1 | 0.02 |

While motor vehicle crashes remained the single leading cause of TBI-related deaths from 2001-2004, it is also noted that almost one-third (32.4%) of the deaths involved firearms. Almost all of the deaths involving firearms (97.5%) were intentionally inflicted injuries, either by self or another person through an assault or by homicide.

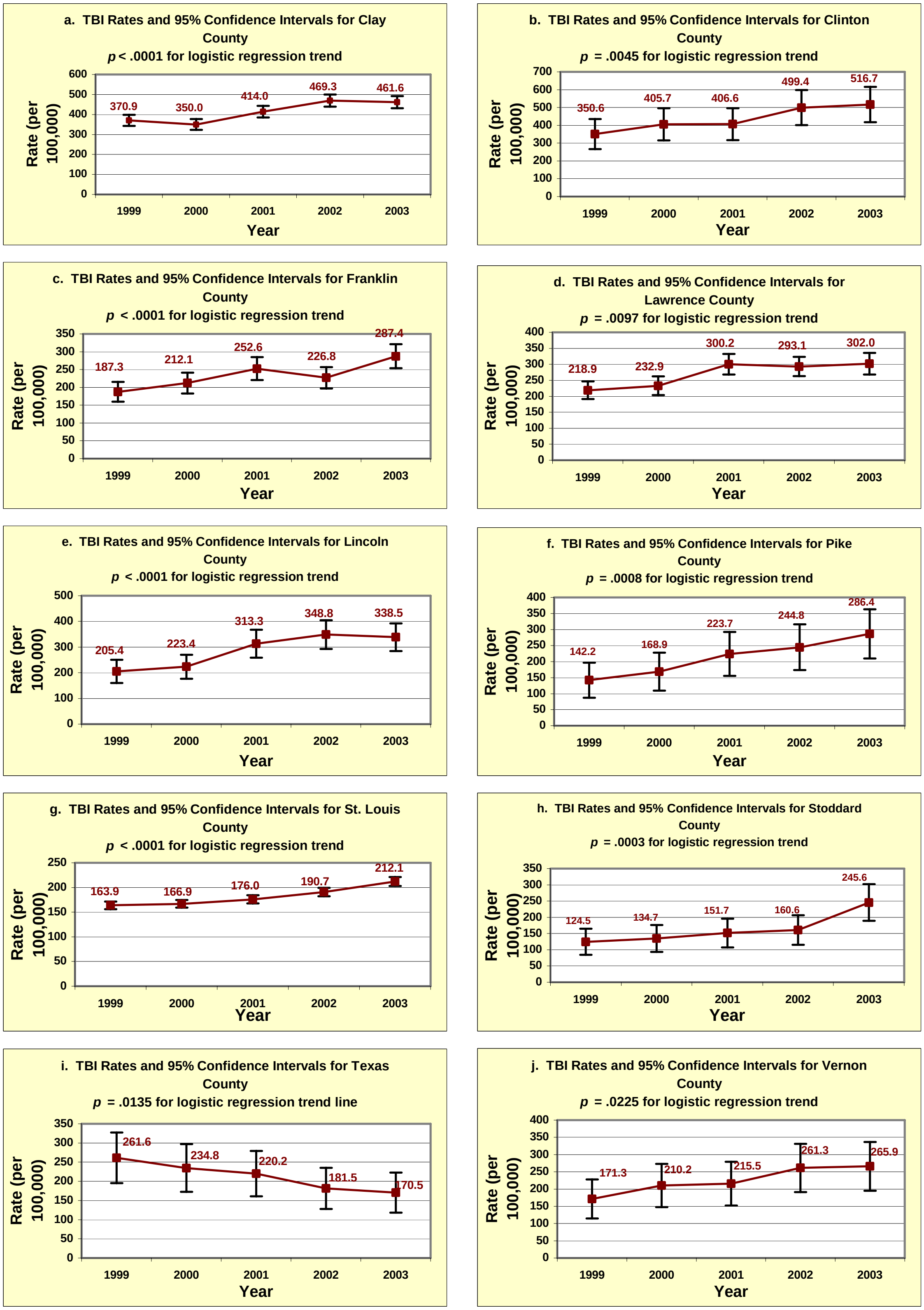
# MISSOURI COUNTY PROFILES 6

The counties with the highest reported annual TBI rates (i.e., ED visits combined with hospitalizations) and the most significant trends during 1999-2003 are shown in this section. Figures 45a-45j illustrate the 10 counties that exhibit the strongest trends (i.e., $p < .05$ for univariate logistic regression) either increasing or decreasing, during 1999-2003.[6] These 10 counties include Clay, Clinton, Franklin, Lawrence, Lincoln, Pike, St. Louis, Stoddard, Texas and Vernon.

Figures 46a-46j show the 10 counties with the highest aggregate TBI rates during 1999-2003 and include Clay, Clinton, Daviess, Harrison, Jackson, Marion, Polk, Randolph, Ray and Warren counties.[6] Missouri counties that have large amounts of missing TBI data or where the TBI numbers were too low to produce stable aggregate rates, are not reported in this county profile analysis. Therefore, these county profile trend analyses represent 82 Missouri counties with 20 or more combined TBI-related ED visits and hospitalizations annually.

The overall trend for TBI-related ED visit and hospitalization combined crude rates in Missouri has significantly increased during 1999-2003 (+15.6% growth, $p < .0001$). This fact is reflected in the trends shown in Figures 45a-45j, where nine of the ten counties (i.e., Clay, Clinton, Franklin, Lawrence, Lincoln, Pike, St. Louis, Stoddard, and Vernon) showed strong increasing trends and only Texas County showed a decreasing trend.

**Figures 45a-45j. Top Ten Missouri Counties with Significant Changes in Crude TBI ED Visits and Hospitalizations Combined Rates, 1999-2003[6]**

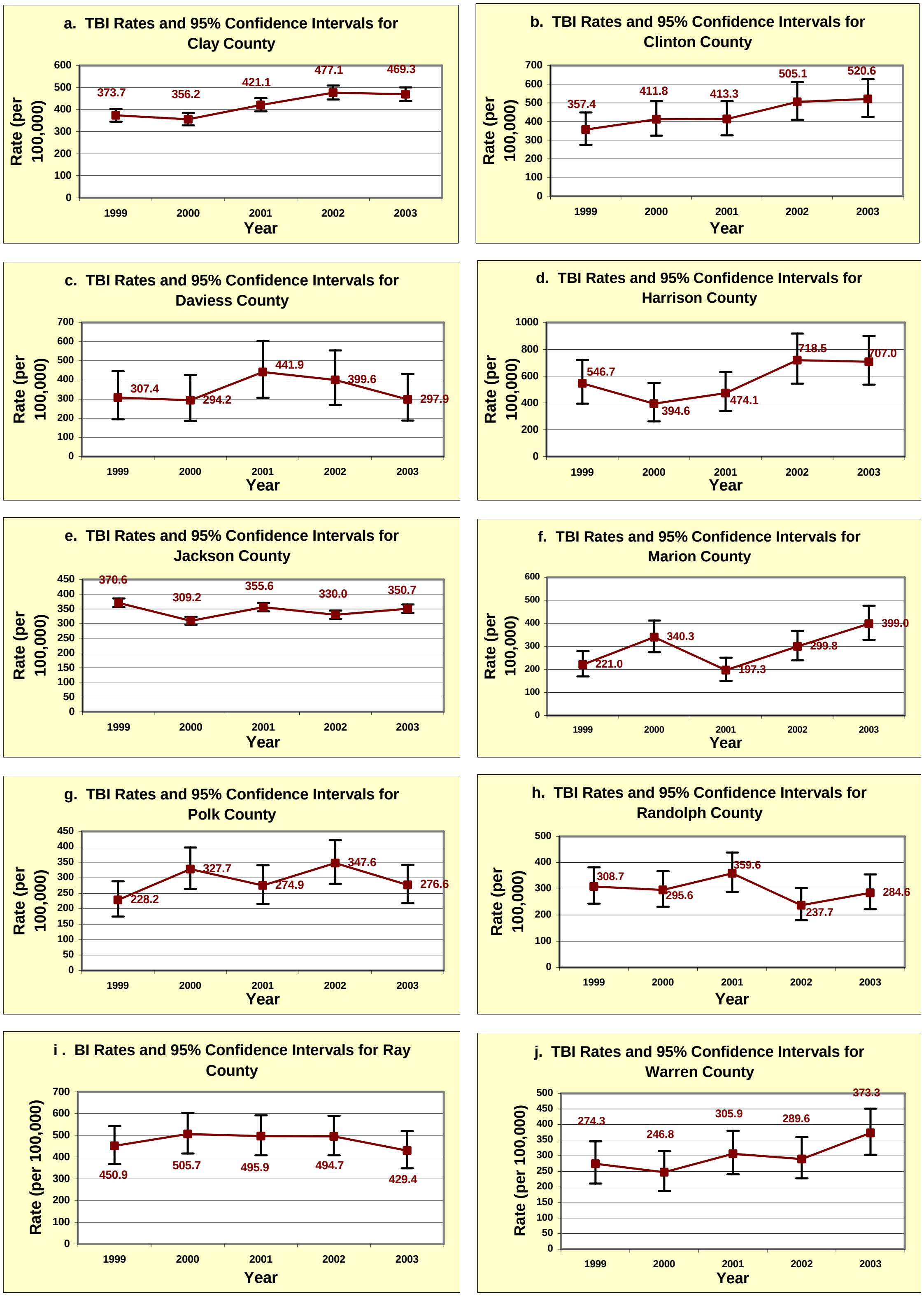


Overall, 56 of the 115 counties in Missouri showed increasing growth trends during 1999-2003 and 26 counties showed decreasing growth trends during the same 5-year time period. Thirty-three (33) counties were excluded from the trend analysis because they reported fewer than five stable TBI-related combined ED visit and hospitalization rates from 1999-2003.

Among the 10 counties having the most significant aggregate TBI-related ED visit and hospitalization rate trends during 1999-2003 (Figures 46a–46j), Pike County showed the highest growth in annual TBI rates, increasing from 142.2 per 100,000 in 1999 to 286.4 per 100,000 in 2003, an increase of 101.4%.[6] In contrast, Texas County showed a striking decrease in TBI-related ED visit and hospitalization combined rates, dropping from 261.6 per 100,000 in 1999 to 170.5 per 100,000 in 2003, a decrease of 34.8%. Of particular note, three of the more populous counties; Clay, St. Louis, and Clinton, experienced growth in annual TBI-related ED visit and hospitalization combined rates during 1999-2003 of 24.5%, 29.4%, and 47.4%, respectively.

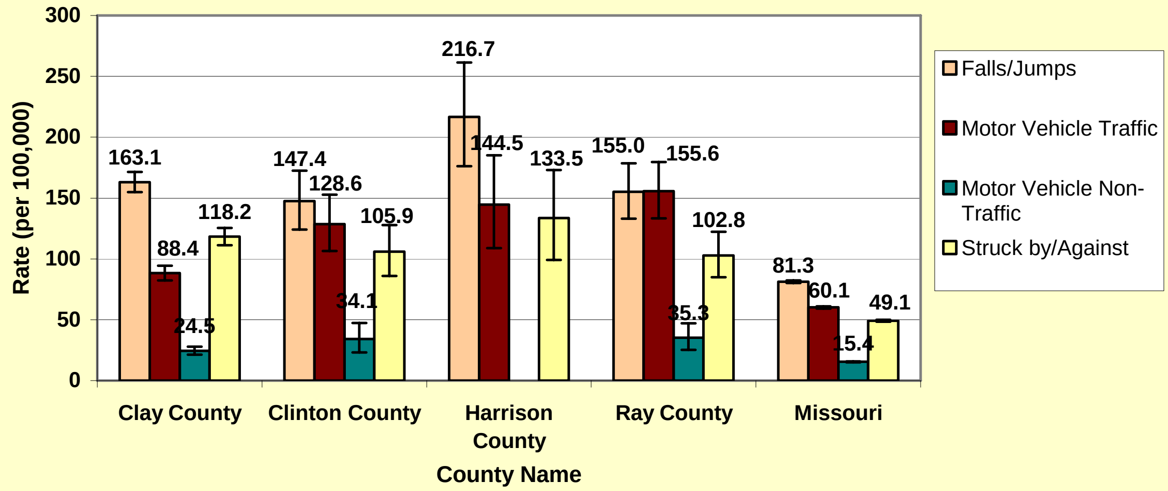
Among the 10 counties showing the highest aggregate TBI combined ED visit and hospitalization rates during the period 1999-2003, Harrison County leads with an aggregate TBI rate of 565.7 per 100,000 population (Figure 46d). Considering that Harrison County is a rural county with a low population, this is somewhat surprising. Clay, Clinton, Daviess, Jackson, and Ray counties, also included in the "top ten" list, had annual average TBI combined ED visit and hospitalization rates of 420.3, 443.3, 349.2, 343.4, and 475.1 per 100,000, respectively.

**Figures 46a-46j. Top Ten Missouri Counties with Highest Aggregate TBI-related ED Visits and Hospitalizations Combined Rates, 1999-2003[6]**



An explanation for the higher TBI annual average rates seen in these particular six counties (i.e., Clay, Clinton, Daviess, Harrison, Jackson, and Ray) is elusive. However, graphing the annual average TBI-related ED visit and hospitalization combined rates caused by different mechanisms is revealing (Figure 47). Note that TBI numbers are too low in Daviess County to produce stable rates). The four counties illustrated in Figure 47: Clay, Clinton, Harrison, and Ray, show elevated aggregate TBI-related ED visit and hospitalization combined rates caused by falls/jumps, motor vehicle traffic crashes, and being struck by or against an object or person.[6]

**Figure 47. Average Annual TBI ED Visits and Hospitalizations Combined Rates by Mechanism and 95% Confidence Intervals for Clay, Clinton, Harrison, and Ray Counties and Missouri, 1999-2003**

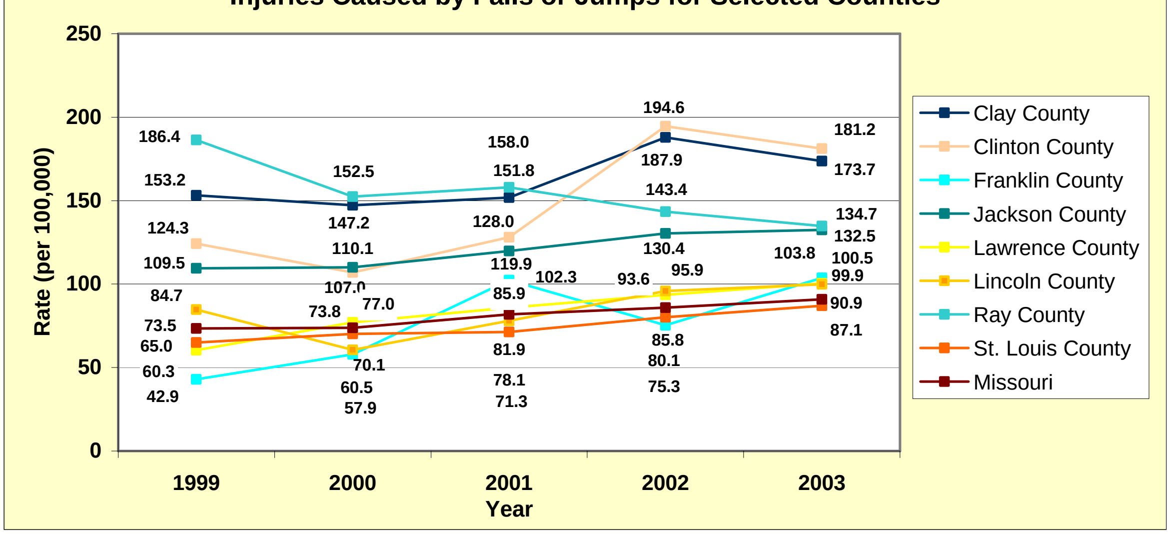


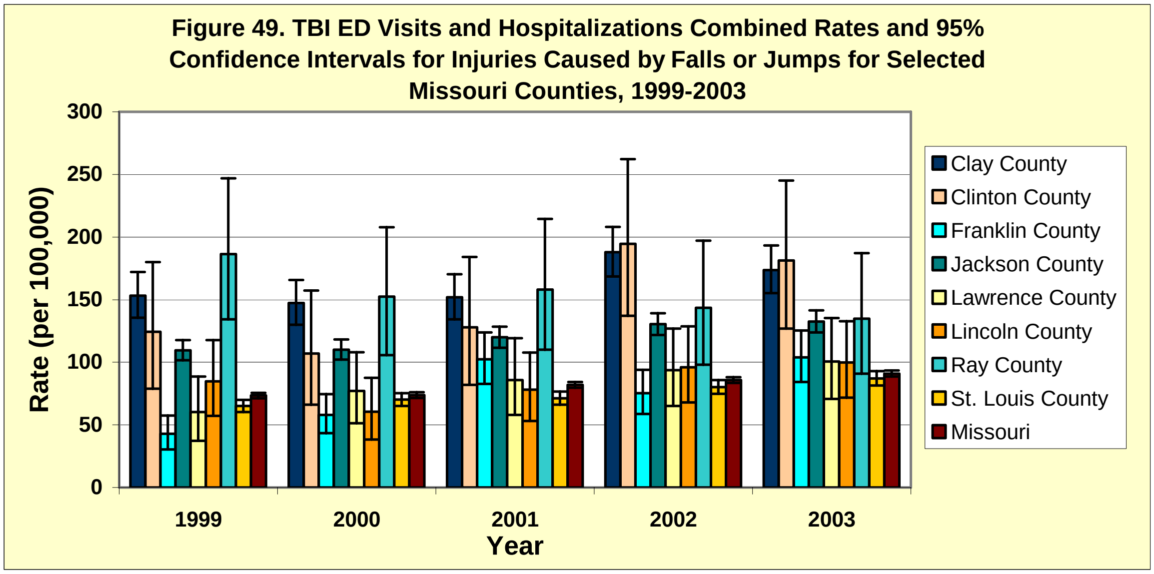

One potential explanation for this pattern could be higher than average percentages of residents in the 15-24 age category (who are at higher risk for TBIs caused by motor vehicle traffic crashes) and higher than average percentages of residents in the 0-4 and 65+ age categories (who are at higher risk for TBIs caused by falls or jumps) in these counties.

All six counties (i.e., Clay, Clinton, Daviess, Harrison, Jackson, and Ray) at high risk for TBI-related events are located in or near the “I-35 corridor” in northwestern Missouri. One explanation for the observed high TBI rates in these counties is increased risk of motor vehicle crashes for the residents living close to I-35. The TBI rates for injuries caused by motor vehicle traffic crashes are significantly higher in these counties than the Missouri average (Figures 46 and 47; Maps 15 and 16; Appendix 4). This might explain why TBI rates caused by motor vehicle traffic crashes are higher in these counties. Why TBIs caused by falls or jumps are higher in these counties remains a mystery.

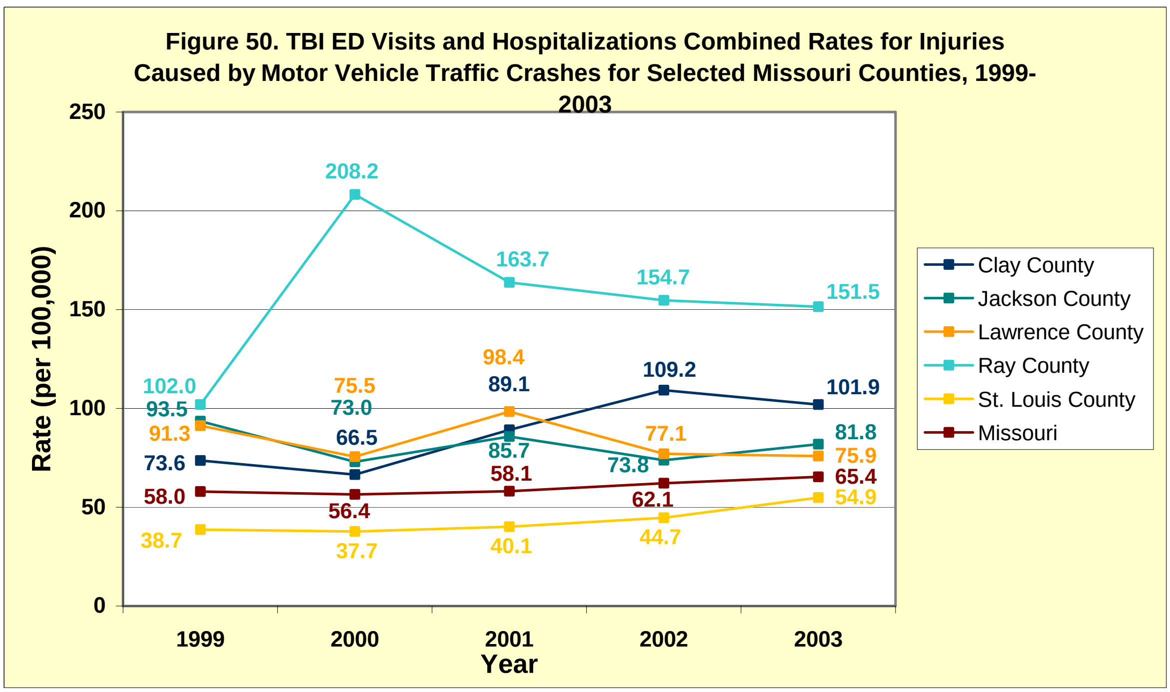
Figures 48-55 graph TBI ED visit and hospitalization combined rates and associated 95% confidence intervals by county (when stable rates could be calculated) for the four most common causal mechanisms: falls/jumps, motor vehicle traffic crashes, motor vehicle non-traffic crashes, and strikes by or against.[6] Clay, Ray, and Clinton counties had the highest reported aggregate TBI-related ED visit and hospitalization rates caused by falls/jumps in the State at 163.1 per 100,000 (154.9 to 171.5 CI) for Clay County, 155.0 per 100,000 (133.0 to 178.6 CI) for Ray County, and 147.4 per 100,000 (124.2 to 172.5 CI) for Clinton County. While Clay and Clinton counties have shown increased trends since 2001, Ray showed a declining trend in falls/jumps.

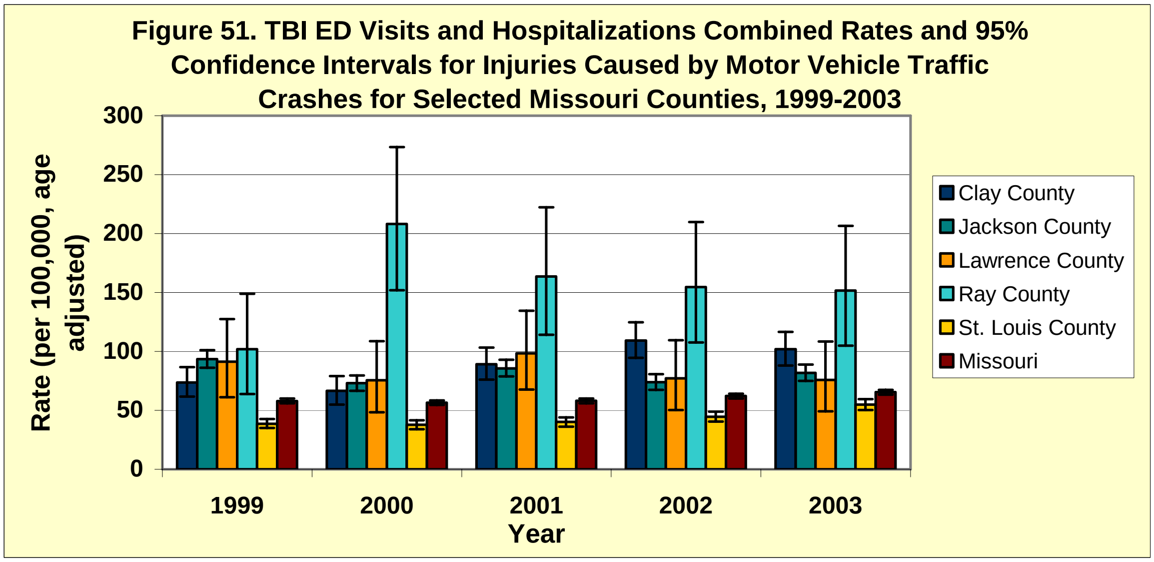
**Figure 48. TBI ED Visits and Hospitalizations Combined Rates for Injuries Caused by Falls or Jumps for Selected Counties**



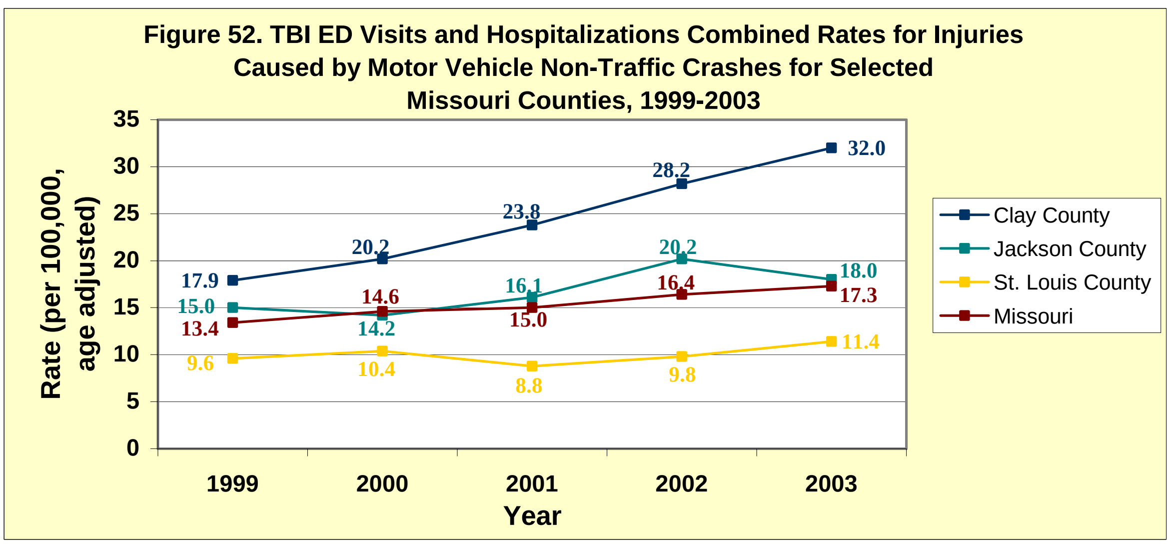


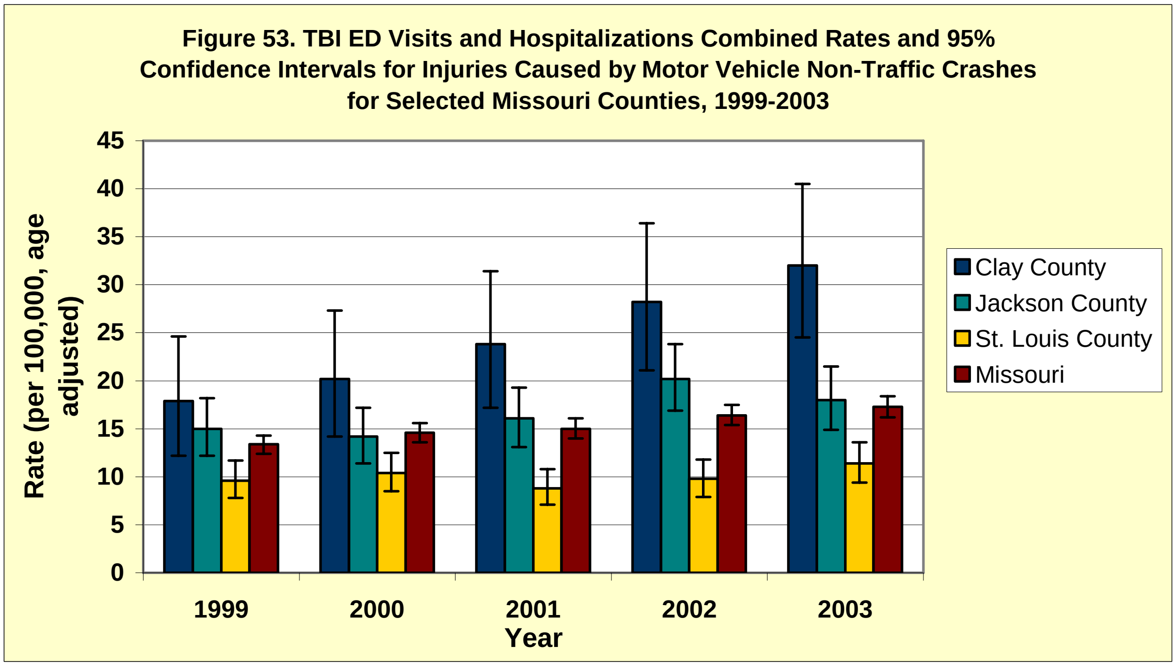

Ray County had the highest reported aggregate TBI-related ED visit and hospitalization rate caused by motor vehicle traffic crashes in the State, at 115.6 per 100,000, (133.4 to 179.6 CI).



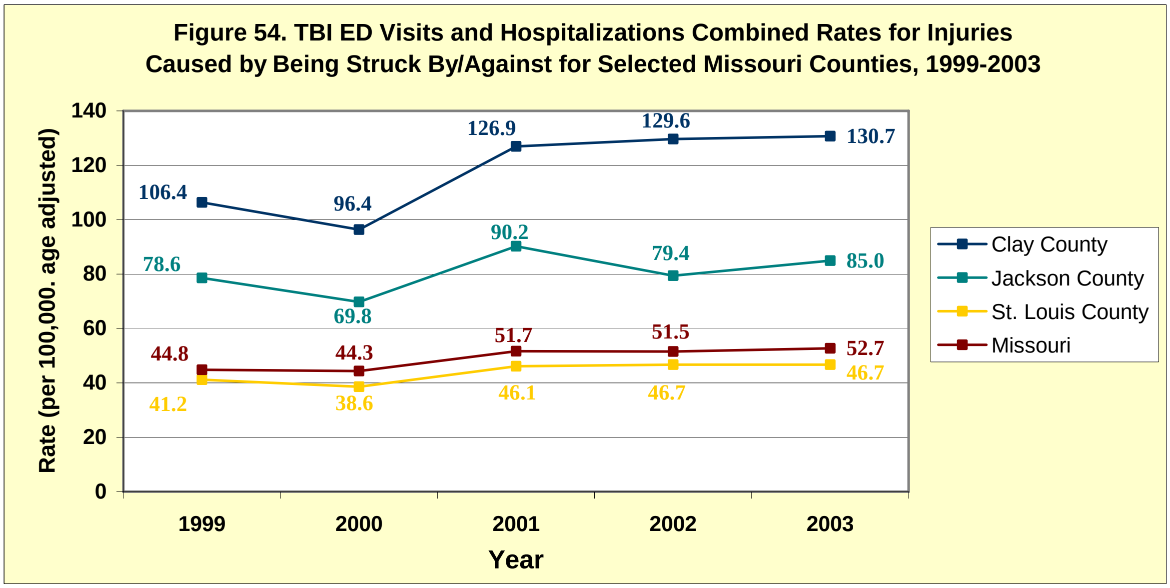



Clay County exhibited the highest reported aggregate TBI-related ED visit and hospitalization rate caused by motor vehicle non-traffic crashes, at 24.5 per 100,000 (21.4 to 27.8 CI).






Clay County also had the highest reported aggregate TBI-related ED visits and hospitalizations caused by being struck by or against an object or person, at 118.2 per 100,000 (111.3 to 125.3 CI).



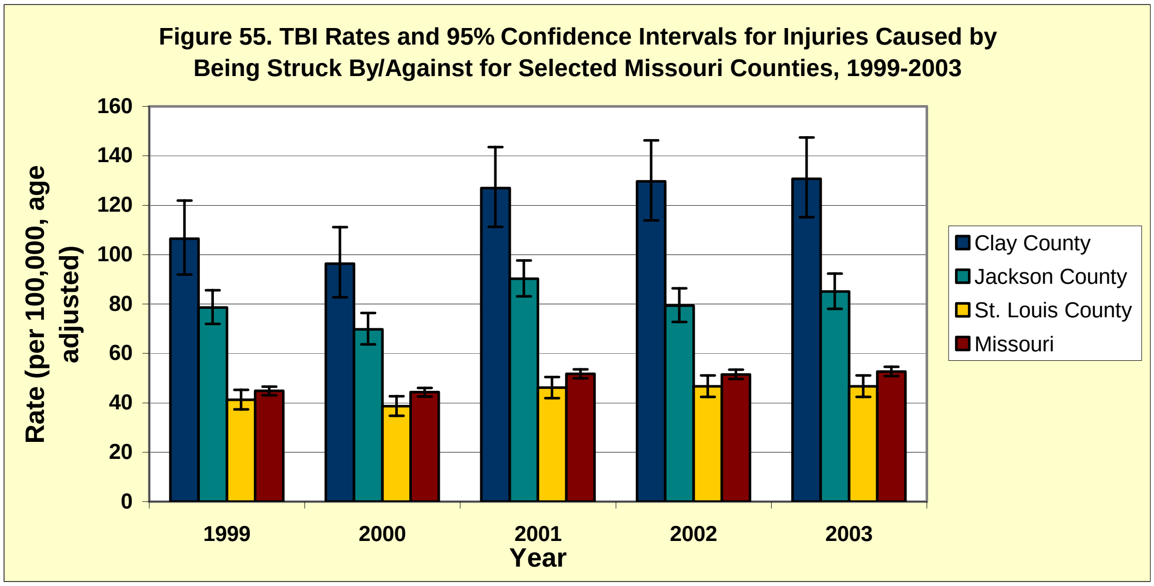


Figure 55. TBI Rates and 95% Confidence Intervals for Injuries Caused by Being Struck By/Against for Selected Missouri Counties, 1999-2003
Rate (per 100,000, age adjusted)
160
140
120
100
80
60
40
20
0
1999
2000
2001
2002
2003
Year
Clay County
Jackson County
St. Louis County
Missouri

# ECONOMIC IMPACT OF TBI IN MISSOURI 7

Cost analysis was conducted for estimating the economic burden of TBIs in Missouri. Like other injuries, there are several components of cost associated with TBI. TBI impacts human life in several ways: either it will terminate a person's life (mortality); a person will recover from it; or become disabled. If a TBI victim recovers from the injury and is sent home, there are short-term costs involved in terms of hospital charges (direct cost) and the indirect costs in terms of lost earnings. If the TBI victim becomes partially or fully disabled, there are additional long-term costs for acute care or skilled nursing facility, intermediate care facility, or hospice involved. Further exploration of literature and data review beyond this report is needed to quantify the direct care and the lost earnings cost for the disabled.

Cost of TBI fatalities can be measured by computing social and economic costs. Estimating the YPLL and the economic cost in terms of productivity loss due to premature death of the TBI victim measure social cost to society.

## Morbidity - Direct Cost: Hospital and ED Charges

In order to calculate the direct cost associated with TBIs, the related ED and hospital charges are a good measure of prevalence and incidence based cost of TBI. DHSS maintains the database of inpatient and emergency room charges by ICD-9-CM codes. Keeping in mind the yearly fluctuations, it is important to gather several years of data to get a yearly estimate. Five years of annual charge data from inpatient hospitalizations and ED visits available for the years 1999-2003 were obtained from the Patient Abstract System maintained by DHSS. Because of the five-year span, these charges potentially have the impact of inflation in the medical care industry. Therefore, these annual charges were adjusted for inflation using the Consumer Price Index (CPI) for Medical Care for All-Urban-Consumers in the Midwest region.

The CPI is calculated by the Bureau of Labor Statistics, U.S. Department of Labor (1999-2003).[18] Furthermore, each year different numbers of TBI mortalities occur, therefore, weighted-annual-average charges attributable to TBI were computed by using the number of TBI mortalities as weight. Since the hospital charges do not reflect the true economic cost of health care, Medicare uses a cost-to-charge ratio as the basis for reimbursement.[19] Similarly, we used a cost-to-charge ratio of 0.442 for Missouri, calculated by Haddix et. al. (2003) to estimate the direct cost of TBIs.[19]

In order to standardize and compare the charges and costs across counties of Missouri (Maps 50-53, Appendix 4), the rates per 100,000 of county residents were computed by using the population estimates for 2003 (U.S. Census Bureau). Direct charges and cost of TBIs by all Missouri counties for the years 1999-2003 are listed in Appendix 5. Missouri's annual direct cost associated with TBIs was about $67 million for the period 1999-2003. This amount translates into an annualized direct cost of about $1.18 million per 100,000 populations for the same period. Table 3 lists the four Missouri counties ranked the highest with annualized direct costs in excess of $2 million per 100,000 of population, for the period 1999-2003. Eighteen Missouri counties had annualized direct costs per 100,000 of population between $1.5 million and $2 million (Table 4).

| Table 3: Annual Direct Cost of TBI by Missouri Counties, 1999-2003* | |
|---|---|
| (Counties With Cost in Excess of $2 Million) | |
| **County** | **Annual TBI Cost: Rate per 100,000 of Population**** |
| Knox | $2,673,347 |
| Randolph | $2,522,795 |
| Maries | $2,257,755 |
| Mercer | $2,015,461 |

Sources: Missouri Department of Health and Senior Services. Population Estimates 2003, U.S. Census Bureau.
Haddix et. al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et. al. (2003) in March 2001.
Rates were calculated per 100,000 of Missouri population by county for the year 2003.

| Table 4: Annual Direct Cost of TBI by Missouri Counties, 1999-2003* | |
|---|---|
| (Counties With Cost Between $1.5 Million and $2 Million) | |
| **County** | **Annual TBI Cost: Rate per 100,000 of Population**** |
| St. Louis City | $1,941,385 |
| Macon | $1,936,727 |
| Sullivan | $1,921,217 |
| Gasconade | $1,754,379 |
| Benton | $1,738,553 |
| Bates | $1,733,810 |
| Shelby | $1,687,059 |
| Iron | $1,670,655 |
| Camden | $1,656,740 |
| Schuyler | $1,655,284 |
| Monroe | $1,622,590 |
| Montgomery | $1,599,278 |
| Moniteau | $1,576,826 |
| Pike | $1,548,511 |
| Miller | $1,541,186 |
| Cooper | $1,537,642 |
| St. Francois | $1,527,408 |
| Pettis | $1,503,993 |

Sources: Missouri Department of Health and Senior Services. Population Estimates 2003, U.S. Census Bureau.
Haddix et. al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et. al. (2003) in March 2001.
Rates were calculated per 100,000 of Missouri population by county for the year 2003.

Forty-Nine Missouri counties with annualized direct costs per 100,000 of population between $1 million and $1.5 million are presented in Table 5.

| Table 5: Annual Direct Incident Cost of TBI by Missouri Counties, 1999-2003* | | | |
|---|---|---|---|
| (Counties With Cost Between $1Million and $1.5 Million) | | | |
| **County** | **Annual TBI COST: Rate per 100,000 of Population**** | **County** | **Annual TBI Cost: Rate per 100,000 of Population**** |
| Morgan | $1,485,186 | Stoddard | $1,156,929 |
| Osage | $1,475,197 | Jefferson | $1,152,615 |
| Lincoln | $1,434,201 | Polk | $1,146,426 |
| Warren | $1,414,512 | Callaway | $1,136,433 |
| Wayne | $1,393,296 | Grundy | $1,126,347 |
| Franklin | $1,367,572 | Perry | $1,111,683 |
| Jackson | $1,350,777 | Daviess | $1,098,732 |
| Linn | $1,309,308 | St Louis County | $1,094,976 |
| Lawrence | $1,303,191 | Gentry | $1,088,197 |
| Clinton | $1,290,922 | Cedar | $1,085,506 |
| Boone | $1,283,953 | Carroll | $1,078,154 |
| Howell | $1,234,682 | Cass | $1,074,177 |
| Newton | $1,229,230 | Dade | $1,071,913 |
| Dent | $1,229,118 | Saline | $1,064,672 |
| Marion | $1,227,943 | Henry | $1,063,229 |
| Scotland | $1,223,339 | Clay | $1,051,444 |
| Wright | $1,218,975 | Audrain | $1,049,848 |
| Taney | $1,203,688 | McDonald | $1,045,610 |
| Washington | $1,194,516 | Harrison | $1,042,200 |
| Vernon | $1,186,136 | Adair | $1,028,699 |
| Ray | $1,183,638 | Caldwell | $1,016,706 |
| Bollinger | $1,182,578 | St Charles | $1,009,039 |
| Dallas | $1,165,317 | Lafayette | $1,008,918 |
| Jasper | $1,161,357 | Douglas | $1,004,723 |
| Cole | $1,159,497 | | |

Sources: Missouri Department of Health and Senior Services; Population Estimates 2003, U.S. Census Bureau.
Haddix et. al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et. al. (2003) in March 2001.
Rates were calculated per 100,000 of Missouri population by county for the year 2003.

Table 6 lists the remaining 44 counties in Missouri with annualized incident costs per 100,000 of population of less than $1 million. Four counties, Holt, Worth, Lewis, and Clark had direct TBI costs less than half a million.

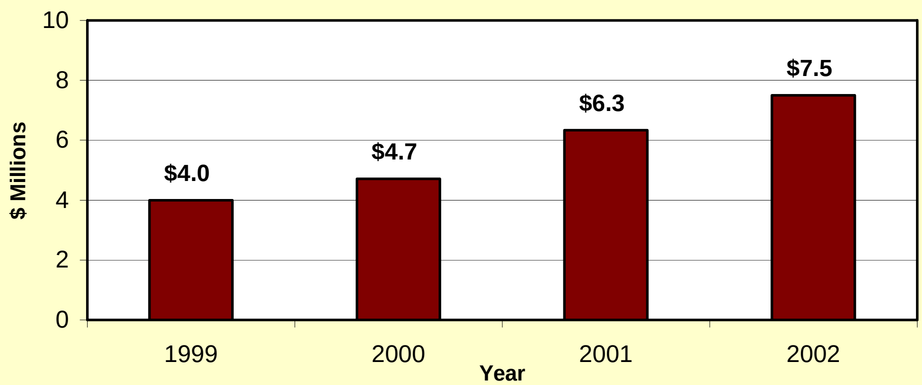
| Table 6: Annual Direct Cost of TBI by Missouri Counties, 1999-2003* | | | |
|---|---|---|---|
| (Counties With Cost Less Than $1Million **Highlighted Counties Had Less than $500,000 in TBI Cost** | | | |
| **County** | **Annual TBI Cost: Rate per 100,000 of Population**** | **County** | **Annual TBI Cost: Rate per 100,000 of Population**** |
| Mississippi | $996,984 | Butler | $811,645 |
| Phelps | $996,410 | Laclede | $803,622 |
| Livingston | $989,530 | Putnam | $801,368 |
| Johnson | $985,417 | Texas | $797,180 |
| Scott | $978,719 | Ste Genevieve | $797,164 |
| Crawford | $974,361 | Reynolds | $781,849 |
| Cape Girardeau | $964,737 | Stone | $780,963 |
| Webster | $960,255 | Howard | $752,107 |
| Ripley | $955,438 | Christian | $718,227 |
| Carter | $944,223 | Oregon | $708,056 |
| Chariton | $942,668 | Ralls | $691,586 |
| St Clair | $926,777 | De Kalb | $687,230 |
| Greene | $916,531 | Andrew | $677,549 |
| Barton | $906,148 | Pulaski | $663,435 |
| New Madrid | $902,451 | Ozark | $620,622 |
| Atchison | $891,144 | Dunklin | $613,566 |
| Shannon | $883,926 | Pemiscot | $605,118 |
| Barry | $868,529 | Nodaway | $598,000 |
| Platte | $857,712 | Holt | $487,279 |
| Madison | $849,549 | Worth | $278,857 |
| Hickory | $844,552 | Lewis | $240,908 |
| Buchanan | $835,271 | Clark | $161,702 |

Sources: Missouri Department of Health and Senior Services; Population Estimates 2003, U.S. Census Bureau.
Haddix et. al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et. al. (2003) in March 2001.
Rates were calculated per 100,000 of Missouri population by county for the year 2003.

## Medicaid Cost

A substantial amount of the TBI cost burden is borne by the State's Medicaid system. Based on fee-for-service payments by ICD-9 codes, over $22.5 million dollars was expended on TBI-related care in Missouri for a four year period (1999-2002).[16] This care included physician visits, home health, hospitalizations, rehabilitation, and nursing homes. This amount does not include managed care payments, pharmacy payments, or non-emergency transfer service charges. As shown in Figure 56, the Medicaid fee-for-service expenditures have increased each of the four years reviewed, representing a 46% increase from 1999-2002.[16]

**Figure 56. Missouri Medicaid Net Fee-For-Service Payments For TBI, 1999-2002**




Many of the Medicaid TBI costs are associated with an intracranial injury, including concussion, contusion, laceration and hemorrhage. Approximately 41% of the total Medicaid fee-for-service TBI-related costs were incurred by males, aged 15-49. Overall, males accounted for 61.2% of the total net payments related to TBI from 1999-2001. Among females, during this same time frame, those aged 20-24 incurred the most charges related to TBI. Looking at race, the majority of the TBI net payments were for white Medicaid recipients (82.6%) followed by African-Americans (14.8%).

## Mortality

In case of mortality, the burden of injury is measured by estimating the lost productivity and the number of YPLL.

### Years of Potential Life Lost (YPLL)

YPLL due to premature death of a TBI victim is computed by counting the remaining years of expected life with the help of a life table. This approach is referred to as YPLL-Life Expectancy (YPLL-LE) since it takes into consideration that there is some life expectancy at every age.[25] A more standard approach is to define premature death as death before age 65 (YPLL-65). However, as lengths of life increases, not counting deaths over age 65 under estimates the burden of chronic disease in the population. Nevertheless, it is noted that life expectancy changes with age and time and must be incorporated in future comparisons using the YPLL-LE approach.

TBI-related death data by age and gender from Missouri Vital Statistics for the years 2001-04 were obtained.[24] The Abridged Life Table from the Missouri Vital Statistics for the year 2003 was used to compute the YPLL attributable to TBIs in Missouri.[26] Estimated YPLL due to mortalities resulting from TBI injury annually for the period 2001-2004 for all age groups and genders are 45,606 (Table 7).

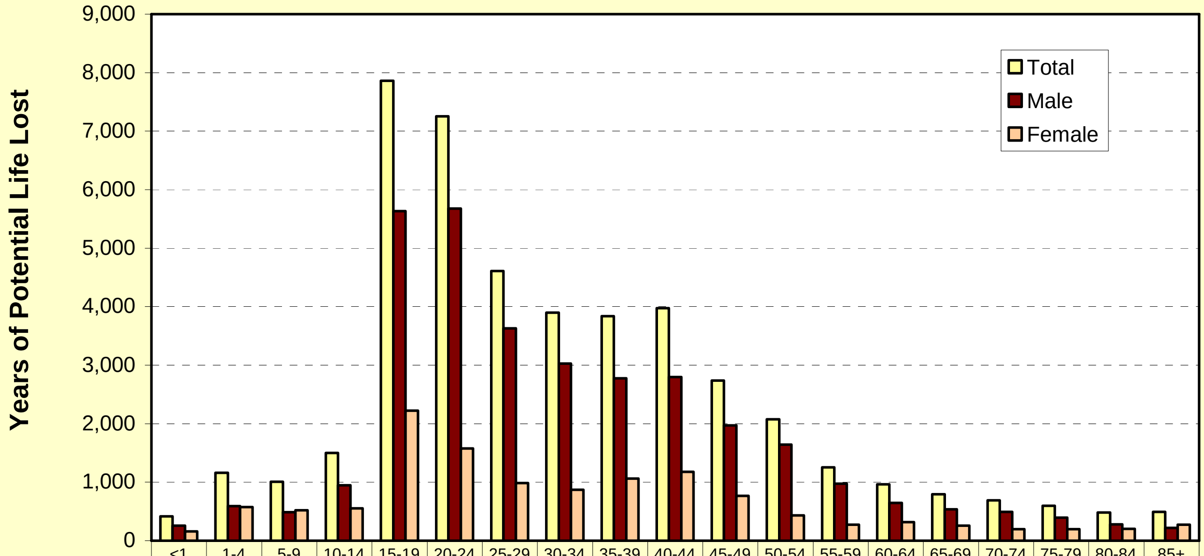
Missouri males of all age groups account for approximately 72% (32,990) of the total YPLL, while Missouri females of all age groups count for approximately 28% (12,616). This translates into an average of 35 YPLL for each Missourian during 2001-04 due to TBI-related deaths. Although the numbers of YPLL for males was 72% of the total YPLL, the average number of years is smaller for males (34 versus 35 for females) due to the lower life expectancy for males.

| Table 7: Annual Years of Potential Life Lost due to Mortality Resulting from TBI by Age Groups and Gender, Missouri, 2001-04* | | | |
|---|---|---|---|
| | **Total** | **Male** | **Female** |
| **All Age Groups** | **45,606** | **32,990** | **12,616** |
| **%** | **100** | **72** | **28** |
| **Per Person Years of Potential Life Lost to TBI** | **35** | **34** | **35** |
| **Age Group** | | | |
| <1 | 415 | 258 | 157 |
| 1-4 | 1,163 | 590 | 573 |
| 5-9 | 1,008 | 486 | 522 |
| 10-14 | 1,502 | 948 | 554 |
| **15-19** | **7,859** | **5,635** | **2,224** |
| **20-24** | **7,255** | **5,678** | **1,577** |
| 25-29 | 4,612 | 3,628 | 984 |
| 30-34 | 3,898 | 3,027 | 871 |
| 35-39 | 3,836 | 2,774 | 1,062 |
| 40-44 | 3,975 | 2,800 | 1,175 |
| 45-49 | 2,739 | 1,973 | 766 |
| 50-54 | 2,073 | 1,642 | 431 |
| 55-59 | 1,251 | 977 | 274 |
| 60-64 | 964 | 646 | 318 |
| 65-69 | 795 | 535 | 260 |
| 70-74 | 691 | 495 | 196 |
| 75-79 | 594 | 396 | 198 |
| 80-84 | 484 | 281 | 203 |
| 85+ | 492 | 221 | 271 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics, 2003.
*In order to compute Average number of years of life remaining the Abridged Life Table for Missouri for the year 2003 was used.[26]

Figure 57 shows the YPLL due to TBI-related deaths.[24, 26] YPLL peaked at the age groups 15-19 and 20-24, and then gradually declined. A similar pattern is observed in both genders with higher YPLL for males across all age groups. The higher numbers of YPLL are attributable to the higher mortalities for males since average numbers of YPLL per TBI fatality are almost the same for both genders.

**Figure 57: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI by Age Groups and Gender, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 415 | 1,163 | 1,008 | 1,502 | 7,859 | 7,255 | 4,612 | 3,898 | 3,836 | 3,975 | 2,739 | 2,073 | 1,251 | 964 | 795 | 691 | 594 | 484 | 492 |
| Male | 258 | 590 | 486 | 948 | 5,635 | 5,678 | 3,628 | 3,027 | 2,774 | 2,800 | 1,973 | 1,642 | 977 | 646 | 535 | 495 | 396 | 281 | 221 |
| Female | 157 | 573 | 522 | 554 | 2,224 | 1,577 | 984 | 871 | 1,062 | 1,175 | 766 | 431 | 274 | 318 | 260 | 196 | 198 | 203 | 271 |

Age Groups

Data on TBIs identified four major causes: motor vehicle crashes; fall-unintentional; all firearms not just unintentional; and motorcycle crashes. Table 8 presents YPLL due to TBI by these four major categories. These four categories are the cause of 93% of total YPLL.

**Table 8: Annual Average Per Person Years of Potential Life Lost and Average Age at Death by All TBI, Major Causes, and Gender, Missouri, 2001-2004**

| | All TBI | | Motor Vehicle Crash | | Falls-Unintentional | | All Firearms, Not Just Unintentional | | Motorcycle Crash | |
|---|---|---|---|---|---|---|---|---|---|---|
| | YPLL Per Person | Average Age at Deaths | YPLL Per Person | Average Age at Deaths | YPLL Per Person | Average Age at Deaths | YPLL Per Person | Average Age at Deaths | YPLL Per Person | Average Age at Deaths |
| Total | 35 | 45-50 | 42 | 35 | 14 | 70 | 35 | 45 | 38 | 40 |
| Male | 34 | 40-45 | 41 | 35 | 15 | 65-70 | 34 | 40-45 | 38 | 35-40 |
| Female | 35 | 45-50 | 44 | 35-40 | 11 | 75-80 | 39 | 40-45 | 38 | 40-45 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics, 2003.
*In order to compute Average number of years of life remaining the Abridged Life Table for Missouri for the year 2003 was used.[26]

In Table 8, the YPLL per TBI-related fatality, are shown by gender for four major causes.[24] Annually during the period 2001-2004, Missourians, on average, lost 35 years of potential life to TBI-related deaths.  Based on the Missouri life table for 2003, this implies that the average age of TBI fatality was between 45 and 50 years.  However, TBI victims of motor vehicle crashes died younger, at an average age of 35 years, whereas, TBI victims of falls died older at an age of 70 years.  Figures 58 and 59 show how different causes of TBI impact YPLL and average age at death of the TBI victims.

**Figure 58: Annual Years of Potential Life Lost by Major Causes and Gender, Missouri, 2001-2004**

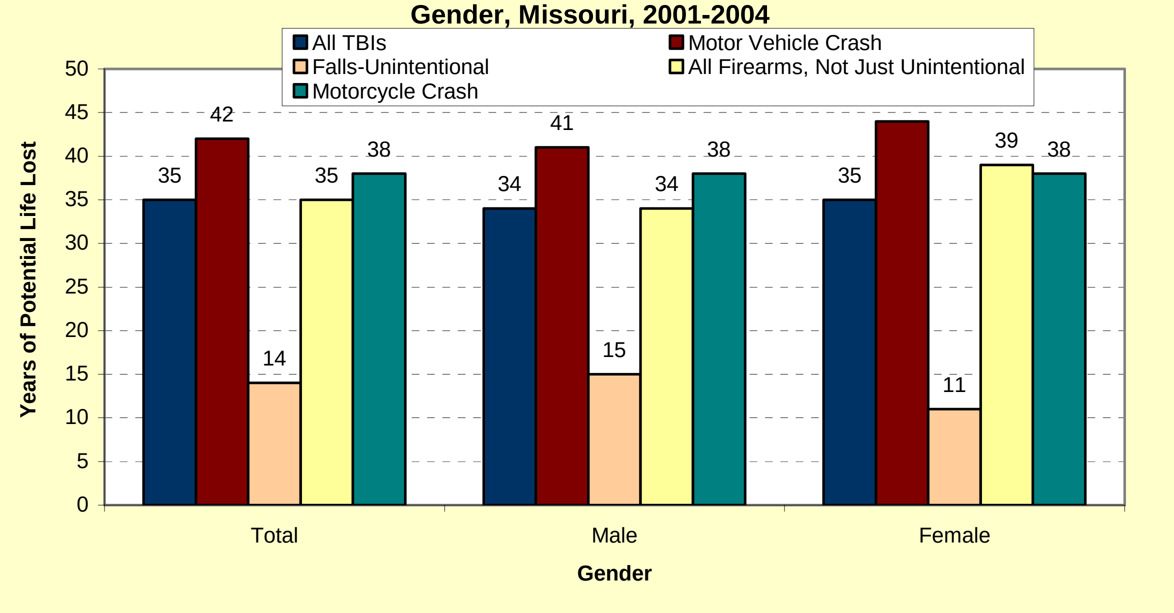


Figure 59: Average Age at Death from TBI by Major Causes and Gender, Missouri, 2001-2004

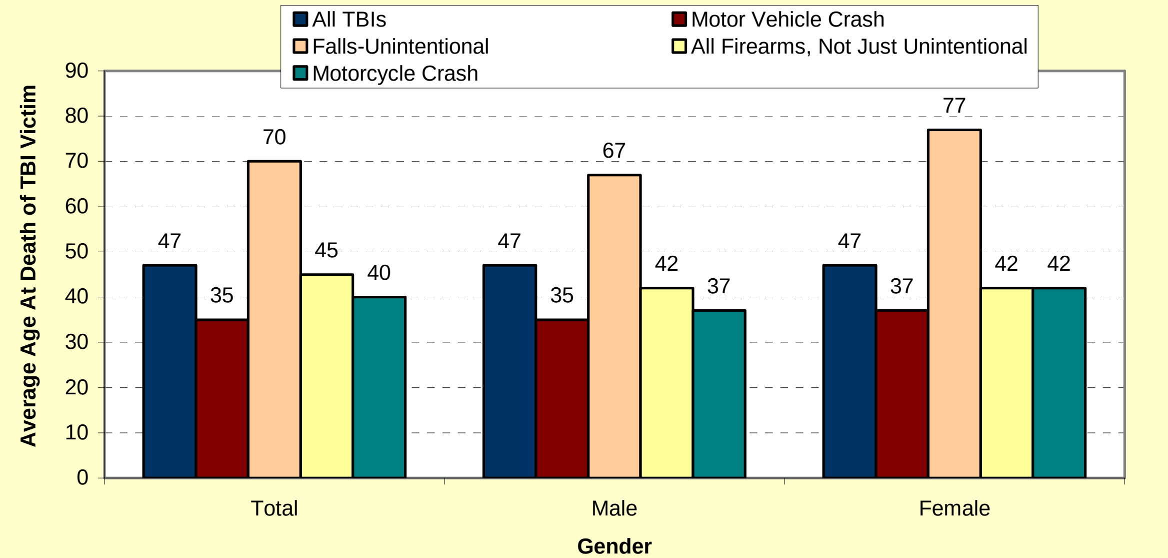



Table 9 and Figure 60 compares the YPLL by the four major categories and by gender. These categories caused 93% of total YPLL (95% in male and 91% in female). Motor vehicle crashes caused highest loss of potential life (52%) followed by firearms (32%). Both genders followed a similar pattern, but for females, motor vehicle crash fatalities caused a disproportionately higher number of YPLL (64 vs. 48 for males) and a disproportionately lower firearm related mortalities (18 vs. 38 for males).

**Table 9: Percent of Years of Potential Life Lost Attributable to TBI by Four Major Causes and Gender, Missouri, 2001-2004**

| | Motor Vehicle Crash | Falls-Unintentional | All Firearms, Not Just Unintentional | Motorcycle Crash |
|---|---|---|---|---|
| Total | 52 | 6 | 32 | 3 |
| Male | 48 | 5 | 38 | 4 |
| Female | 64 | 8 | 18 | 1 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics, 2003.
*In order to compute Average number of years of life remaining the Abridged Life Table for Missouri for the year 2003 was used.[26]

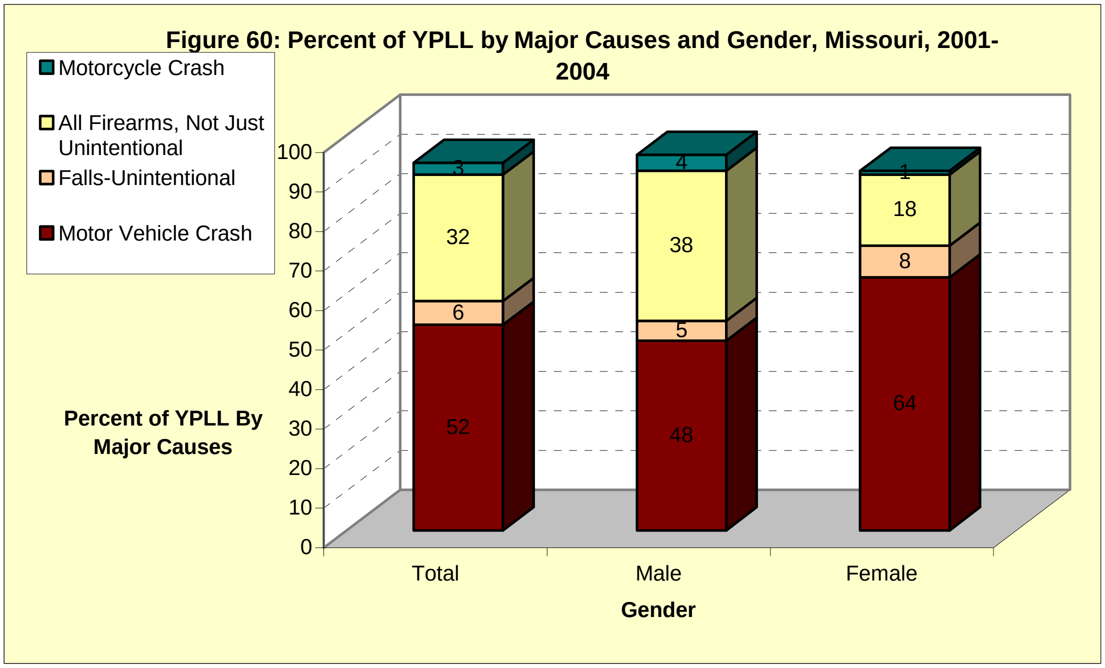


Figure 60: Percent of YPLL by Major Causes and Gender, Missouri, 2001-2004
Motorcycle Crash
All Firearms, Not Just Unintentional
Falls-Unintentional
Motor Vehicle Crash
Percent of YPLL By Major Causes
100
90
80
70
60
50
40
30
20
10
0
3
32
6
52
4
38
5
48
1
18
8
64
Total
Male
Female
Gender

Missourians, especially males, in the age groups of 15-19 and 20-24 have the highest YPLL attributable to motor vehicle crashes (Table 10). Motor vehicle TBI-related deaths (23,852) account for the largest total share of the estimated YPLL, with males in that category accounting for 15,786 of the motor vehicle TBI-related deaths.

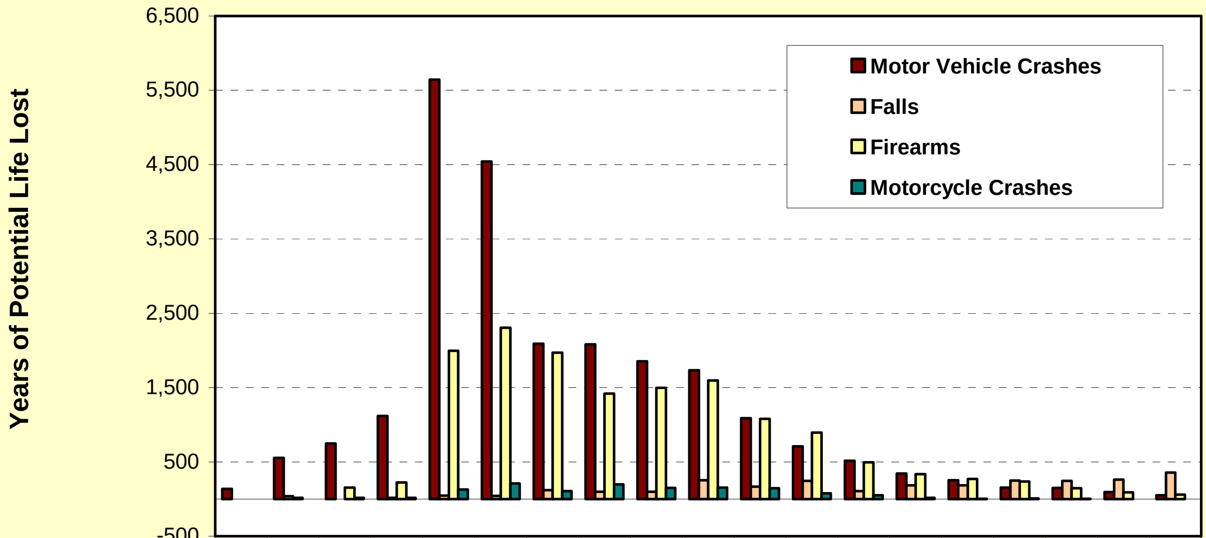
**Table 10: Annual Years of Potential Life Lost due to Mortality Resulting from TBI by Major Causes, Age Groups, and Gender, Missouri, 2001-2004***

| Cause of TBI | Motor Vehicle Crash Related YPLL 2001-04 | | | Falls-Unintentional Related YPLL 2001-04 | | | All Firearms, Not Just Unintentional Mortality 2001-04 | | | Motorcycle Related YPLL 2001-04 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Male | Female | Total | Male | Female | Total | Male | Female | Total | Male | Female |
| All Age Groups | 23,852 | 15,786 | 8,066 | 2,711 | 1,695 | 1,016 | 14,773 | 12,510 | 2,263 | 1,287 | 1,163 | 124 |
| % | 100 | 66 | 34 | 100 | 63 | 37 | 100 | 85 | 15 | 100 | 90 | 10 |
| Per Person Years of Potential Life Lost to TBI | 42 | 41 | 44 | 14 | 15 | 11 | 35 | 34 | 39 | 38 | 38 | 38 |
| Age Group | | | | | | | | | | | | |
| <1 | 136 | 18 | 118 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1-4 | 555 | 268 | 287 | 37 | 18 | 19 | 18 | 18 | 0 | 0 | 0 | 0 |
| 5-9 | 748 | 352 | 396 | 0 | 0 | 0 | 156 | 84 | 72 | 17 | 17 | 0 |
| 10-14 | 1,116 | 730 | 386 | 16 | 16 | 0 | 222 | 155 | 67 | 16 | 16 | 0 |
| 15-19 | 5,645 | 3,670 | 1,975 | 45 | 29 | 16 | 1,994 | 1,807 | 187 | 129 | 129 | 0 |
| 20-24 | 4,543 | 3,281 | 1,262 | 40 | 26 | 14 | 2,307 | 2,121 | 186 | 211 | 211 | 0 |
| 25-29 | 2,090 | 1,526 | 564 | 121 | 108 | 13 | 1,969 | 1,706 | 263 | 108 | 108 | 0 |
| 30-34 | 2,080 | 1,508 | 572 | 100 | 76 | 24 | 1,419 | 1,204 | 215 | 198 | 174 | 24 |
| 35-39 | 1,854 | 1,232 | 622 | 98 | 87 | 11 | 1,496 | 1,174 | 322 | 150 | 107 | 43 |
| 40-44 | 1,731 | 1,062 | 669 | 252 | 214 | 38 | 1,595 | 1,242 | 353 | 156 | 137 | 19 |
| 45-49 | 1,087 | 725 | 362 | 169 | 127 | 42 | 1,078 | 800 | 278 | 145 | 120 | 25 |
| 50-54 | 708 | 489 | 219 | 244 | 193 | 51 | 892 | 760 | 132 | 78 | 71 | 7 |
| 55-59 | 515 | 353 | 162 | 108 | 71 | 37 | 496 | 434 | 62 | 49 | 43 | 6 |
| 60-64 | 342 | 175 | 167 | 186 | 108 | 78 | 334 | 287 | 47 | 18 | 18 | 0 |
| 65-69 | 255 | 127 | 128 | 186 | 105 | 81 | 270 | 240 | 30 | 4 | 4 | 0 |
| 70-74 | 153 | 92 | 61 | 248 | 140 | 108 | 234 | 220 | 14 | 6 | 6 | 0 |
| 75-79 | 150 | 95 | 55 | 244 | 132 | 112 | 144 | 123 | 21 | 2 | 2 | 0 |
| 80-84 | 93 | 51 | 42 | 261 | 122 | 139 | 89 | 83 | 6 | 0 | 0 | 0 |
| 85+ | 51 | 32 | 19 | 356 | 123 | 233 | 60 | 52 | 8 | 0 | 0 | 0 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics, 2003.
*In order to compute average number of years of life remaining the Abridged Life Table for Missouri for the year 2003 was used.[26]

Figures 61-63 portray the YPLL due to four major causes (total and by gender).

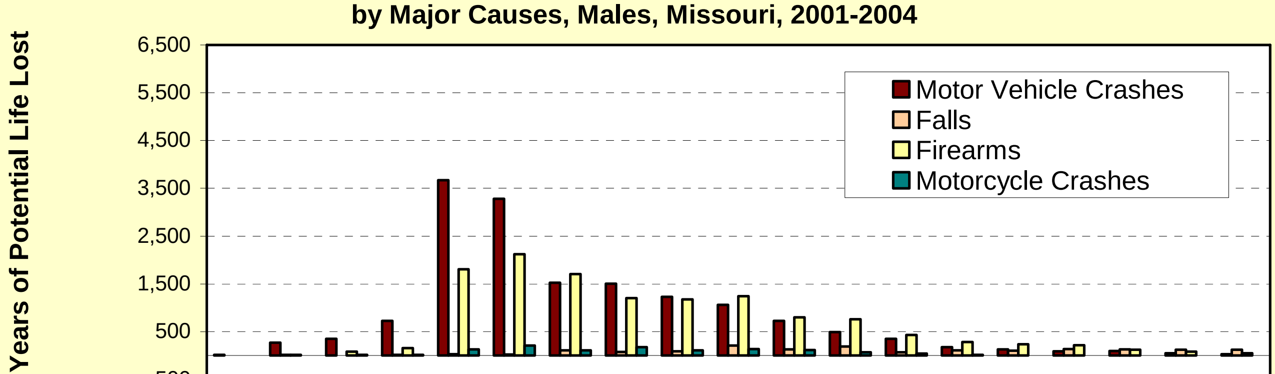
**Figure 61: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI by Major Causes and Age Groups, Missouri, 2001-04**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Motor Vehicle Crashes | 136 | 555 | 748 | 1,116 | 5,645 | 4,543 | 2,090 | 2,080 | 1,854 | 1,731 | 1,087 | 708 | 515 | 342 | 255 | 153 | 150 | 93 | 51 |
| Falls | 0 | 37 | 0 | 16 | 45 | 40 | 121 | 100 | 98 | 252 | 169 | 244 | 108 | 186 | 186 | 248 | 244 | 261 | 356 |
| Firearms | 0 | 18 | 156 | 222 | 1,994 | 2,307 | 1,969 | 1,419 | 1,496 | 1,595 | 1,078 | 892 | 496 | 334 | 270 | 234 | 144 | 89 | 60 |
| Motorcycle Crashes | 0 | 0 | 17 | 16 | 129 | 211 | 108 | 198 | 150 | 156 | 145 | 78 | 49 | 18 | 4 | 6 | 2 | 0 | 0 |

Age Groups

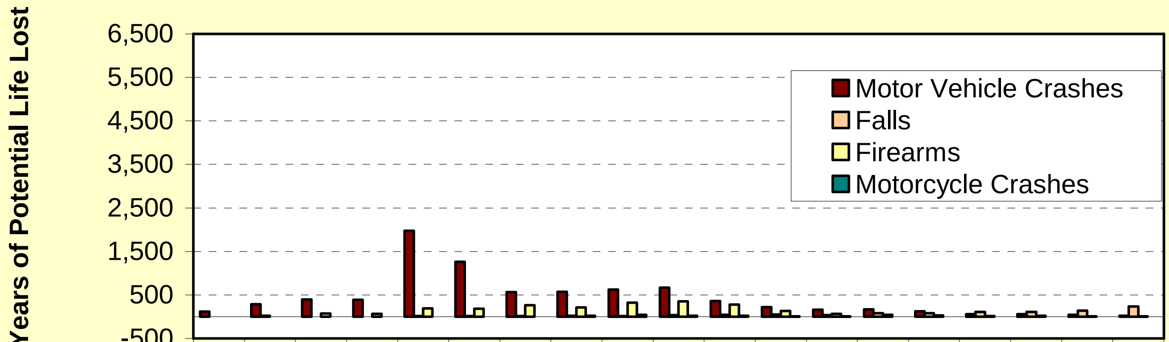
**Table 62: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI by Major Causes, Males, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Motor Vehicle Crashes | 18 | 268 | 352 | 730 | 3,670 | 3,281 | 1,526 | 1,508 | 1,232 | 1,062 | 725 | 489 | 353 | 175 | 127 | 92 | 95 | 51 | 32 |
| Falls | 0 | 18 | 0 | 16 | 29 | 26 | 108 | 76 | 87 | 214 | 127 | 193 | 71 | 108 | 105 | 140 | 132 | 122 | 123 |
| Firearms | 0 | 18 | 84 | 155 | 1,807 | 2,121 | 1,706 | 1,204 | 1,174 | 1,242 | 800 | 760 | 434 | 287 | 240 | 220 | 123 | 83 | 52 |
| Motorcycle Crashes | 0 | 0 | 17 | 16 | 129 | 211 | 108 | 174 | 107 | 137 | 120 | 71 | 43 | 18 | 4 | 6 | 2 | 0 | 0 |

Age Groups

**Table 63: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI by Major Causes, Females, Missouri, 2001-2004**

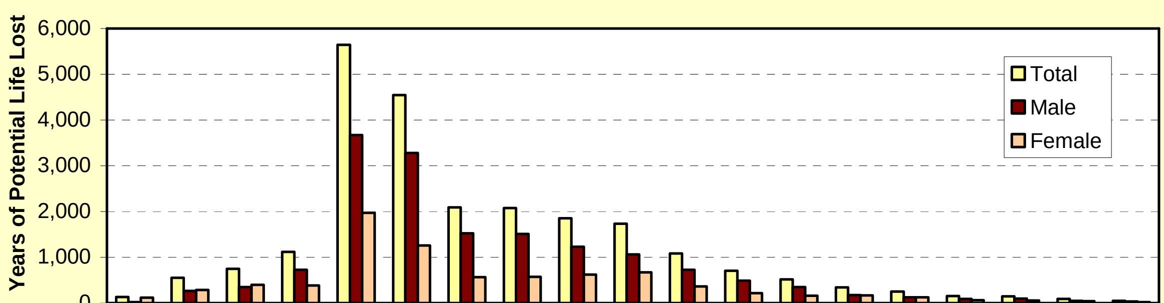



| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Motor Vehicle Crashes | 118 | 287 | 396 | 386 | 1,975 | 1,262 | 564 | 572 | 622 | 669 | 362 | 219 | 162 | 167 | 128 | 61 | 55 | 42 | 19 |
| Falls | 0 | 19 | 0 | 0 | 16 | 14 | 13 | 24 | 11 | 38 | 42 | 51 | 37 | 78 | 81 | 108 | 112 | 139 | 233 |
| Firearms | 0 | 0 | 72 | 67 | 187 | 186 | 263 | 215 | 322 | 353 | 278 | 132 | 62 | 47 | 30 | 14 | 21 | 6 | 8 |
| Motorcycle Crashes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 43 | 19 | 25 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |

**Age Groups**

YPLL due to mortalities resulting from traumatic brain injury in Missouri, annually during 2001-2004, by four major causes (motor vehicle crashes, falls-unintentional, all firearms (not just unintentional) and motorcycle crashes) are depicted in Figures 64-67.

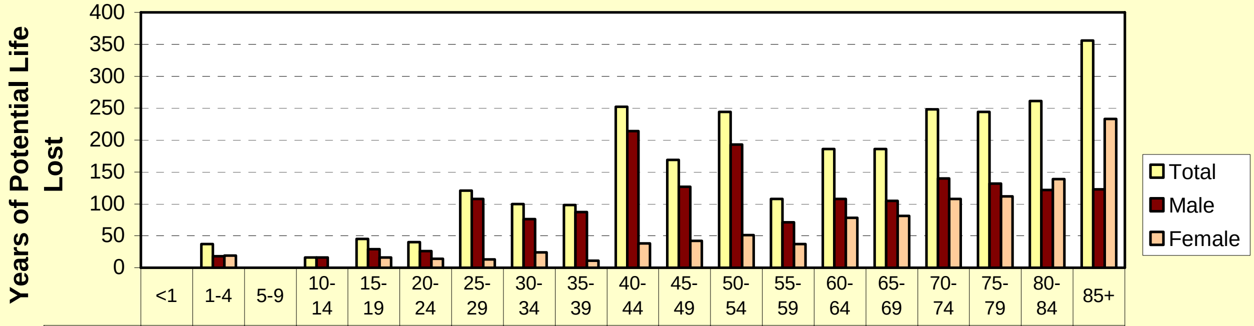
**Table 64: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI for Motor Vehicle Crashes by Age Groups and Gender, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 136 | 555 | 748 | 1,116 | 5,645 | 4,543 | 2,090 | 2,080 | 1,854 | 1,731 | 1,087 | 708 | 515 | 342 | 255 | 153 | 150 | 93 | 51 |
| Male | 18 | 268 | 352 | 730 | 3,670 | 3,281 | 1,526 | 1,508 | 1,232 | 1,062 | 725 | 489 | 353 | 175 | 127 | 92 | 95 | 51 | 32 |
| Female | 118 | 287 | 396 | 386 | 1,975 | 1,262 | 564 | 572 | 622 | 669 | 362 | 219 | 162 | 167 | 128 | 61 | 55 | 42 | 19 |

**Age Groups**

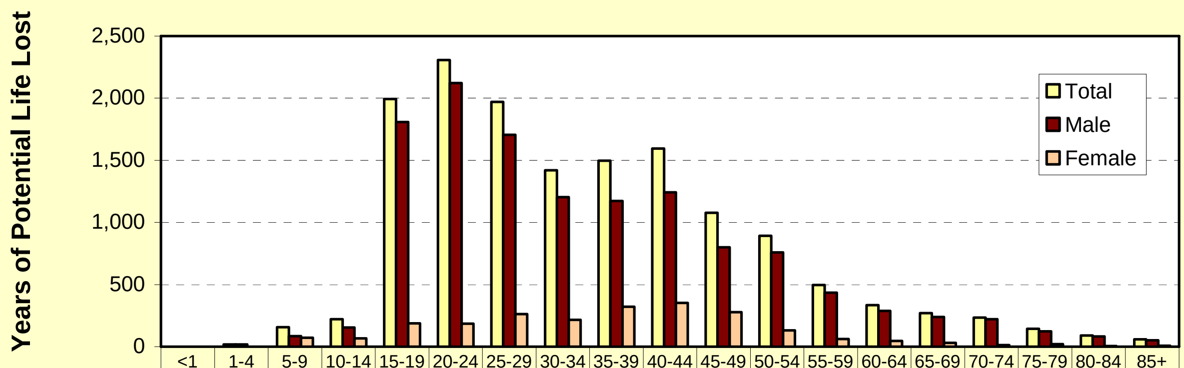
**Table 65: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI for Unintentional Falls by Age Groups and Gender, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0 | 37 | 0 | 16 | 45 | 40 | 121 | 100 | 98 | 252 | 169 | 244 | 108 | 186 | 186 | 248 | 244 | 261 | 356 |
| Male | 0 | 18 | 0 | 16 | 29 | 26 | 108 | 76 | 87 | 214 | 127 | 193 | 71 | 108 | 105 | 140 | 132 | 122 | 123 |
| Female | 0 | 19 | 0 | 0 | 16 | 14 | 13 | 24 | 11 | 38 | 42 | 51 | 37 | 78 | 81 | 108 | 112 | 139 | 233 |

Age Groups

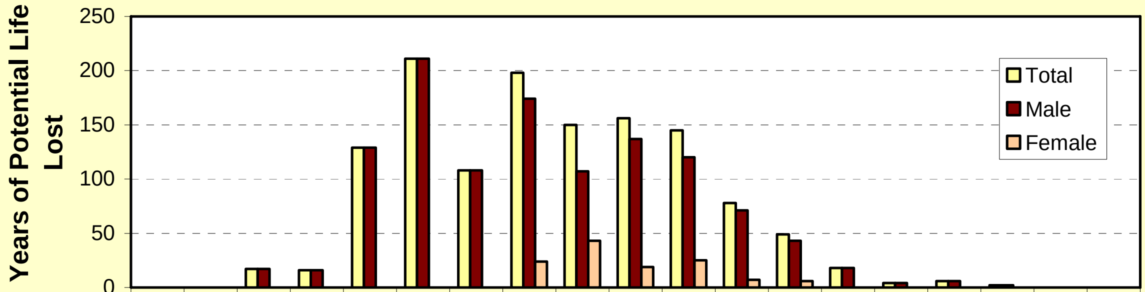
**Table 66: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI for Firearms by Age Groups and Gender, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0 | 18 | 156 | 222 | 1,994 | 2,307 | 1,969 | 1,419 | 1,496 | 1,595 | 1,078 | 892 | 496 | 334 | 270 | 234 | 144 | 89 | 60 |
| Male | 0 | 18 | 84 | 155 | 1,807 | 2,121 | 1,706 | 1,204 | 1,174 | 1,242 | 800 | 760 | 434 | 287 | 240 | 220 | 123 | 83 | 52 |
| Female | 0 | 0 | 72 | 67 | 187 | 186 | 263 | 215 | 322 | 353 | 278 | 132 | 62 | 47 | 30 | 14 | 21 | 6 | 8 |

Age Groups

**Table 67: Annual Years of Potential Life Lost Due to Mortality Resulting from TBI for Motorcycle Crashes by Age Groups and Gender, Missouri, 2001-2004**




| | <1 | 1-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 0 | 0 | 17 | 16 | 129 | 211 | 108 | 198 | 150 | 156 | 145 | 78 | 49 | 18 | 4 | 6 | 2 | 0 | 0 |
| Male | 0 | 0 | 17 | 16 | 129 | 211 | 108 | 174 | 107 | 137 | 120 | 71 | 43 | 18 | 4 | 6 | 2 | 0 | 0 |
| Female | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 43 | 19 | 25 | 7 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |

Age Groups

## Productivity Loss

Unavailability of Missouri specific 2004 estimates of Present Discounted Value of Future Earnings (PDVFE) rendered using the national estimates for 2000 computed by Max et. al. (2004) to estimate the PDVFE for Missouri for the year 2004.[21] The PDVFE was computed by age, gender, and 5% discount rate for the year 2000. The productivity losses due to TBI-related deaths were generated with the annual average mortality for the years 2001-2004 and the PDVFE in 2000 at the national level. Missouri's estimated total productivity losses due to TBI-related deaths was about $796 million annually, of that amount, about 82% is attributable to males while 18% is attributable to females (Table 11).

| Table 11: Productivity Losses due to TBI-related Deaths by Age Groups and Gender, 2001-2004* | | | |
|---|---|---|---|
| **Age Groups** | **All** | **Male** | **Females** |
| **Missouri** | **$795,511,063** | **$653,045,839** | **$142,465,225** |
| **Percent** | | **82%** | **18%** |
| <1 | $2,438,465 | $1,695,673 | $742,792 |
| 1-4 | $7,486,487 | $4,412,447 | $3,074,040 |
| 5-9 | $8,165,211 | $4,623,108 | $3,542,104 |
| 10-14 | $16,717,161 | $11,819,177 | $4,897,984 |
| 15-19 | $116,677,139 | $91,509,068 | $25,168,072 |
| 20-24 | $135,229,870 | $113,896,168 | $21,333,703 |
| 25-29 | $98,177,049 | $83,582,049 | $14,595,000 |
| 30-34 | $89,264,491 | $75,819,296 | $13,445,195 |
| 35-39 | $88,918,140 | $72,389,174 | $16,528,966 |
| 40-44 | $91,351,773 | $73,630,917 | $17,720,856 |
| 45-49 | $60,328,407 | $49,693,578 | $10,634,829 |
| 50-54 | $41,989,836 | $36,902,325 | $5,087,511 |
| 55-59 | $19,906,873 | $17,496,630 | $2,410,243 |
| 60-64 | $9,560,964 | $7,779,276 | $1,781,688 |
| 65-69 | $4,858,739 | $4,025,632 | $833,108 |
| 70-74 | $2,615,168 | $2,261,629 | $353,539 |
| 75-79 | $1,176,578 | $979,605 | $196,973 |
| 80-84 | $536,192 | $420,793 | $115,400 |
| 85+ | $112,522 | $109,297 | $3,225 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics. Max et. al. (2004).
*Present Value of Future Earnings by age, gender, and 5% discount rate for the year 2000 calculated by Max et. al. 2004 was used to calculate the productivity losses from TBI.[21]

Figures 68-70 present productivity losses for major causes by gender and age groups. Motor vehicle crash related productivity losses were the leading cause followed by firearms. A similar pattern was observed for both genders. These two mechanisms were the leading causes of productivity losses between the ages of 15-50.

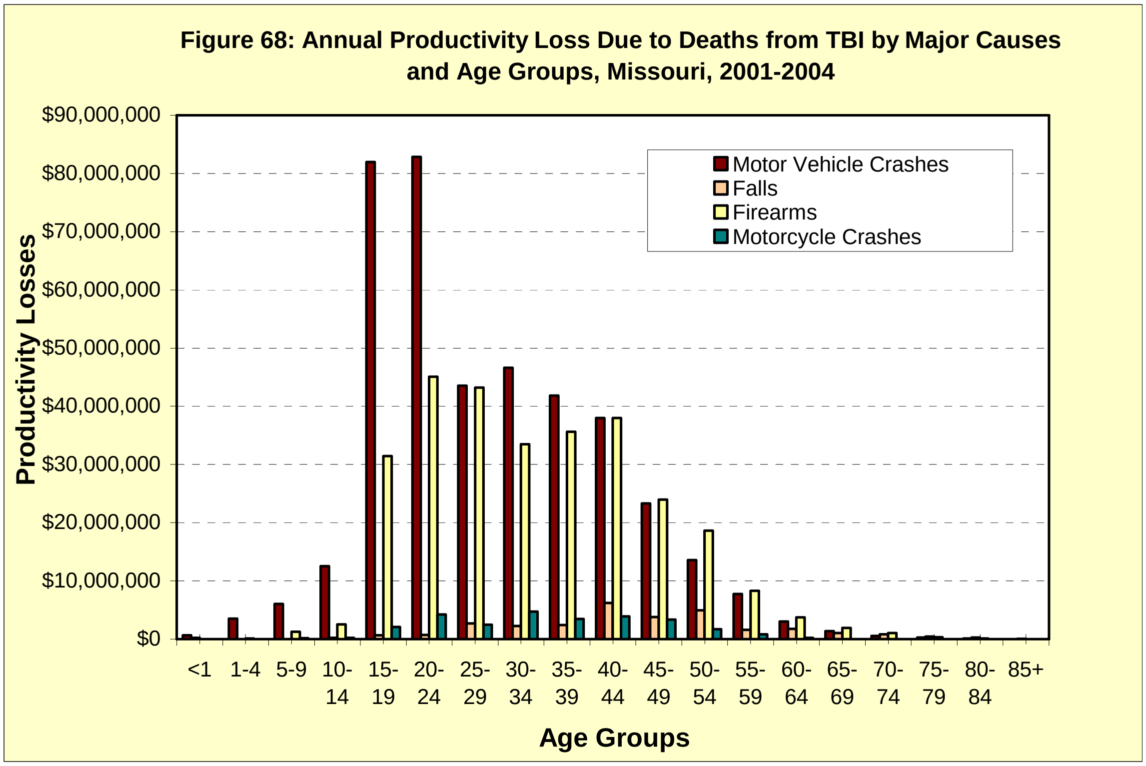


Figure 68: Annual Productivity Loss Due to Deaths from TBI by Major Causes and Age Groups, Missouri, 2001-2004
Productivity Losses
$90,000,000
$80,000,000
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Motor Vehicle Crashes
Falls
Firearms
Motorcycle Crashes
<1
1-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Age Groups

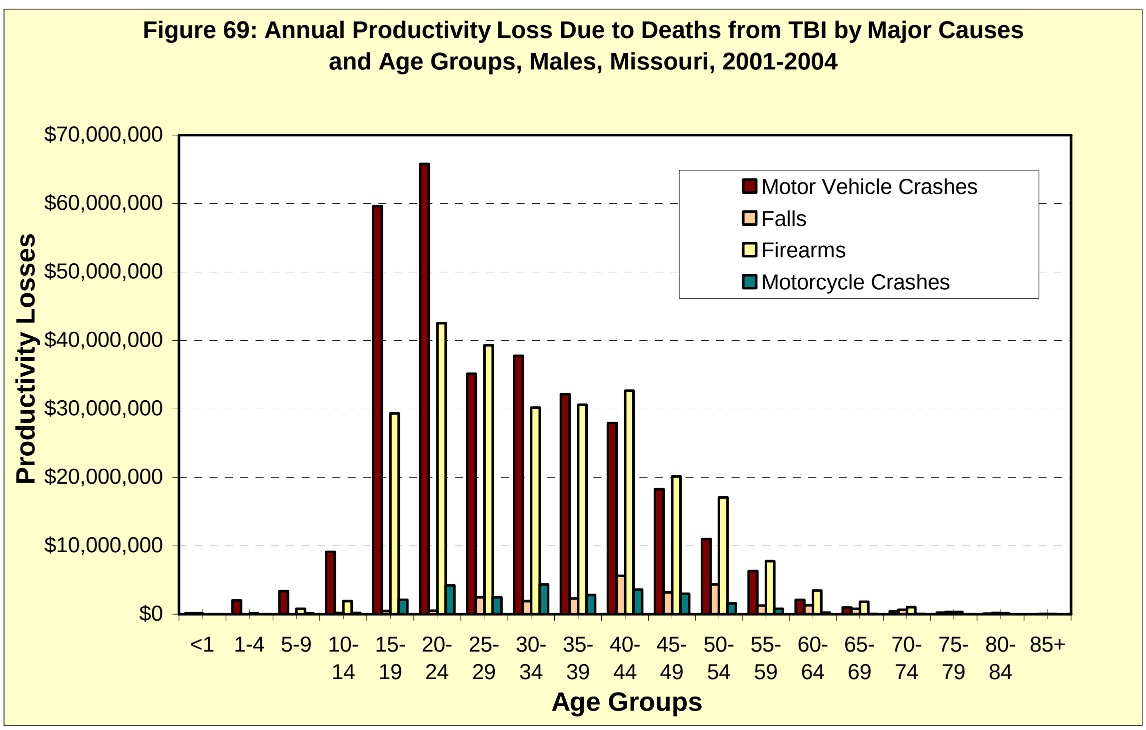


Figure 69: Annual Productivity Loss Due to Deaths from TBI by Major Causes and Age Groups, Males, Missouri, 2001-2004
Productivity Losses
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Motor Vehicle Crashes
Falls
Firearms
Motorcycle Crashes
<1
1-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Age Groups

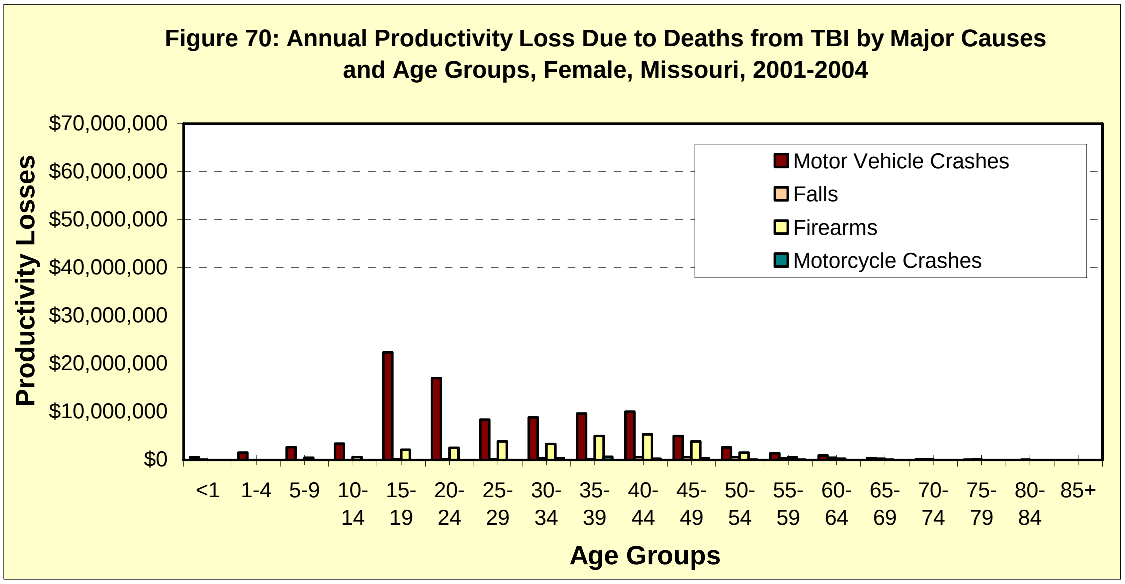


Figure 70: Annual Productivity Loss Due to Deaths from TBI by Major Causes and Age Groups, Female, Missouri, 2001-2004
Productivity Losses
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Motor Vehicle Crashes
Falls
Firearms
Motorcycle Crashes
<1
1-4
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85+
Age Groups

The estimated annual productivity loss in Missouri due to TBI-related deaths by motor vehicle crashes was $407 million for all age groups (Table 12). The estimated annual productivity loss for all age groups of males in Missouri was $312 million (77%), while the estimated productivity loss for all age groups of females in Missouri was $95 million (23%). The largest estimated productivity losses for both males and females in Missouri were in the 15-19 and 20-24 age groups with estimated total losses of $81 million and $82 million respectively. The estimated total productivity loss for Missouri males in the 5-19 age group was $59 million versus $22 million for Missouri females in the same age group. The estimated total productivity cost for males in Missouri aged 20-24 was $65 million versus $17 million for females in the same age group.

**Table 12: Annual Productivity Losses due to TBI-related Deaths for Motor Vehicle Traffic Crashes by Age Groups and Gender, Missouri, 2001-2004***

| Age Groups | Total | Male | Female |
|---|---|---|---|
| **Missouri** | **$407,524,989** | **$312,365,006** | **$95,159,983** |
| **Percent** | | **77%** | **23%** |
| <1 | $678,214 | $121,120 | $557,094 |
| 1-4 | $3,542,678 | $2,005,658 | $1,537,020 |
| 5-9 | $6,034,881 | $3,347,768 | $2,687,113 |
| 10-14 | $12,520,325 | $9,106,579 | $3,413,746 |
| 15-19 | $81,961,024 | $59,608,960 | $22,352,064 |
| 20-24 | $82,867,764 | $65,800,802 | $17,066,962 |
| 25-29 | $43,516,542 | $35,148,742 | $8,367,800 |
| 30-34 | $46,614,447 | $37,773,771 | $8,840,676 |
| 35-39 | $41,828,480 | $32,144,843 | $9,683,637 |
| 40-44 | $38,006,244 | $27,921,204 | $10,085,040 |
| 45-49 | $23,283,874 | $18,258,625 | $5,025,249 |
| 50-54 | $13,585,210 | $10,998,340 | $2,586,870 |
| 55-59 | $7,742,462 | $6,318,228 | $1,424,235 |
| 60-64 | $3,041,543 | $2,106,887 | $934,656 |
| 65-69 | $1,368,209 | $958,484 | $409,725 |
| 70-74 | $528,055 | $418,336 | $109,719 |
| 75-79 | $288,444 | $234,017 | $54,427 |
| 80-84 | $100,460 | $76,733 | $23,727 |
| 85+ | $16,135 | $15,910 | $225 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics. Max et. al. (2004).

*Present Value of Future Earnings by age, gender, and 5% discount rate for the year 2000 calculated by Max et. al. 2004 was used to calculate the productivity losses due to deaths resulting from TBI.[21]

Total estimated productivity loss in Missouri for all age groups attributable to TBI-related deaths caused by unintentional falls was $30 million (Table 13). Mortality among Missouri males for all age groups accounted for almost $26 million of the estimated productivity loss due to unintentional falls while Missouri females accounted for $4 million of the total estimated productivity loss due to unintentional falls.

**Table 13: Annual Productivity Losses due to TBI-related Deaths for Unintentional Falls by Age Groups and Gender, Missouri, 2001-2004***

| Age Groups | Total | Male | Female |
|---|---|---|---|
| **Missouri** | **$30,087,638** | **$25,716,414** | **$4,371,224** |
| **Percent** | | **85%** | **15%** |
| <1 | $213,969 | $121,120 | $92,849 |
| 1-4 | $0 | $0 | $0 |
| 5-9 | $0 | $0 | $0 |
| 10-14 | $193,757 | $193,757 | $0 |
| 15-19 | $641,696 | $465,695 | $176,001 |
| 20-24 | $722,463 | $528,521 | $193,943 |
| 25-29 | $2,685,456 | $2,490,856 | $194,600 |
| 30-34 | $2,270,638 | $1,902,276 | $368,362 |
| 35-39 | $2,444,940 | $2,277,981 | $166,959 |
| 40-44 | $6,205,563 | $5,629,275 | $576,288 |
| 45-49 | $3,784,297 | $3,199,965 | $584,331 |
| 50-54 | $4,945,053 | $4,341,450 | $603,603 |
| 55-59 | $1,592,315 | $1,263,646 | $328,670 |
| 60-64 | $1,734,666 | $1,296,546 | $438,120 |
| 65-69 | $1,053,665 | $794,172 | $259,493 |
| 70-74 | $835,633 | $640,577 | $195,056 |
| 75-79 | $437,980 | $326,535 | $111,445 |
| 80-84 | $261,899 | $183,169 | $78,731 |
| 85+ | $63,649 | $60,874 | $2,775 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics. Max et. al. (2004).

*Present Value of Future Earnings by age, gender, and 5% discount rate for the year 2000 calculated by Max et. al. 2004 was used to calculate the productivity losses due to deaths resulting from the TBI.[21]

Total estimated productivity loss due to TBI-related deaths by all firearms for all Missouri age groups was $289 million (Table 14). Missouri males of all age groups accounted for $259 million, while Missouri females of all age groups accounted for $29 million.

**Table 14: Annual Productivity Losses due to TBI-related Deaths for Firearms by Age Groups and Gender, Missouri, 2001-2004***

| Age Groups | Total | Male | Female |
|---|---|---|---|
| **Missouri** | **$288,838,735** | **$259,213,107** | **$29,625,628** |
| **Percent** | | **90%** | **10%** |
| <1 | $0 | $0 | $0 |
| 1-4 | $133,711 | $133,711 | $0 |
| 5-9 | $1,285,654 | $797,088 | $488,566 |
| 10-14 | $2,531,265 | $1,937,570 | $593,695 |
| 15-19 | $31,450,791 | $29,338,785 | $2,112,006 |
| 20-24 | $45,067,156 | $42,545,900 | $2,521,256 |
| 25-29 | $43,192,169 | $39,300,169 | $3,892,000 |
| 30-34 | $33,479,920 | $30,164,666 | $3,315,254 |
| 35-39 | $35,634,967 | $30,626,189 | $5,008,778 |
| 40-44 | $37,980,459 | $32,649,795 | $5,330,664 |
| 45-49 | $23,997,544 | $20,140,958 | $3,856,586 |
| 50-54 | $18,628,492 | $17,076,370 | $1,552,122 |
| 55-59 | $8,324,063 | $7,776,280 | $547,783 |
| 60-64 | $3,720,328 | $3,457,456 | $262,872 |
| 65-69 | $1,903,029 | $1,807,427 | $95,603 |
| 70-74 | $1,031,003 | $1,006,621 | $24,382 |
| 75-79 | $325,500 | $304,766 | $20,734 |
| 80-84 | $126,998 | $123,763 | $3,236 |
| 85+ | $25,689 | $25,595 | $94 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics. Max et. al. (2004).

*Present Value of Future Earnings by age, gender, and 5% discount rate for the year 2000 calculated by Max et. al. 2004 was used to calculate the productivity losses due to deaths resulting from TBI.[21]

Estimated total productivity loss in Missouri for all age groups due to TBI-related deaths by motorcycle crashes was $27 million (Table 15). Lost contribution of Missouri's males was $25.6 million while for females this cost was $1.8 million.

**Table 15: Annual Productivity Losses due to TBI-related Deaths for Motorcycle Crashes by Age Groups and Gender, Missouri, 2001-2004***

| Age Groups | Total | Male | Female |
|---|---|---|---|
| **Missouri** | **$27,375,055** | **$25,559,106** | **$1,815,949** |
| **Percent** | | **93%** | **7%** |
| <1 | $0 | $0 | $0 |
| 1-4 | $0 | $0 | $0 |
| 5-9 | $159,418 | $159,418 | $0 |
| 10-14 | $193,757 | $193,757 | $0 |
| 15-19 | $2,095,628 | $2,095,628 | $0 |
| 20-24 | $4,228,164 | $4,228,164 | $0 |
| 25-29 | $2,490,856 | $2,490,856 | $0 |
| 30-34 | $4,716,422 | $4,348,060 | $368,362 |
| 35-39 | $3,452,036 | $2,784,199 | $667,837 |
| 40-44 | $3,890,880 | $3,602,736 | $288,144 |
| 45-49 | $3,362,331 | $3,011,732 | $350,599 |
| 50-54 | $1,678,094 | $1,591,865 | $86,229 |
| 55-59 | $832,406 | $777,628 | $54,778 |
| 60-64 | $216,091 | $216,091 | $0 |
| 65-69 | $27,385 | $27,385 | $0 |
| 70-74 | $26,146 | $26,146 | $0 |
| 75-79 | $5,442 | $5,442 | $0 |
| 80-84 | $0 | $0 | $0 |
| 85+ | $0 | $0 | $0 |

Source: Missouri Department of Health and Senior Services, Missouri Vital Statistics. Max et. al. (2004).

*Present Value of Future Earnings by age, gender, and 5% discount rate for the year 2000 calculated by Max et. al. 2004 was used to calculate the productivity losses due to deaths resulting from TBI.[21]

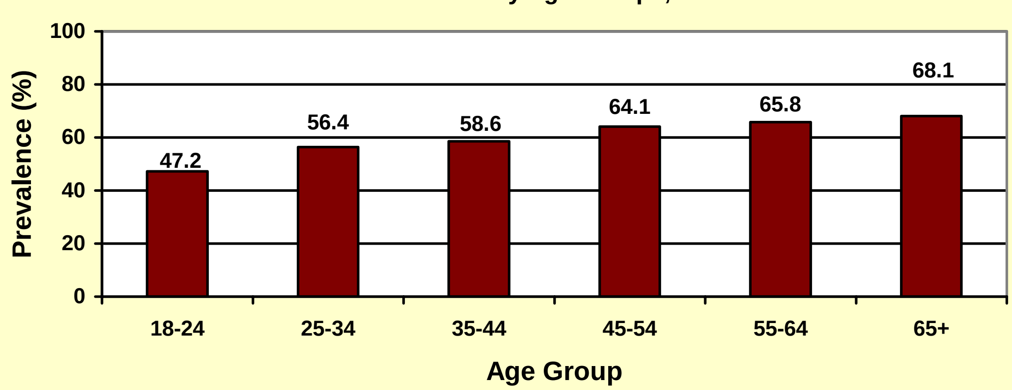
# SAFETY ISSUES & PREVENTIVE PRACTICES 8

The leading causes of TBI-related morbidity and mortality are falls/jumps primarily among the youngest and oldest population subgroups, motor vehicle crashes in traffic or in non-traffic locations, being involved in a physical altercation or struck by a blunt object, and the use of firearms. Preventing or reducing such injuries can be achieved through wide adoption of knowledge-based safety precautions by the population.

## Falls

There is little detailed information within the current surveillance systems pertaining to jumps. However, when comparing falls that occurred within the past year among adults by age group, there is an increase in falls by age (Figure 71).[13]

Figure 71. Prevalence of Falls Among Missouri Adults (age 18 and older) Within the Past 12 Months by Age Groups, BRFSS 2004



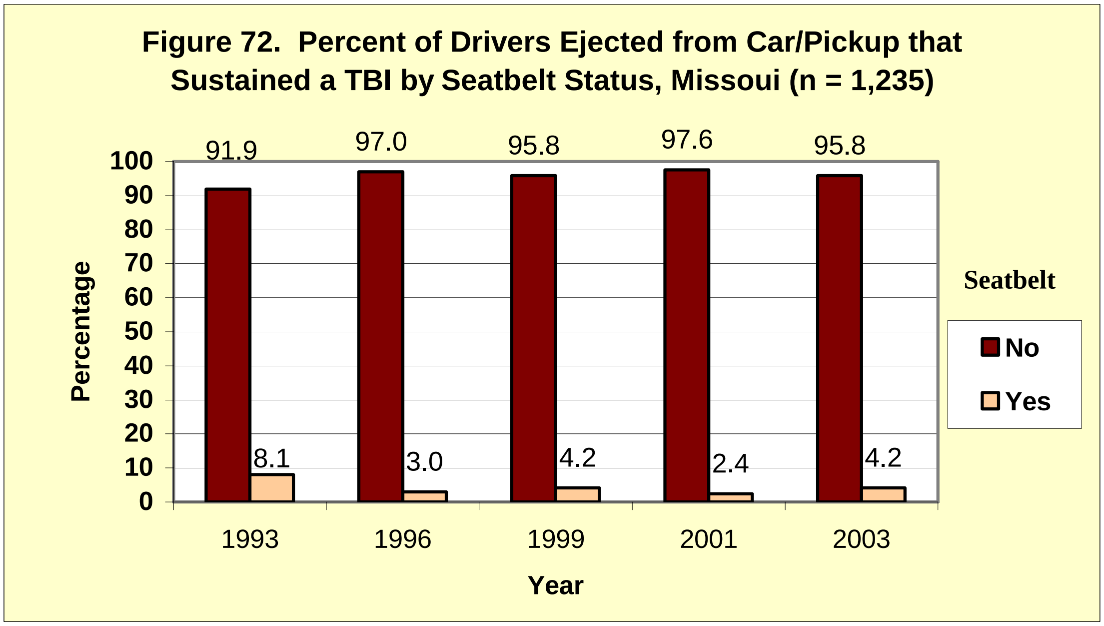

A number of risk factors have been associated with falls among older adults including impairments in cognition, vision, hearing, feet, lower extremity strength, balance or gait, blood pressure regulation upon standing, as well as the total number of medications being used and in particular, the use of sedative hypnotics.[27-29] In fact, the greater the number of risk factors the higher the risk of falling. It is estimated that if an elderly person (age 70 or greater) has four or more risk factors, their chance of falling is 78%.[28] In addition, taking four or more medications (including over the counter medications) also places a person at high risk of falling. Implementing measures to reduce falls, particularly among the elderly, will substantially reduce the number of TBI-related ED visits and hospitalizations among this group.

## Motor Vehicle Traffic Crashes

### Seatbelts

Seatbelt use while driving can be an important safety device in reducing the impact from a motor vehicle crash. The Motor Vehicle Crash Variables and Outcomes for Drivers MICA was queried to determine the impact of the use and non-use of safety belts on being ejected from a car or pick-up truck during a motor vehicle crash for five years–1993, 1996, 1999, 2001 and 2003.[14] These are the five years of data currently in this MICA.

For these five years, a total of 17, 068 car and pickup crashes resulted in drivers sustaining a TBI. Of these, 1,345 drivers were ejected from a car or pickup truck. Of this total, the seatbelt status is unknown for 110 drivers. Figure 72 shows the percentage of drivers ejected from a car or pickup truck by seatbelt status and year. Overall for these five years, of those with known seatbelt status, 95.9% (1,184) were not wearing a seatbelt. Of the 281 drivers who were ejected and died with seatbelt status known, 96.4% (271) were not wearing a seatbelt. Based on the same five years of data, when a TBI occurred there was a 3.9 times greater risk of dying if not wearing a seatbelt. These data clearly show that not wearing a seatbelt increases the risk of the driver being ejected as well as TBI-related death.

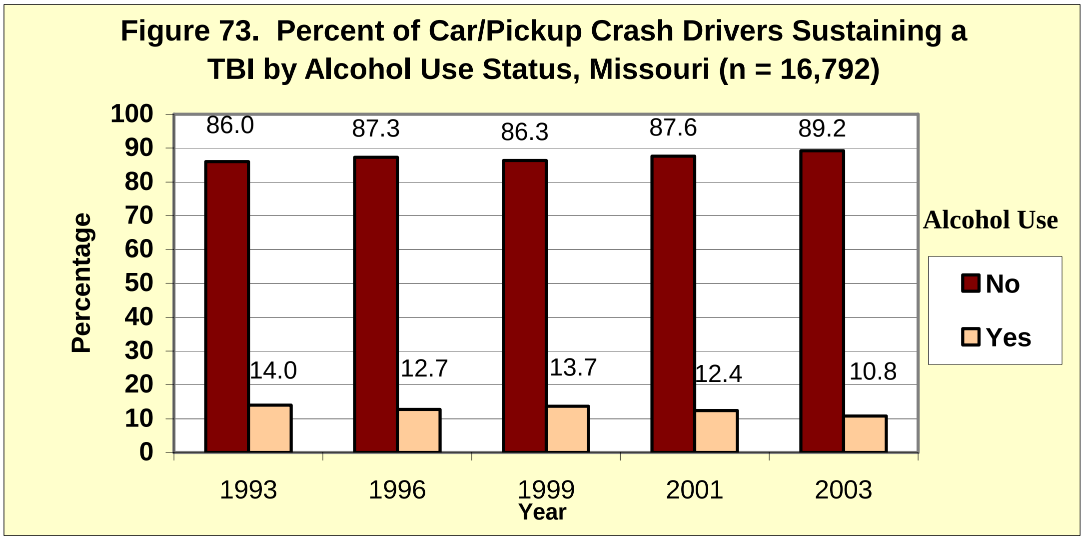



## Driving Impaired (Alcohol)

Operating a motor vehicle impaired, particularly under the influence of alcohol, is also an important risk factor for motor vehicle crashes. In 2001, the alcohol-related fatality rate from all motor vehicle crashes in the U.S. was 0.63 per 100 million vehicle miles of travel (VMT).[30] For the same year, the alcohol-related fatality rate from motorcycle crashes was 14.3 fatalities per 100 million VMT, or 22.7 times higher than the rate for all motor vehicles. This demonstrates that consuming alcohol while operating motorcycles is especially dangerous.

Figure 73 depicts the percentage of car/pickup crashes in which the driver sustained a head injury by alcohol status and year.[14] "Alcohol Use" is defined as a citation for alcohol use and based on the judgment of the investigating officer that alcohol use contributed to the crash. Figure 73 reveals that alcohol use contributed to approximately 11-14% of the car and pickup crashes per year that resulted in traumatic brain injuries in the drivers. While this might appear to be a small percentage, car and pickup drivers in alcohol-related crashes were at a 4.9 times greater risk of sustaining a TBI and almost two times (1.9) greater risk of not surviving the TBI.

Initiating measures to reduce drinking and driving would be an important measure for reducing motor vehicle crashes and the severity of such accidents.




## Helmets

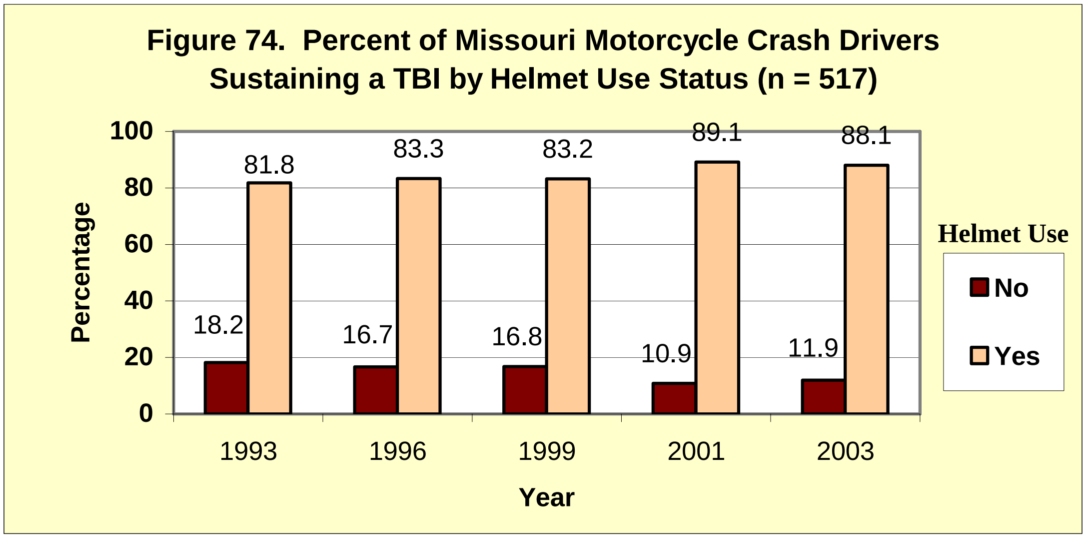
Helmet use when riding a motorcycle, all terrain vehicle (ATV) or bicycle is an important safety device that can reduce the impact of vehicle crashes on head injuries. Again, the Motor Vehicle Crash Variables and Outcomes for Drivers MICA was queried to determine the impact of the use and non-use of helmets in motorcycle, ATV, and bicycle crashes for five years–1993, 1996, 1999, 2001 and 2003.[14]

While it is realized that not all motorcycle crashes will be prevented, the overarching goals are to reduce fatalities and mitigate injuries.[30] Although only 3% of registered passenger vehicles in the U.S. are motorcycles, motorcyclist fatalities represent about 9% of all passenger vehicle occupant fatalities.[31] Nationally, from 1990-2001, motorcycle fatalities in the 20-29 year old age group decreased, while fatalities in the 40 and over age groups increased. In addition, the mean age of motorcyclists' fatalities has also increased from 29.3 years in 1990 to 36.3 years in 2001.

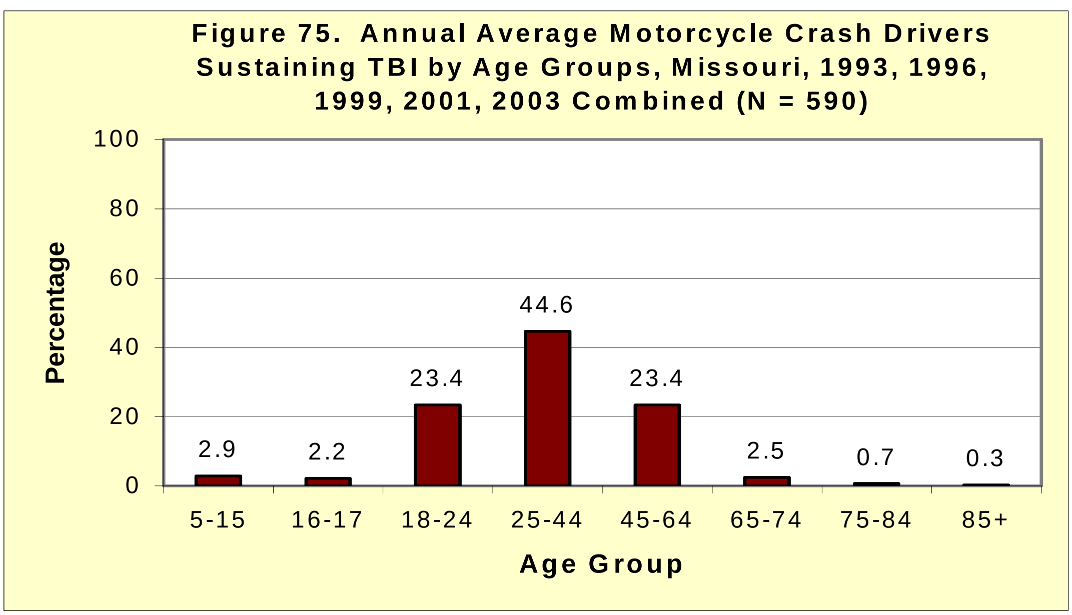
There are several reasons why motorcycles are more likely to be in crashes–they are less stable and less visible than cars, they have high performance capabilities and their riders lack the protection of an enclosed vehicle.[32] Since head injury is the leading cause of death in motorcycle crashes, helmets are designed to cushion and protect riders' heads from the impact of a crash thus decreasing brain injuries by 67%, reducing the likelihood of death by as much as 37% and preventing an overall increase in the cost of medical care–inpatient charges due to TBI which would almost double with less helmet use.[31, 33]

For the five years queried, a total of 590 Missouri drivers sustained a TBI from a motorcycle crash. Alcohol use was involved in approximately 12.4% of these crashes. Motorcyclists consuming alcohol and crashing had over twice the risk (2.1 RR) of sustaining a TBI and not surviving their brain injury (2.1 RR). Of the 517 injured in these five years with a helmet status known, 14.1% (73) were not wearing a helmet. Again, while this percentage seems low, motorcyclist in a crash not wearing a helmet had 2.7 times the risk of sustaining a TBI and a greater risk of not surviving the TBI (1.3 RR). Figure 74 shows the percentage of motorcycle drivers involved in a crash and sustaining a TBI by helmet status and year.[14]

As shown in the graph, the majority of motorcycle drivers injured were wearing a helmet. However, of the 590 motorcycle drivers sustaining a TBI, 12.0% (71) died; 12 of the 71 who died were not wearing a helmet and the helmet status was unknown for 4.

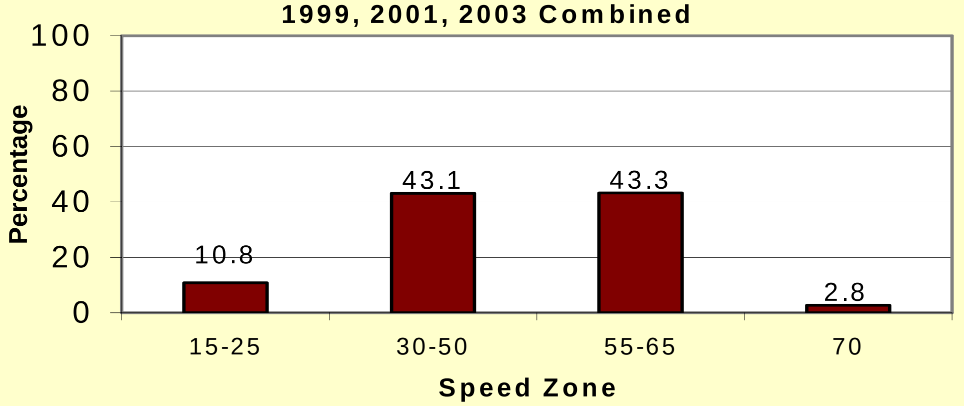



Finding that the majority of motorcycle drivers involved in a crash were wearing a helmet is not surprising since Missouri has had a universal helmet law (302.020 RSMo) since 1967, meaning mandatory helmet use for every person operating or riding as a passenger on any motorcycle or motortricycle. As shown in Figure 75, the largest proportion of motorcycle drivers in Missouri involved in a crash and sustaining a TBI were in the age group 25-44.[14] This age group also experienced the most fatalities for the five years combined (33 of the 71 deaths).



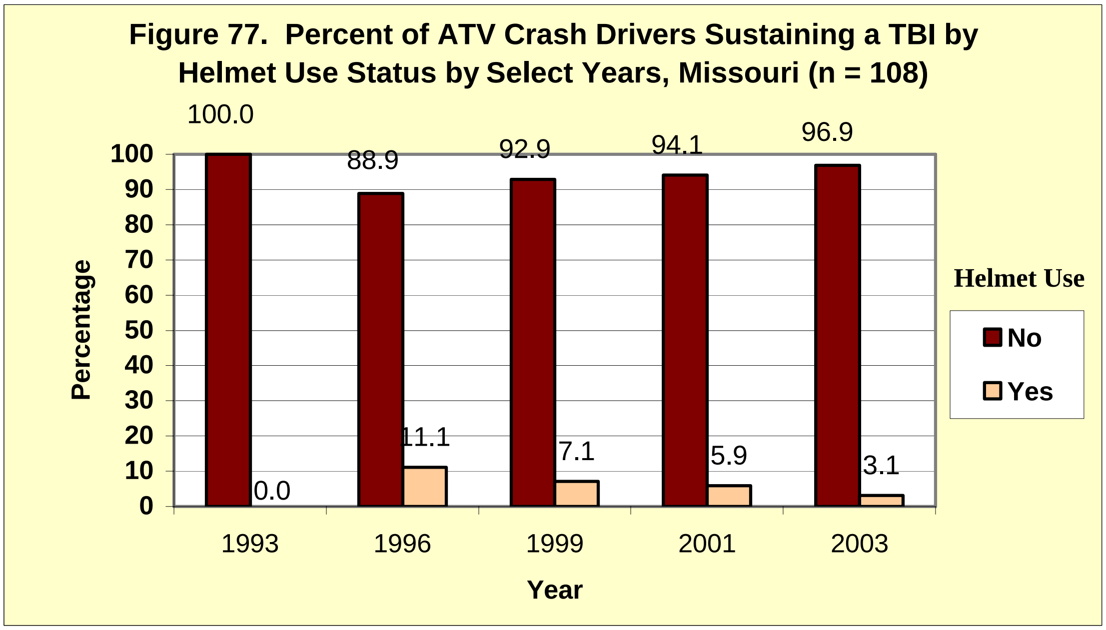
In addition, as shown in Figure 76, the majority of the motorcycle crashes occurred in speed zones posted as greater than 30 miles per hour, but the majority of deaths (47.8%) occurred in the 55-65 miles per hour zone.[14] Based on national data, other contributing factors in motorcycle fatalities include speeding; problems negotiating a curve prior to a crash; riding off the roadway (e.g., on the shoulder, median, roadside, outside right-of-way and off roadway); riding at night; riding on undivided-rural roadways; and collisions with fixed objects.[30]

**Figure 76. Motorcycle Crashes, Driver Sustaining TBI by Speed Zone Posting, Missouri, 1993, 1996, 1999, 2001, 2003 Combined**

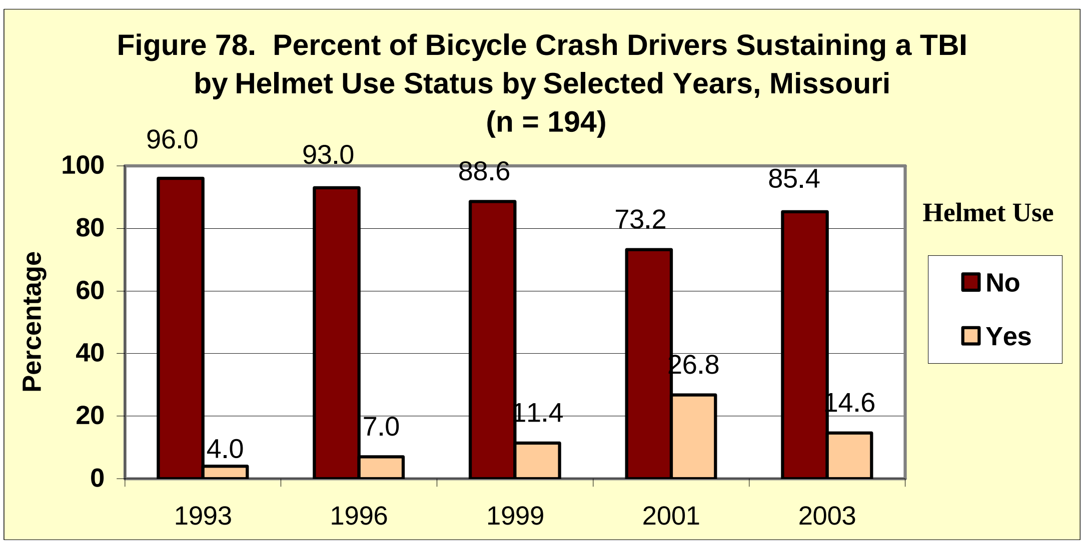



A special in-depth study beyond the scope of this report would be required to determine if greater traumatic brain injuries would be expected in Missouri without the universal helmet law. However, based on states that have repealed or weakened their universal helmet use law, helmet use decreased (Colorado from 99% to 49%, Kentucky from 96% to 56% and Louisiana from 100% to 52%; fatalities increased by 21% (Arkansas), 31% (Texas), 50% (Kentucky) and over 100% (Louisiana); and injuries increased substantially (Louisiana 48% and Kentucky 34%).[31, 33]

When exploring helmet use for drivers of ATVs and bicycles, the data indicate that helmets provide protection from sustaining a TBI in a crash. ATV drivers that crashed not wearing a helmet were at three times the risk of sustaining a TBI than those drivers wearing a helmet. Bicyclist had almost two times the risk (1.8 RR) of sustaining a TBI in a crash if not wearing a helmet. The relative risks for selected factors are shown in Appendix 6. Figures 77 and 78 show the proportions of ATV drivers and bicyclists sustaining a TBI by helmet use.




For ATVs, a total of 131 drivers sustained a TBI during the five years queried, of which the helmet status of 23 was unknown. Of those with a known helmet status, 94.4% (102) were not wearing a helmet. For bicycles, a total of 425 drivers sustained a TBI during these five years, of which the helmet status of 231 was unknown. Of those with a known helmet status, 86.6% (168) were not wearing a helmet.



## Violence

As discussed under *Etiology of TBI in Missouri* (Chapter 4) in this report, being struck by or against an object or person is the third leading cause of TBI combined ED visits and hospitalizations in Missouri. The rate is highest in the 15-17 year old age group and showed a significant increase from 1999-2003, increasing 35.4% ($p < .0001$). The TBI combined ED visit and hospitalization rate from this cause is also higher among males compared to females. Therapeutic foster care, also known as therapy foster care or family-based treatment, places juvenile offenders in specially trained foster families for several months (average duration 6-7 months) where they are rewarded for positive social behavior and penalized for disruptive and aggressive behavior. This approach was found to reduce violent crime by youth 12-18 years of age by an estimated 70% when compared to similar youth in standard group residential treatment facilities. In addition, it is estimated that for every dollar invested in therapeutic foster care, about $14 are saved in justice system costs. However, the challenge to therapeutic foster care is recruiting and retaining foster families.

Children who have been physically abused are more likely to perpetrate aggressive behavior and violence later in their lives. Therefore, preventing child maltreatment, including abuse and neglect, may be an important factor in preventing violence among children. Programs may include training of parent(s) on care and parenting, child abuse and neglect prevention, problem solving and life skills, linkage with community services and many other services. Early childhood home visitation programs in high-risk families can be effective and these programs have shown up to a 40% reduction in child maltreatment episodes. Visits must occur during at least part of the child's first two years of life and longer duration programs produce larger effects. Programs of less than two years duration do not appear to be effective. Also professional home visitors may be more effective than trained paraprofessionals, but longer-duration programs with trained paraprofessionals can also be effective.

When TBI deaths are considered, almost one-third (32.4%) involved firearms and the majority were intentionally inflicted injuries, either by self (i.e., suicide) or another person through an assault or by homicide. While laws and policies have been shown to be effective strategies for improving important health outcomes (e.g., vaccinations and reducing alcohol impaired driving), additional research specifically on firearms laws and policies is needed. Nevertheless, firearm laws and policies such as bans on specified firearms or ammunition, restrictions on firearm acquisition, child access prevention laws and others are promising practices that may offer reasonable approaches to the problem of firearm-related violence.

In the U.S., suicide rates are lowest in the winter and highest in the spring and men are four times more likely to die from suicide then females. While easy access to lethal methods (e.g., firearms around the home that are loaded and unlocked) is the mechanism, the factors increasing the likelihood of suicide is frequently related to a history of mental disorders, particularly depression; alcohol and substance abuse; feelings of hopelessness; physical illness, isolation, a substantial loss; and/or cultural or religious beliefs that condone the practice. Prevention interventions that include screening; crisis intervention; referral; access to effective care for mental, physical, and substance abuse disorders; and family and community support are the most promising for reducing suicide deaths.

## Strategies to Reduce and Prevent TBI

Table 16 summarizes strategies from select references related to preventing and reducing TBI.[27-30, 34-36]

**Table 16. Summary of Evidence Supported Strategies to Prevent TBI by Cause**

| Cause of TBI | Preventive Strategies |
|---|---|
| **Falls** | ■ **Create safe environment**<br>❖ Remove tripping hazards<br>❖ Use of non-slip mats and grab bars in bathtub and showers<br>❖ Handrails and safety gates on stairways and improved lighting<br>❖ Window guards<br>❖ Playgrounds made of shock-absorbing material – hardwood mulch or sand<br>■ **Conduct Risk Assessment and implement measures to reduce risk**<br>■ **Increase Physical activity to improve balance and strength** |
| **Motor Vehicle Occupant Injury** | ■ **Use of child safety seats**<br>❖ Child safety seat laws<br>❖ Booster seat recommended when child reaches about 40 lbs and continue with booster seat until seatbelt fits properly – about 4'9" tall.<br>❖ Distribution & Education Campaigns<br>■ **Use of safety belts**<br>❖ Safety belt laws<br>❖ Primary enforcement laws<br>❖ Enhanced enforcement<br>■ **Reduce alcohol impaired driving**<br>❖ .08 blood alcohol content (BAC) laws<br>❖ Minimum legal drinking age laws<br>❖ Sobriety checkpoints<br>■ **Mass media campaigns** |
| **Motorcycles** (and other vehicles) | ■ **Use of helmet** (particularly helmets that meet or exceed the U.S. Department of Transportation's Federal Motor Vehicle Safety Standard No. 218)<br>■ **Use of other protective gear**<br>■ **Operator training**<br>■ **Riding unimpaired** |
| **Violence (**struck by or against an object or person, assault or suicide by discharge of a firearm) | ■ **Behavioral Interventions**<br>* Therapeutic foster care for the prevention of violence<br>■ **Health and education systems interventions**<br>* Early childhood home visitation programs<br>■ **Laws and policies to limit accessibility to firearms** (promising practice)<br>**Suicide prevention** (promising practice) |

While this document focuses a great deal on prevention, which offers the greatest potential benefit for TBI, it is recognized that emergency response and accessibility to medical services are critical in treating injuries and overall survival. In addition, rehabilitation and long-term care are essential to optimize functioning. Further, surveillance and evaluation are vital to developing and improving strategies for reducing the occurrence and mitigating the effects of TBI.

## Prevalence of Safety Precautions in Missouri

To understand some of the safety issues in Missouri, prevalence estimates were generated for usage of seat belts, driving while under the influence of alcohol, firearms around the home that are kept loaded and unlocked, falls, and use of a bike helmet when riding bikes among children under the age of 16 years. The BRFSS data from 1997-2004 was used to estimate the prevalence of these safety indicators (Table 17).[13]

In Missouri, the use of seatbelts has increased from 79.5% in 1997 to 83% in 2002. Driving while under the influence of alcohol has declined from 5.7% in 1999 to 4% in 2004. Firearms kept around the house have increased from 41.7% in 2001 to 44.2% in 2004. There is an increase in the percent of adults that have reported falls within the past year from 29.4% in 1999 to 39.5% in 2004. Bike helmets worn by children under the age of 16 years have also increased from 32% in 1997 to 37.4% in 1999.

**Table 17. Prevalence of TBI-Related Safety Indicators, Missouri Behavioral Risk Factor Surveillance System, 1997-2004[13]**

| Safety Indicator | Prevalence (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1997** | **1998** | **1999** | **2001** | **2002** | **2003** | **2004** |
| Seatbelt usage | | | | | | | |
| Always, Nearly always | 79.5 | | | | 83.0 | | |
| Sometimes, Seldom, Never | 20.5* | | | | 17.0* | | |
| Driving when had too much to drink in past month | | | | | | | |
| None | | | 94.3 | | 94.2 | | 96.0 |
| Once | | | 2.7* | | 2.6* | | 2.0* |
| More than once | | | 3.0* | | 3.2* | | 2.0* |
| Firearms kept around the home | | | | | | | |
| Yes | | | | 41.7* | 45.8* | | 44.2* |
| No | | | | 58.3 | 54.2 | | 55.8 |
| Firearm around home that is loaded and unlocked | | | | | | | |
| Yes | | | | 13.4* | | | |
| No | | | | 86.6 | | | |
| Firearms around home now loaded | | | | | | | |
| Yes | | | | | 21.8* | | 20.2* |
| No | | | | | 78.2 | | 79.8 |
| Loaded firearm around home now unlocked | | | | | | | |
| Yes | | | | | 55.9* | | 64.9* |
| No | | | | | 44.1 | | 35.1 |
| Have you fallen in the last 12 months? | | | | | | | |
| Once, twice, more than twice | | | 29.4* | | | | 39.5* |
| Never | | | 70.6 | | | | 60.5 |
| Have you fallen in the last 3 months? | | | | | | | |
| Yes | | | | | | 15.4* | |
| No | | | | | | 84.6 | |
| Children (<16 yrs) who wear bike helmet | | | | | | | |
| Always, Nearly always | 32.0 | | 37.4 | | | | |
| Sometimes, Seldom, Never | 68.0* | | 62.6* | | | | |

# OPPORTUNITIES & CHALLENGES 9

The annual number of ED visits and hospitalizations for TBI are on the rise in Missouri. During 1999-2003, Missouri has seen a troubling increase of 15.6% in the annual ED visits and hospitalizations combined for TBI. During this same period there has been a growth in TBI ED visit and hospitalization combined rates caused by falls and jumps (+22.7%), motor vehicle traffic crashes (+12.9%), motor vehicle non-traffic crashes (+26.1%), and being struck by or against an object or person (+16.1%). The increasing trend in TBI ED visits and hospitalizations combined from motor vehicle crashes occurred particularly among individuals aged 18-19 (+13.9%), 20-24 (+23.6%) and 25-34 (+19.5%). The ED visits and hospitalizations combined for TBIs caused by being struck by or against an object or person among those 15-17 years of age also showed a disturbing increase (+35.4%) for this time period.

## Future Goals

There are several activities that could occur in the future to continue to define the burden of TBI in Missouri, including examining TBI-related disability and the direct costs incurred from acute care, home services, skilled nursing, intermediate care, hospice, and rehabilitation. Monitoring the TBI event trends as well as use of preventive practices over the next five years will indicate the direction TBI-related hospitalizations and ED visits are moving, and better define the populations at risk. It would also be helpful to continue efforts in improving reporting and surveillance of TBI in Missouri that would provide more complete data on specific aspects of TBI, and further improve the implementation and evaluation of strategies to prevent and mitigate the impact of the injuries.

## Opportunities

It is encouraging that many opportunities exist for preventing TBI. Implementing evidence-based and promising strategies offer key opportunities for reducing TBI. Continuing to work with CDC and other federal initiatives will also help reduce TBI in Missouri. Considering the direct costs of TBI, it is expected that prevention would be extremely cost effective, particularly if the indirect cost of TBI can be defined and added.

## Challenges

While this report contains useful information regarding TBI etiology, at risk populations and prevention strategies, it is recognized that major challenges still exist to reduce TBI. These challenges include the difficulty in changing the behavior of a population, financial constraints to implementing and evaluating effective strategies, and balancing competing public health priorities.

## Policy Implications

It is always difficult to balance personal freedom with the societal burden of injuries and costs. However, in the case of TBI, policies such as safety belt and helmet usage, drinking and driving laws, and licensing have been found to be effective strategies in reducing injury severity and fatalities. Therefore, policies can play a significant role in preventing and mitigating brain injuries. Through partnering with other agencies and interested parties; working collaboratively at federal, state and local levels; remaining vigilant in comprehensive prevention efforts; and maintaining safety policies, reducing TBI fatalities and injuries can be accomplished.

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## APPENDIX 1

**A. International Classification of Diseases, Ninth Revision (ICD-9-CM) Codes for Traumatic Brain Injury-Related Emergency Department Visits and Hospitalizations**

| Description | ICD-9-CM (Hospitalizations and ED Visits) |
|---|---|
| Fracture of the vault or base of the skull | 800.0-801.9 |
| Other and unqualified multiple fractures of the skull | 803.0-804.9 |
| Intracranial injury, including concussion, contusion, laceration, and hemorrhage | 850.0-854.1 |
| Other open wound to the head | -- |
| Late effect of fracture of skull and face bones | -- |
| Late effect of intracranial injury without mention of skull fracture | -- |

Source: Langlois JA, Rutland-Brown W, Thomas KE. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004.

**B. International Classification of Diseases, Tenth Revision (ICD-10) Codes for Traumatic Brain Injury-Related Deaths**

| Description | ICD-10 (Deaths) |
|---|---|
| Open wound of the head | S01.0-S01.9 |
| Fracture of skull and facial bones | S02.0, S02.1, S02.3, S02.7-S02.9 |
| Injury to optic nerve and pathways | S04.0 |
| Intracranial injury | S06.0-S06.9 |
| Crushing injury of head | S07.0, S07.1, S07.8, S07.9 |
| Other unspecified injuries of head | S09.7-S09.9 |
| Open wounds involving head with neck | T01.0 |
| Fractures involving head with neck | T02.0 |
| Crushing injuries involving head with neck | T04.0 |
| Injuries of brain and cranial nerve with injuries of nerves and spinal cord at neck level | T06.0 |
| Sequelae of injuries of head | T90.1, T90.2, T90.4, T90.5, T90.8, T90.9 |

Source: Langlois JA, Rutland-Brown W, Thomas KE. Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004.

### C. Missouri TBI Frequency and Percent of Deaths by ICD-10 Codes, 2001-2004 Combined

| Description | ICD-10 Code | Frequency | Percent |
|---|---|---|---|
| ***Open wound of the head*** | S01.0 | 2 | 0.04 |
| | S01.2 | 1 | 0.02 |
| | S01.4 | 1 | 0.02 |
| | S01.5 | 73 | 1.38 |
| | S01.7 | 8 | 0.15 |
| | S01.8 | 35 | 0.66 |
| | S01.9 | 1258 | 23.82 |
| ***Fracture of skull and facial bones*** | S02.0 | 2 | 0.04 |
| | S02.1 | 19 | 0.36 |
| | S02.7 | 6 | 0.11 |
| | S02.8 | 1 | 0.02 |
| | S02.9 | 101 | 1.91 |
| ***Intracranial injury*** | S06.0 | 6 | 0.11 |
| | S06.1 | 4 | 0.08 |
| | S06.2 | 149 | 2.82 |
| | S06.4 | 1 | 0.02 |
| | S06.5 | 151 | 2.86 |
| | S06.6 | 25 | 0.47 |
| | S06.8 | 77 | 1.46 |
| | S06.9 | 229 | 4.34 |
| ***Crushing injury of head*** | S07.1 | 5 | 0.09 |
| | S07.9 | 13 | 0.25 |
| ***Other unspecified injuries of head*** | S09.7 | 42 | 0.80 |
| | S09.8 | 13 | 0.25 |
| | S09.9 | 2986 | 56.54 |
| Sequelae of injuries of head | T90.1 | 8 | 0.15 |
| | T90.5 | 16 | 0.30 |
| | T90.8 | 1 | 0.02 |
| | T90.9 | 48 | 0.91 |

Source: Missouri Department of Health and Senior Services. (2006). Missouri Vital Statistics – Death Data. Jefferson City: MO: Bureau of Health Informatics.

# APPENDIX 2

## International Classification of Diseases, Ninth Revision, External Cause of Injury (ICD-9-E) Codes

### A. External Cause of Injury (Mechanism) Categories

1) Abuse/Neglect/Rape: spouse/partner abuse, sexual abuse, physical abuse, neglect or emotional abuse, shaken baby, rape, abuse unspecified
2) Cut/pierce
3) Drowning
4) Fall/jump
5) Fire/burn
6) Firearm
7) Machinery
8) Motor Vehicle Traffic: pedestrian, bicyclist, motorcyclist, car/truck/etc. occupant
9) Motor Vehicle – Non Traffic: (referring to accidents not occurring on the main roads) pedestrian non-traffic, bicyclist non-traffic, motorcyclist non-traffic, other vehicle (car/truck/etc. occupant), other person non-traffic, pedestrian non-motor vehicle, bicyclist non-motor vehicle
10) Other transport
11) Weather/wildlife: venomous bites/stings, dog bites, other bites/stings, hot weather
12) Over-exertion
13) Poison/overdose: drugs/alcohol, gas/cleaners/caustics/etc
14) Struck by/against: blunt object, fight
15) Suffocate/hang
16) All other / Unknown

**B. ICD-9-E-codes (Mechanism Codes)**

1) Cut, Pierce: '956', '9560', '966', '9660', '9662', '974 '-'9749', '920'-'9209', '986'-'9869'
2) Drowning, Submersion: '830'-'8309', '832'-'8329', '910'-'9109', '984'-'9849', '964', '9643', '954'
3) Fall, Jump: '957'-'9579', '880'-'8869', '888'-'8889', '987'-'9879', '9681'
4) Fire, Burn: '890'-'8999', '924'-'9249', '9881'-'9882', '9581', '9582', '9587', '990'-'9909', '9887', '961', '9680', '9683', '9614'
5) Firearm: '922'-'9229', '965'-'9654', '970', '9709', '9850'-'9854', '9910'-'9913', '9550'-'9554'
6) Machinery: '919'-'9199'
7) Motor Vehicle Traffic: '810'-'8199', '9885', '9585', '9685'
   a) car, truck, etc., occupant: '8100'-'8101', '8110'-'8111', '8120'-'8121', '8130'-'8131', '8140'-'8141', '8150'-'8151', '8160'-'8161', '8170'-'8171', '8180'-'8181', '8190'-'8191'
   b) motorcyclist: '8102'-'8103', '8112'-'8113', '8122'-'8123', '8132'-'8133', '8142'-'8143', '8152'-'8153', '8162'-'8163', '8172'-'8173', '8182'-'8183', '8192'-'8193'
   c) bicyclist: '8106', '8116', '8126', '8136', '8146', '8156', '8166', '8176', '8186', '8196'
   d) pedestrian: '8107', '8117', '8127', '8137', '8147', '8157', '8167', '8177', '8187', '8197'
8) Motor Vehicle, Other: '8206', '8216', '8226', '8236', '8246', '8256', '8260', '8270', '8280', '8290', '8261', '8271', '8281', '8291', '8207', '8217', '8227', '8237', '8247', '8257', '820'-'8205', '821'-'8215', '822'-'8225', '823'-'8235', '824'-'8245', '825'-'8255', '8208'-'8209', '8218'-'8219', '8228'-'8229', '8238'-'8239', '8248'-'8249', '8258'-'8259', '826', '8262'-'8269', '8272'-'8279', '828', '8282'-'8289', '8292'-'8299'
   a) bicyclist, non-traffic: '8003', '8013', '8023', '8033', '8043', '8053', '8063', '8073', '8206', '8216', '8226', '8236', '8246', '8256'
   b) pedestrian, non-traffic: '8002', '8012', '8022', '8032', '8042', '8052', '8062', '8072', '8207', '8217', '8227', '8237', '8247', '8257'
   c) other vehicle (car, ATV, etc) occupant: '8200'-'8201', '8210'-'8211', '8220'-'8221', '8230'-'8231', '8240'-'8241', '8250'-'8251'
   d) motorcyclist, non-traffic: '8202'-'8203', '8212'-'8213', '8222'-'8223', '8232'-'8233', '8242'-'8243', '8252'-'8253'
   e) other person, non-traffic: '8204'-'8205', '8214'-'8215', '8224'-'8225', '8234'-'8235', '8244'-'8245', '8254'-'8255', '8208'-'8209', '8218'-'8219', '8228'-'8229', '8238'-'8239', '8248'-'8249', '8258'-'8259'
   f) pedestrian injured, non-motor vehicle: '8260', '8270', '8280', '8290'
   g) bicyclist injured, non-motor vehicle: '8261', '8271', '8281', '8291'
9) Other Transport: '8002', '8012', '8022', '8032', '8042', '8052', '8062', '8072', '8003', '8013', '8023', '8033', '8043', '8053', '8063','8073', '800'-'8001', '801 '-'8011', '802 '-'8021', '803 '-'8031', '804'-'8041', '805'-'8051', '806'-'8061', '807'-'8071', '8008'-'8009', '8018'-'8019', '8028'-'8029', '8038'-'8039', '8048'-'8049', '8058'-'8059', '8068'-'8069', '8078'-'8079', '831'-'8319', '833'-'8459', '9586', '9886'
10) Weather, Wildlife: '900'-'9099', '9280'-'9282', '9883', '9583'
   a) venomous bites, stings: '9050'-'9052', '9055'-'9056', '9058', '9059'
   b) dog bites: '9060'
   c) other bites, stings: '9053', '9054', '9061'-'9065'
   d) hot weather: '9000'
11) Overexertion: '927'-'9279'
12) Poison: '850'-'8699', '980'-'9829', '950', '9500'-'9529', 962'-'9629', '972'-'9729'

13) Struck By, Against (struck by other people or by objects): '960', '9600', '9682', '9602'-'9609', '916'-'9179', '973'-'9739'
14) Suffocate, Hang: '911'-'9139', '983 '-'9839', '963 ', '953'-'9539'
15) Abuse, Neglect, Rape: E-codes and Diagnosis Codes:
    a) Spouse Abuse: E-code '9673' and age over 14 or missing
    b) Sexual Abuse: if first E-code='9601' and either second E-code is '967' or '9679', or else one of the first 10 diagnoses is one of the following: '9955 ', '99550', '99551', '99553', '99554', '99559', '99580', '99581', '99582', '99583', '99585'; or if one of the first 10 diagnoses is '99553' or '99583' and the E-code is in the range of 960-968 (assault)
    c) Physical, Other Abuse: E-codes '967', '9670'-'9672', '9674'-'9679'; also '9673' if age is less than 14
    d) Neglect: E-code '9684'
    e) Rape by Non-Caretaker: E-code '9601'
    f) Shaken Baby: if one of the first ten diagnoses is '99555' and age is under 5 or missing and the E-code is in the range 960-968(assault)
16) All Other Causes of Injury: E-codes '846'-'8489', '914'-'9159', '918'-'9189', '921'-'9219', '923' - '9239', '925'-'9269', '9288', '887', '9289', '9299', '849'-'8499', '9555', '9556', '9559', '958', '9580', '9584', '9588', '9589', '959', '955'

## APPENDIX 3

**Data Sources - Additional Information**

**Injury MICA**

The information in this MICA are those injuries recorded and reported by hospitals for their emergency room visits and inpatient hospitalizations for Missouri residents. The fields available in the Injury MICA include year, demographics (race, ethnicity, sex, and age), mechanism or external cause of injury, intention of the injury, disposition, and patient type for the state of Missouri and all 115 counties from 1994 to 2003. The injury cases are recorded by county of residence.

Rates were not calculated when the numerator was less than 20 because the frequency is too small to provide stable estimates. Generating county-specific TBI ED visits and hospitalization rates by race was limited to the state and 10 counties in Missouri with the largest minority populations. These 10 counties included: Boone, Greene, Jackson, Mississippi, New Madrid, Pemiscot, Scott, St. Charles, St. Louis County, and St. Louis City.

**Patient Abstract System**

Charge data on emergency department visits and inpatient hospitalizations was obtained from the Patient Abstract System (PAS), which was implemented in 1993. The emergency department data includes emergency room patients, but not observation patients, patients receiving invasive procedures on an outpatient basis, or patients receiving certain specified diagnostic procedures. Since January 1, 1994, ambulatory surgical centers have also been required to report.

## Missouri Vital Statistics

Missouri vital statistics comprises all the death data for Missouri residents by primary and secondary causes of death as well as age at the time of death. TBI fatality frequencies were generated for 2001 to 2004. It is difficult to use death data prior to 2001 because multiple-cause tapes were not available prior to this. Multiple-cause tapes provide information on the cause and the nature of injury. In single cause tapes, the cause of injury is given, but not the codes for the nature of injury—for TBI only a check box indicating whether a head injury occurred was included.

Mortality data was generated by ICD-10 codes, cause of injury, age, gender, and county of residence. Mortality data and life tables by age and gender were utilized to predict years of potential life lost as well as productivity loss due to TBI deaths.

## Bureau of Labor Statistics (BLS)

Consumer Price Index - Medical Care for all urban consumers in the Midwest region calculated by the Bureau of Labor Statistics, U.S. Department of Labor was used to adjust annual charges for inflation in the medical care industry.

**Prevention Effectiveness: A guide to Decision Analysis and Economic Evaluation by Haddix et. al. ( 2003)**

Annual average charges by counties of Missouri were used to estimate the direct cost of TBI by applying a cost-to-charge ratio of 0.442 for Missouri, calculated by Haddix et al. in March 2001.[1]

**Valuing Human Life: Estimating the Present Value of Lifetime Earnings**

Unavailability of Missouri Specific 2004 estimates of Present Discounted Value of Future Earnings (PDVFE), at present, resulted in the use of the national estimates for 2000 computed by Max et. al. (2004)[2] to estimate the PDVFE for Missouri for the year 2004. The PDVFE was computed by age and gender by discounting at 5% rate for the year 2000. The productivity losses due to TBI related deaths were generated with the annual average mortality for the years 2001-04 and the PDVFE in 2000.

**Behavioral Risk Factor Surveillance System (BRFSS)**

The Behavioral Risk Factor Surveillance System (BRFSS), established by the Centers for Disease Control and Prevention (CDC), is an on-going surveillance system that is conducted in all 50 states and the three territories of the United States. The BRFSS collects data on health risk behaviors on a monthly basis among adults, 18 years or older, residing in households with a telephone. Individuals are contacted randomly through a random digit-dialing technique. More

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[1] Haddix, Anne C., Teutsch, Steven M., and Corso, Phaedra S., *Prevention Effectiveness: A guide to Decision Analysis and Economic Evaluation*, 2d ed. NewYork: Oxfiord University Press, 2003.

[2] Max, Wendy; Rice P. Dorithy; Sung, Hai-Yen; and Michel, Martha, *Valuing Human Life: Estimating the Present Value of Lifetime Earnings, 2000, Center for Tobacco Control Research and Education, Economic Studies and Related Methods,* University of California, San Francisco, 2004. http://repositories.cdlib.org/ctcre/esarm/PVLE2000.

information on the BRFSS can be found at: http://www.cdc.gov/brfss/ and through the DHSS website at http://www.dhss.mo.gov/BRFSS

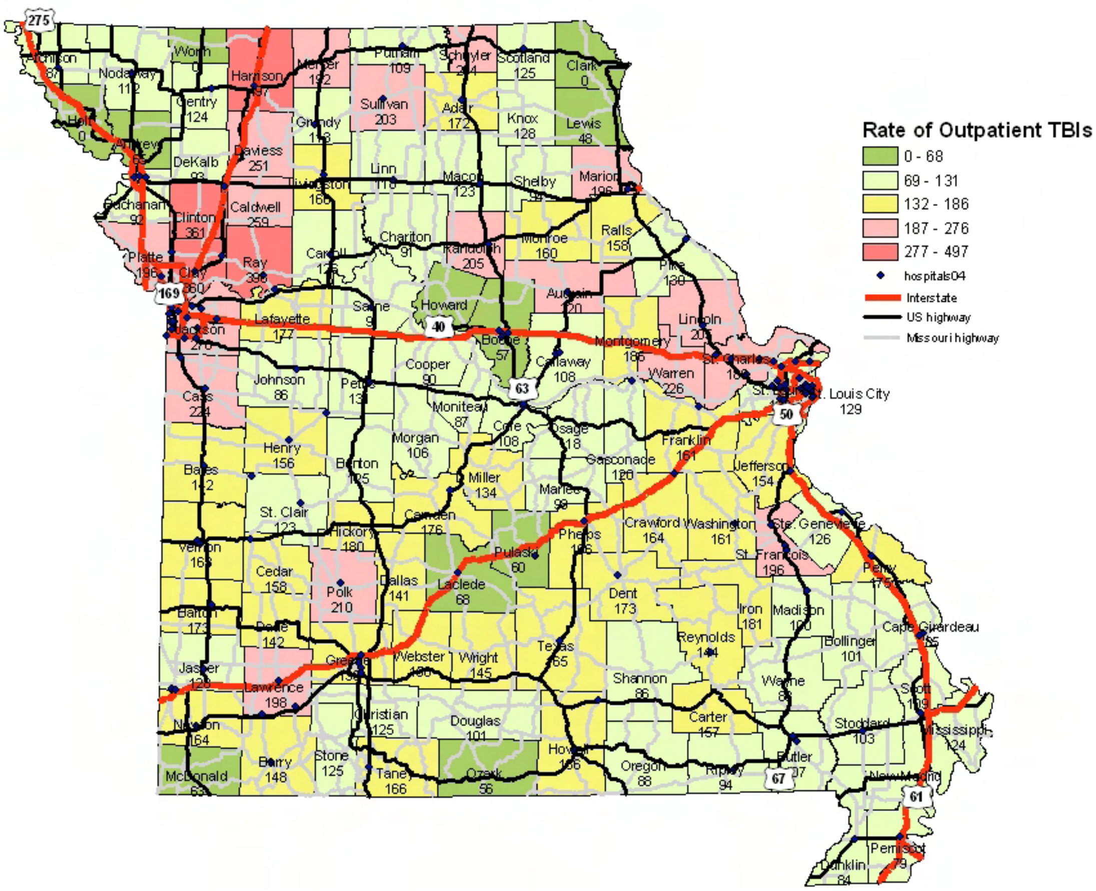
**Missouri Department of Transportation**

Maps generated by Missouri Department of Transportation (MODOT) to demonstrate the locations of motor vehicle crashes in Missouri that resulted in fatality or disability were obtained and included in this report. Although there is no information on whether any of these fatalities or disabilities could be related to TBI, data from Injury MICA indicates that 4.7% of all injuries from motor vehicle traffic resulted in TBI.

**Medicaid Data**

Medicaid fee-for-service cost data were provided by the Missouri Department of Social Services by ICD-9 TBI codes for 1999-2002. Due to changes in coding, the 2003 Medicaid data could not be included.

**Map 1. Emergency Department Visits for Traumatic Brain Injuries: Rate per 100,000 by Missouri Counties, 1999-2003**

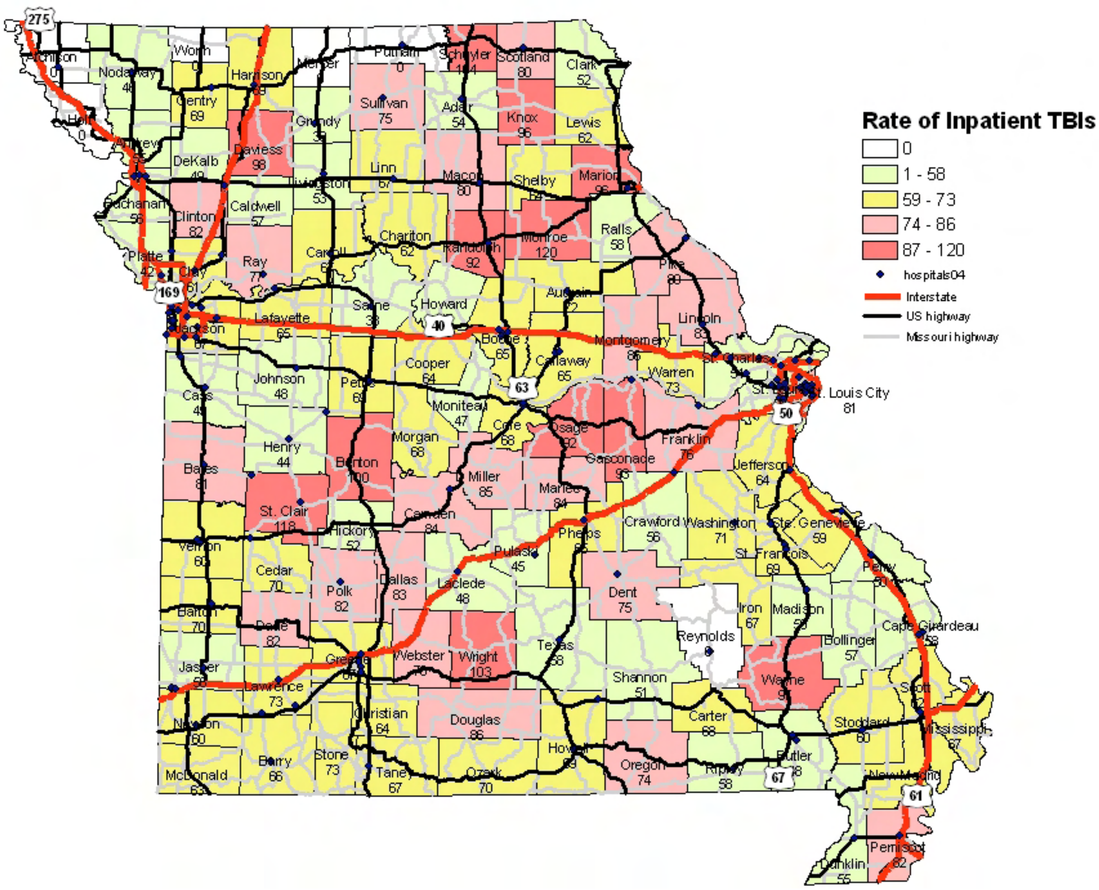



Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 2. Number of Emergency Department Visits for Traumatic Brain Injuries by Missouri Counties, 1999-2003**

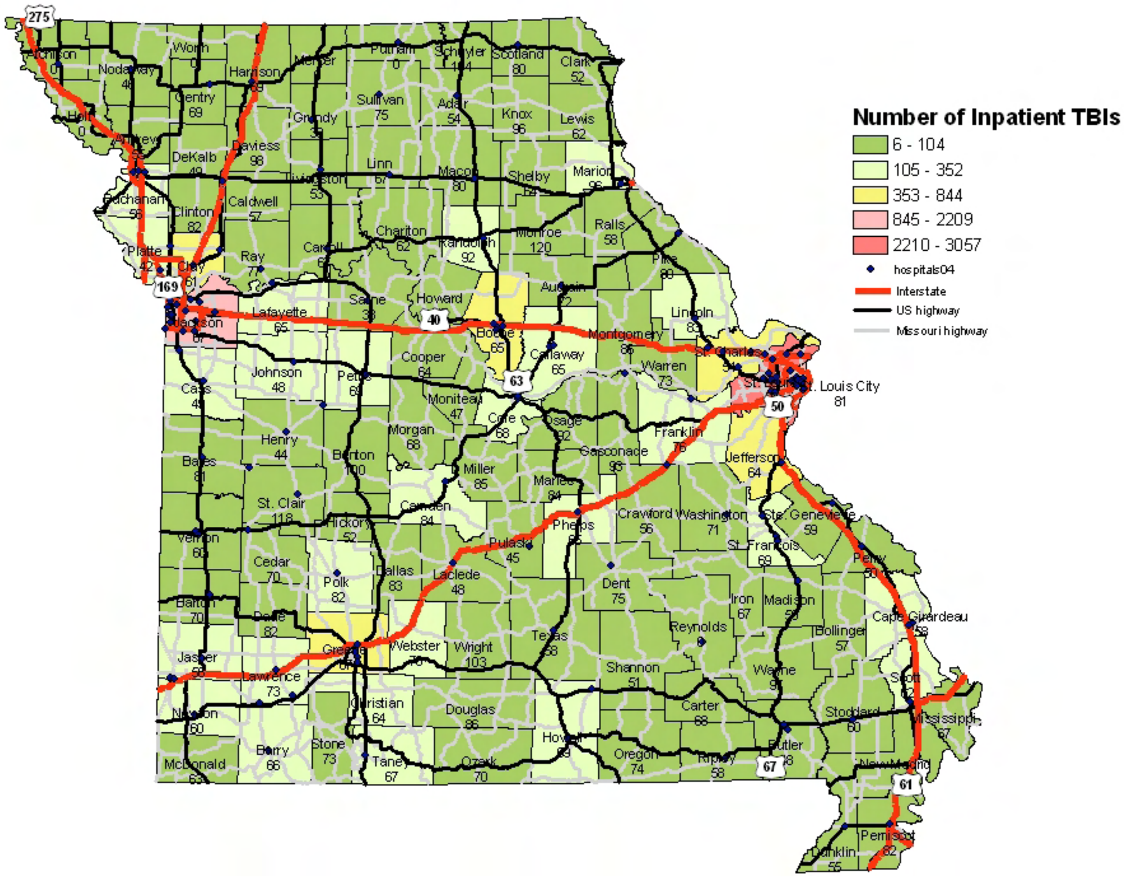

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 3. Inpatient Hospitalizations for Traumatic Brain Injuries: Rate per 100,000 by Missouri Counties, 1999-2003**



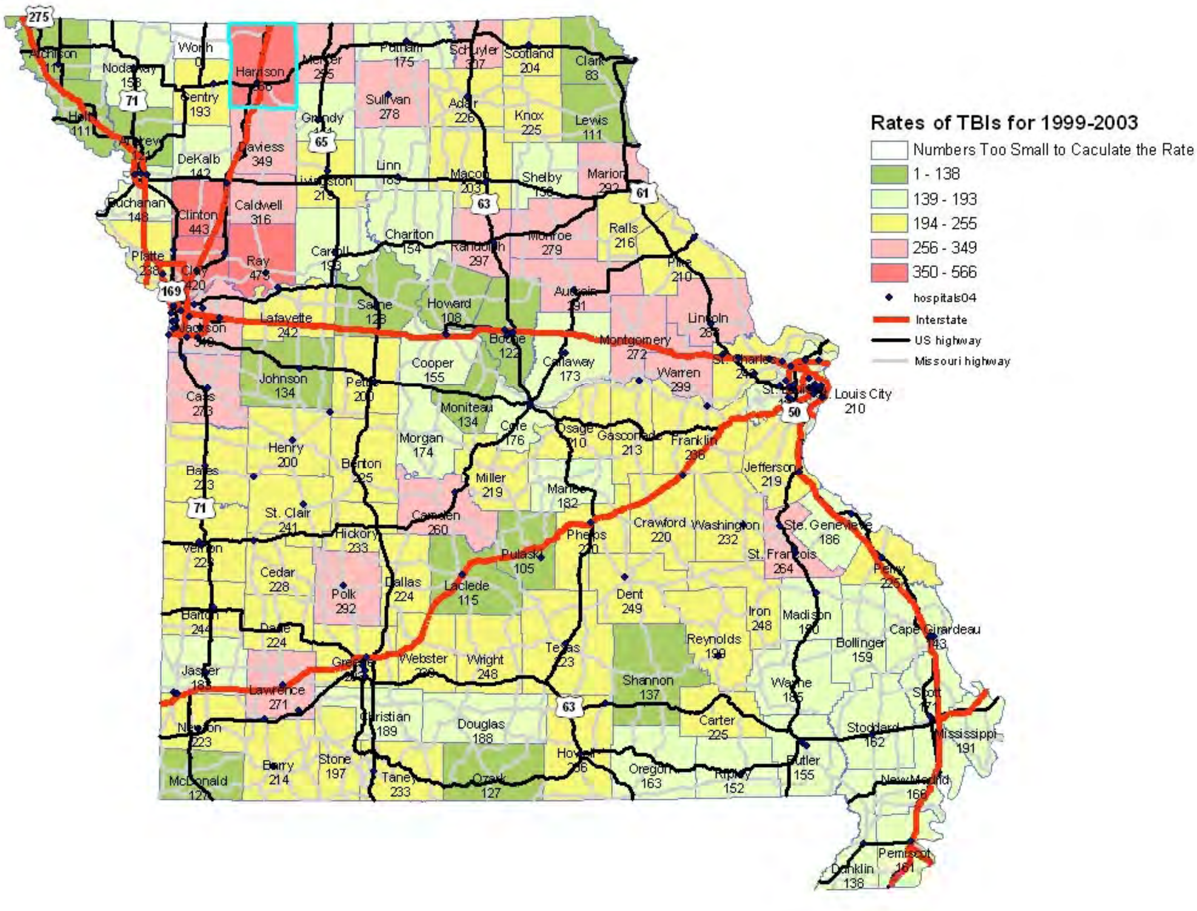

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 4. Number of Inpatient Hospitalizations for Traumatic Brain Injuries by Missouri Counties, 1999-2003**



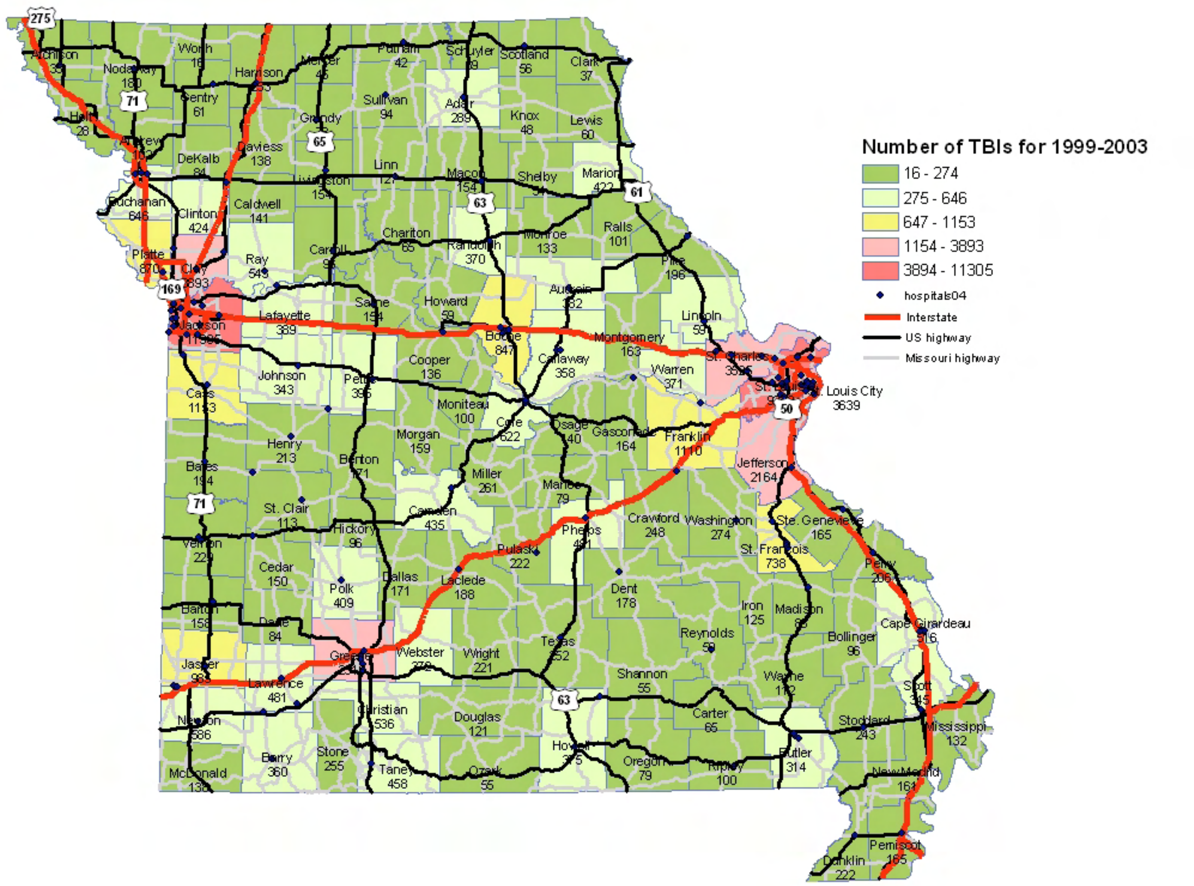

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 5. Traumatic Brain Injuries: ED Visits and Hospitalizations Combined Rate per 100,000 By Missouri Counties, 1999-2003**



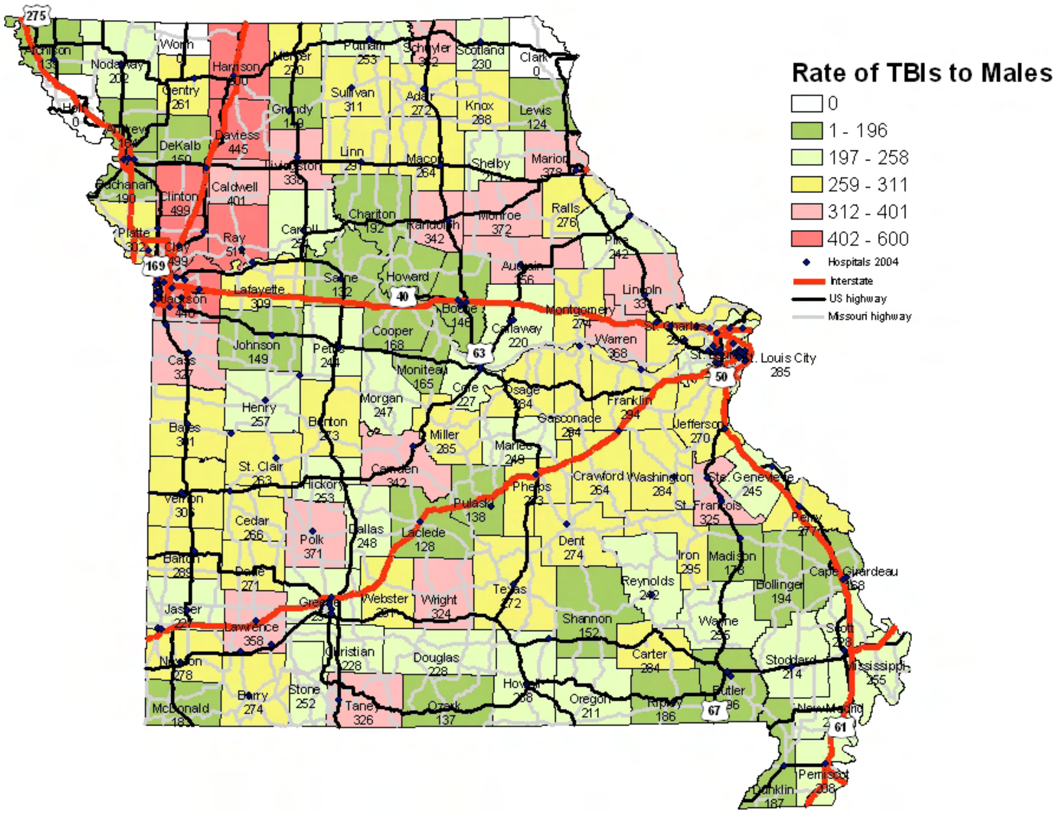

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 6. Number ED Visits and Hospitalizations for Traumatic Brain Injuries By Missouri Counties, 1999-2003**



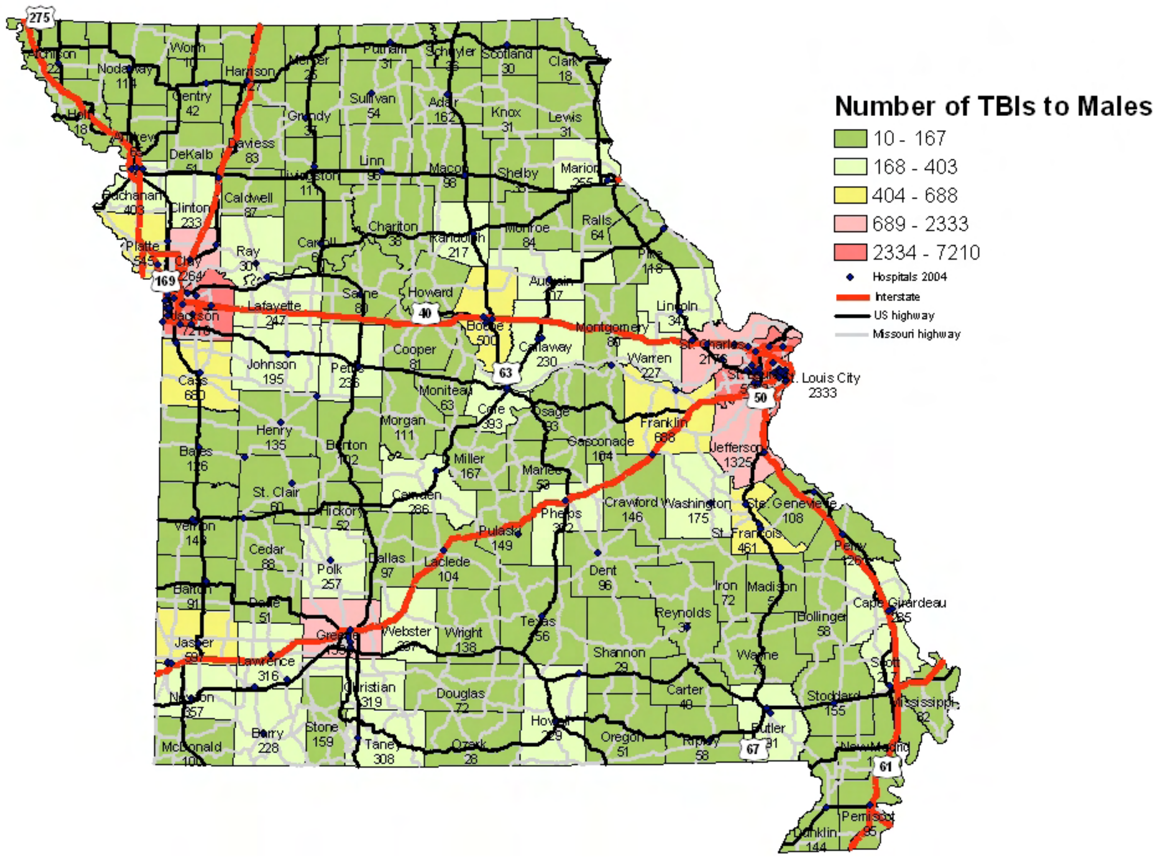

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 7. Traumatic Brain Injuries for Male Population: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



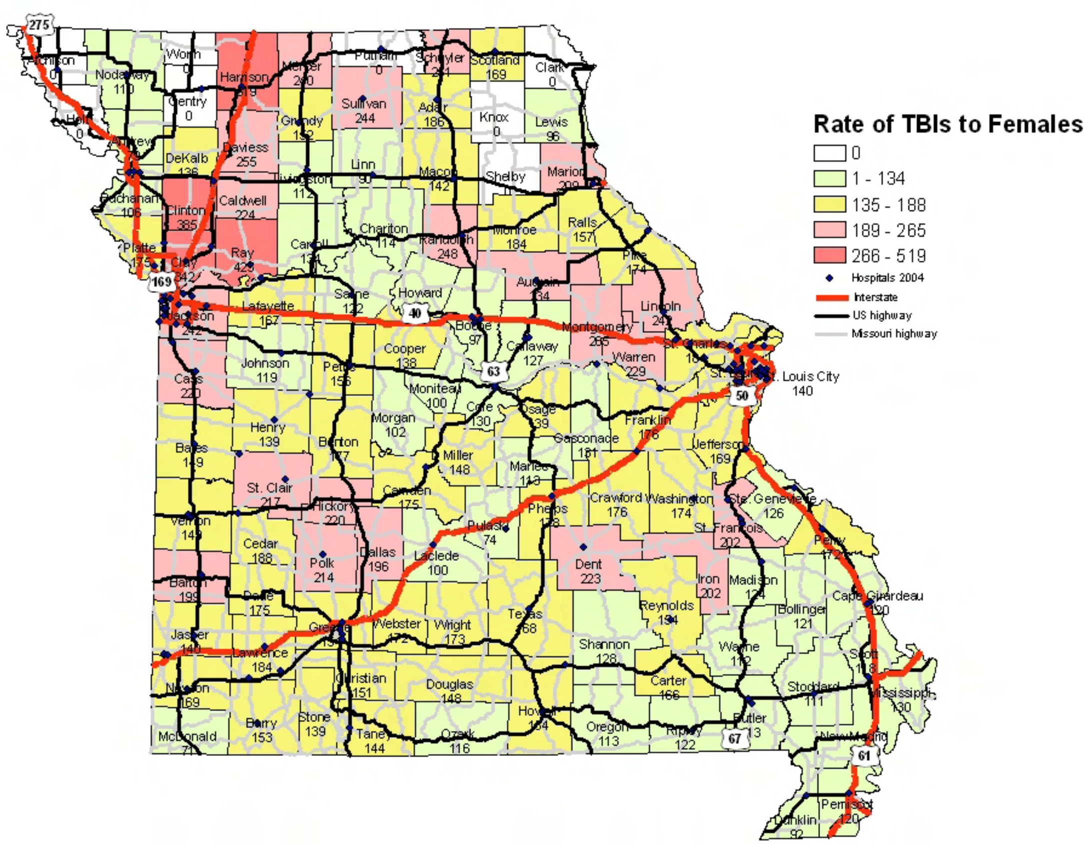

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 8. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries By Missouri Counties, Males, 1999-2003**



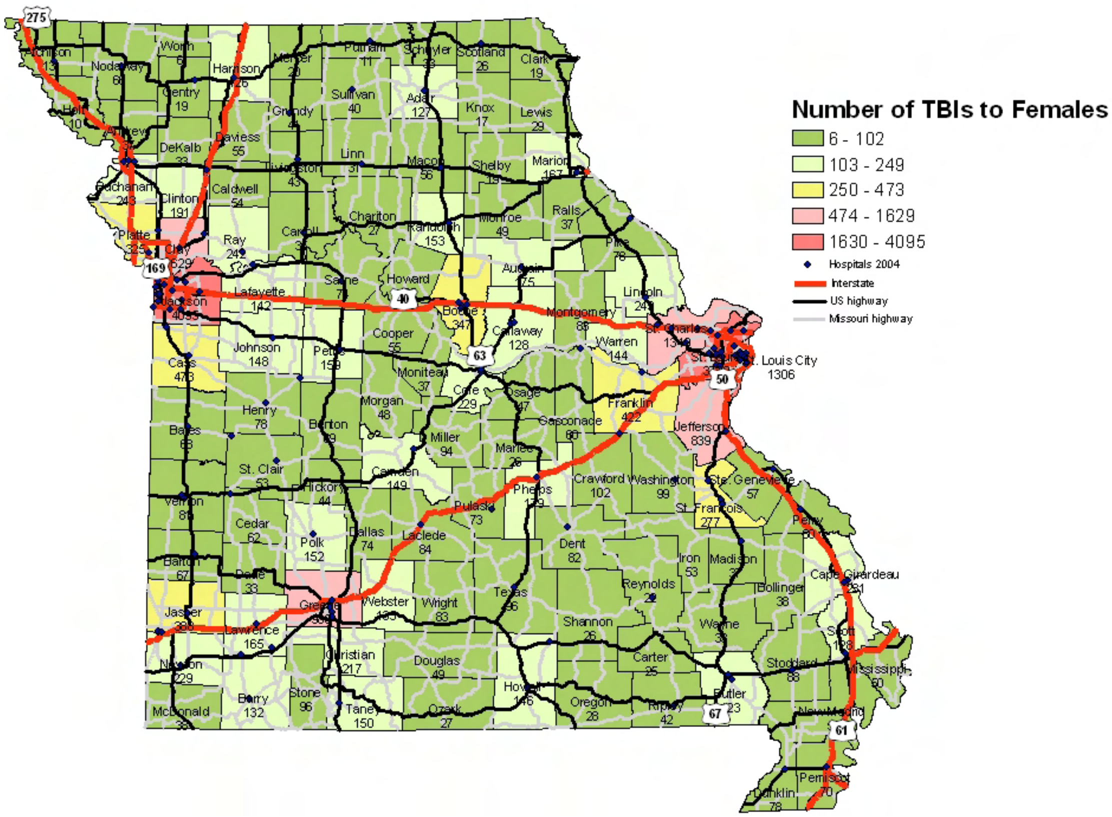

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 9. Traumatic Brain Injuries for Female Population: ED Visits and Hospitalizations Combined Rates per 100,000 by Missouri Counties, 1999-2003**



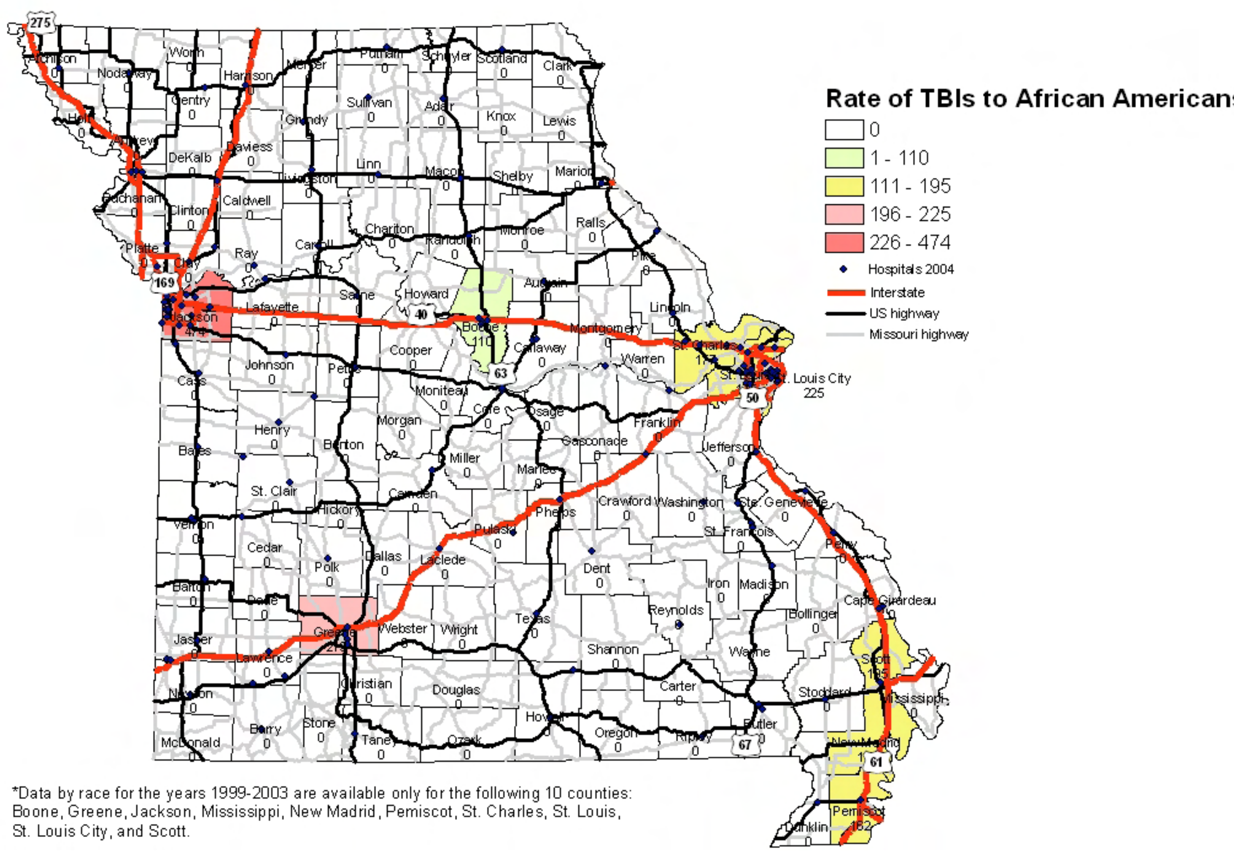

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 10. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries By Missouri Counties, Females, 1999-2003**




Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

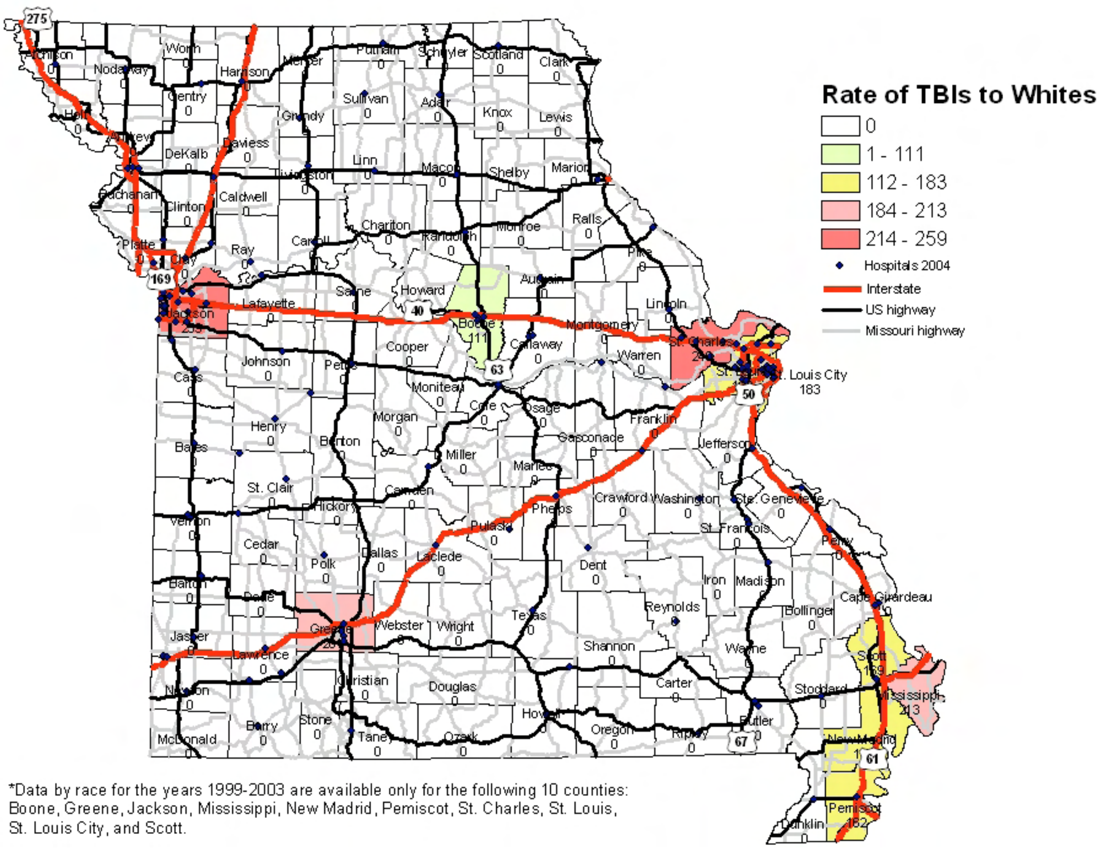
**Map 11. Traumatic Brain Injuries in the African American Population: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties*, 1999-2003**




*Data by race for the years 1999-2003 are available only for the following 10 counties: Boone, Greene, Jackson, Mississippi, New Madrid, Pemiscot, St. Charles, St. Louis, St. Louis City, and Scott.

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

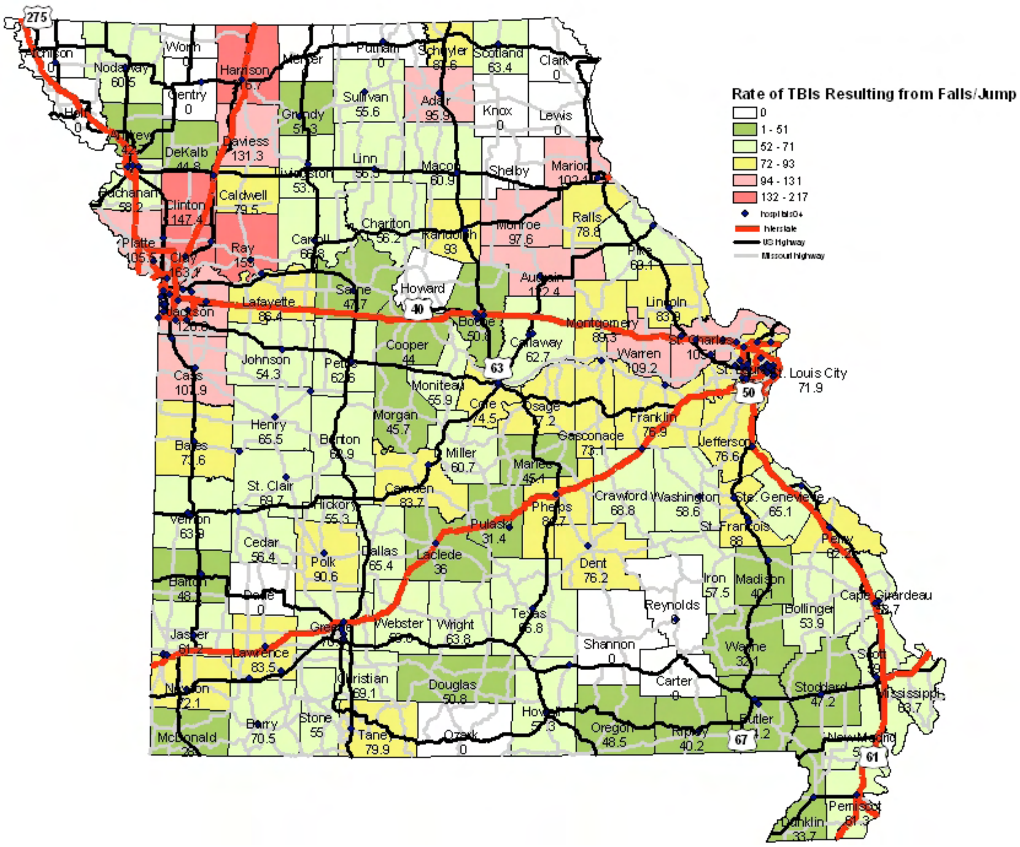
**Map 12. Traumatic Brain Injuries in the White Population: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties*, 1999-2003**




*Data by race for the years 1999-2003 are available only for the following 10 counties: Boone, Greene, Jackson, Mississippi, New Madrid, Pemiscot, St. Charles, St. Louis, St. Louis City, and Scott.

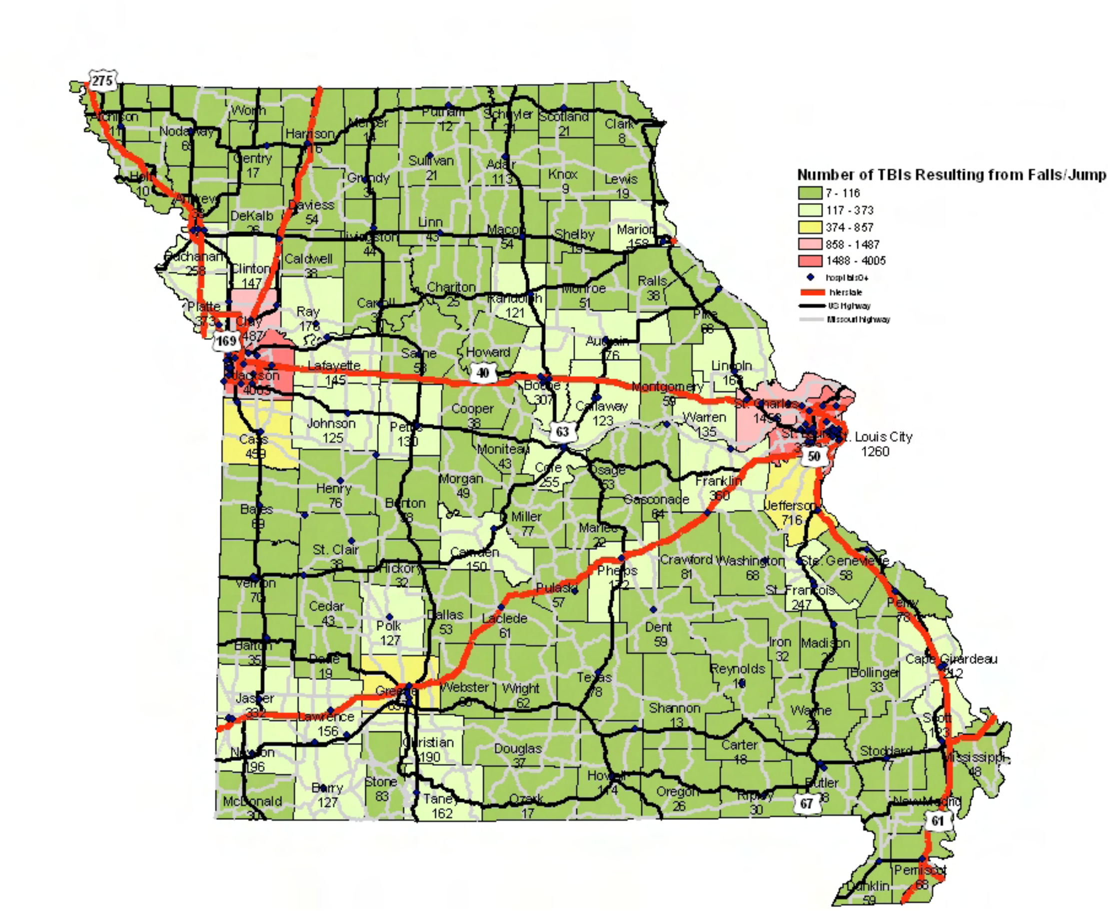
Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 13. Traumatic Brain Injuries Resulting from Falls/Jumps: ED Visits and Hospitalizations Combined Rates per 100,000 by Missouri Counties, 1999-2003**



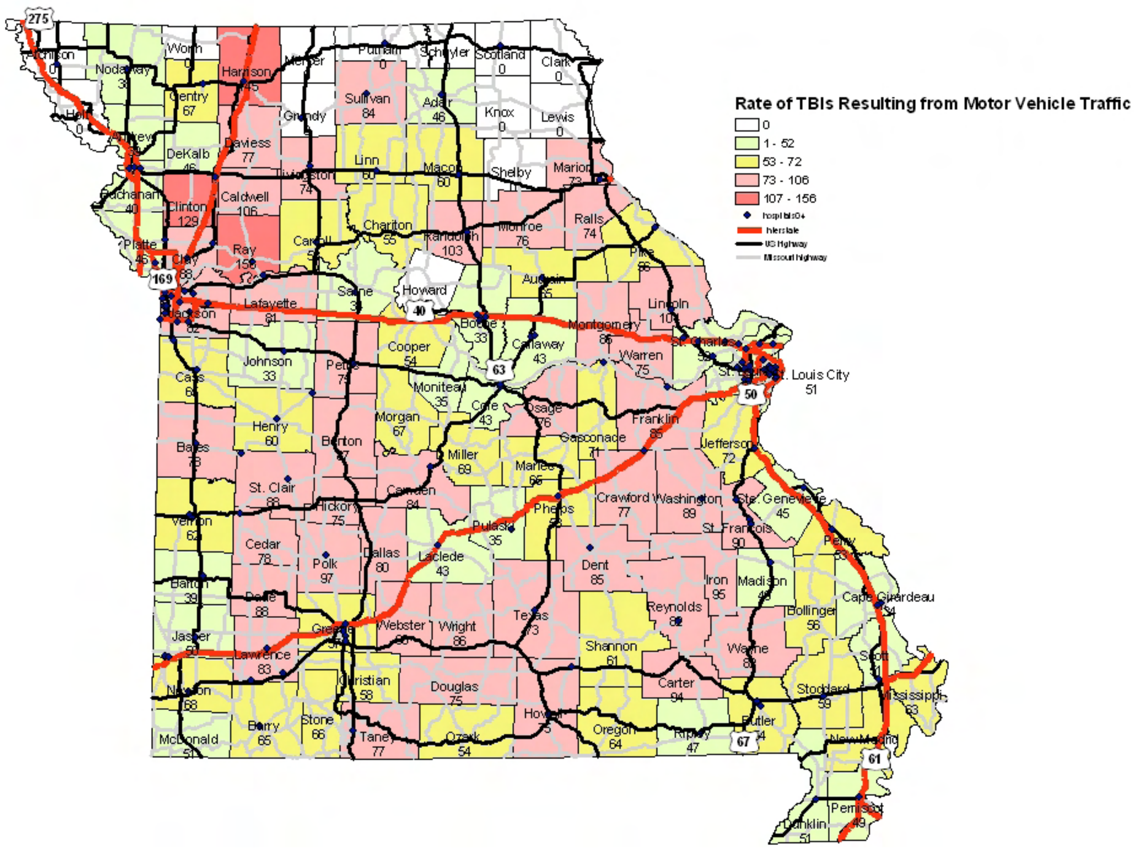

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 14. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Falls/Jumps By Missouri Counties, 1999-2003**



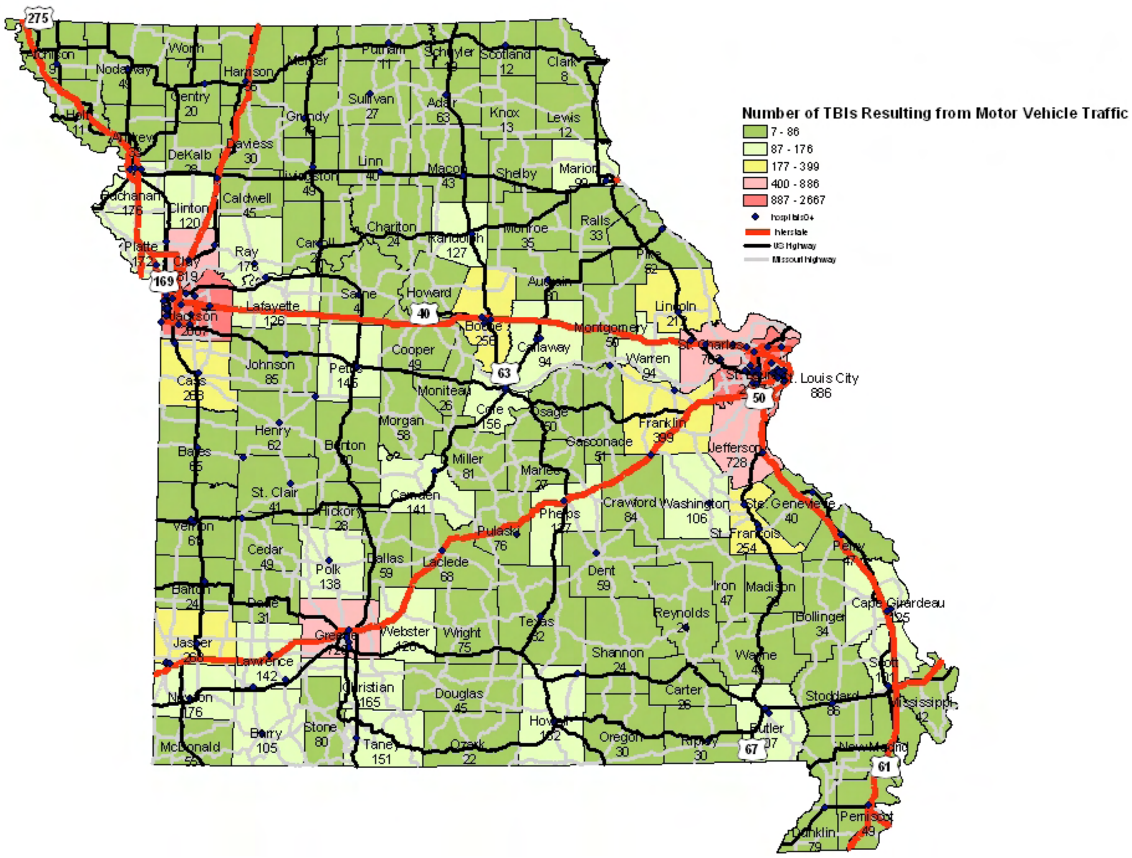

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 15. Traumatic Brain Injuries from Motor Vehicle Traffic Crashes: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



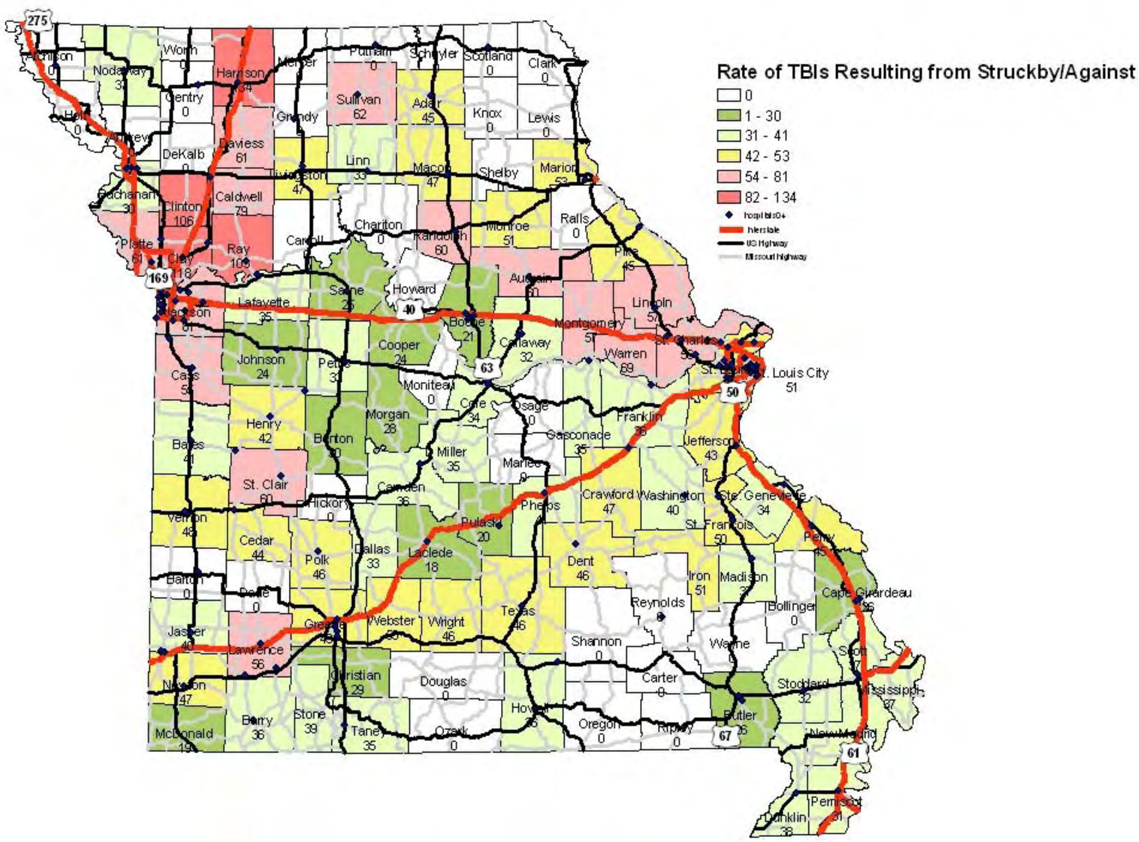

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, [http://www.dhss.mo.gov/InjuryMICA/](http://www.dhss.mo.gov/InjuryMICA/)

**Map 16. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Motor Vehicle Traffic Crashes By Missouri Counties, 1999-2003**



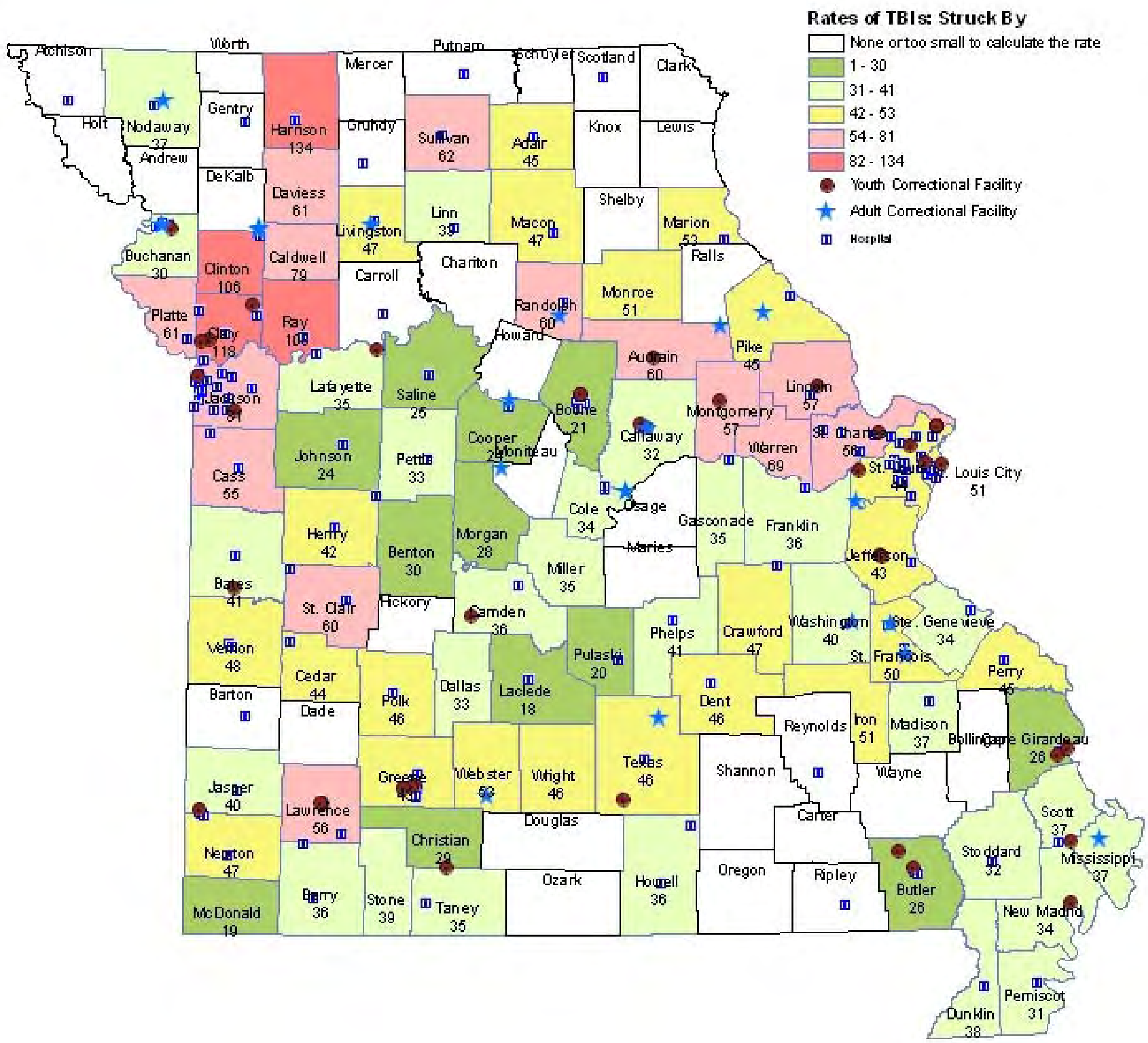

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, [http://www.dhss.mo.gov/InjuryMICA/](http://www.dhss.mo.gov/InjuryMICA/)

**Map 17. Traumatic Brain Injuries Resulting from Struck by/Against: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**

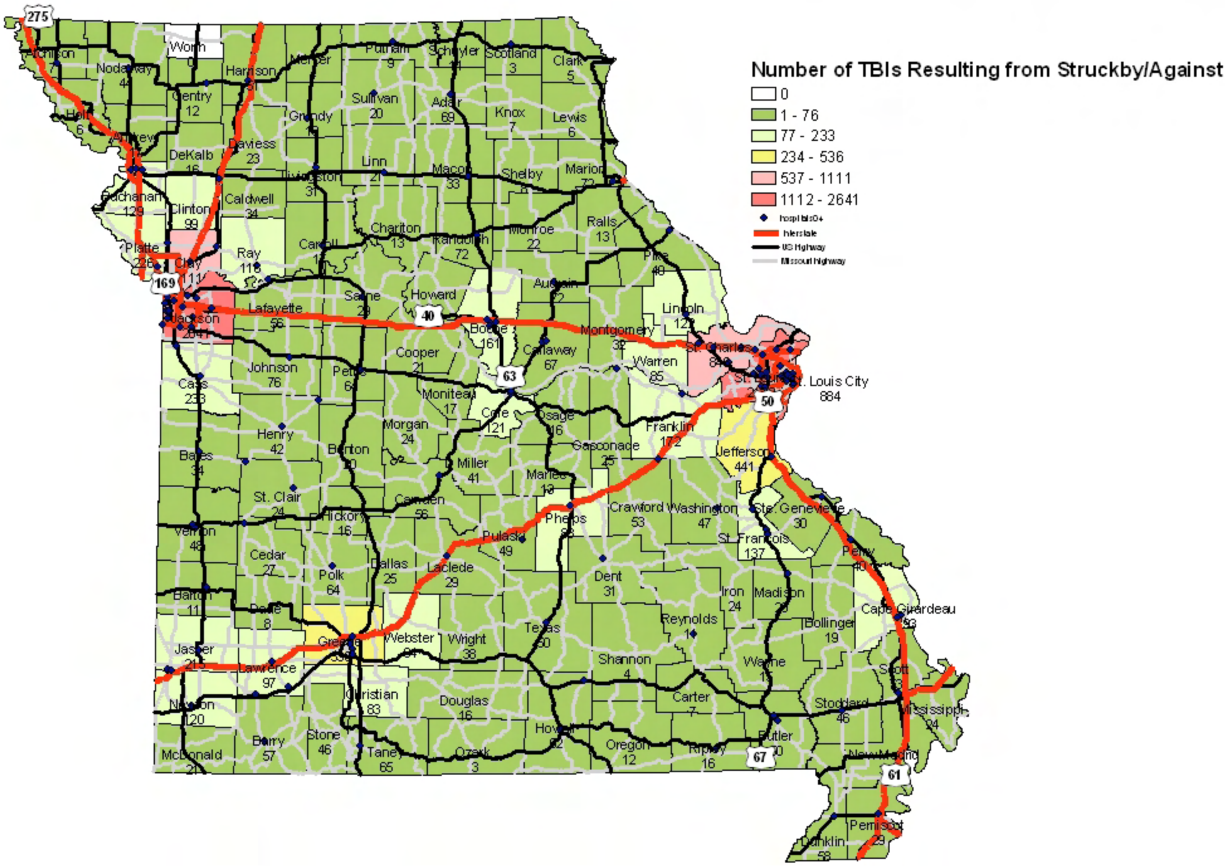



Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 18. Geographical Locations of Missouri Adult and Juvenile Correctional Facilities by Traumatic Brain Injuries Resulting from Struck by/Against and Missouri Counties, 2006**

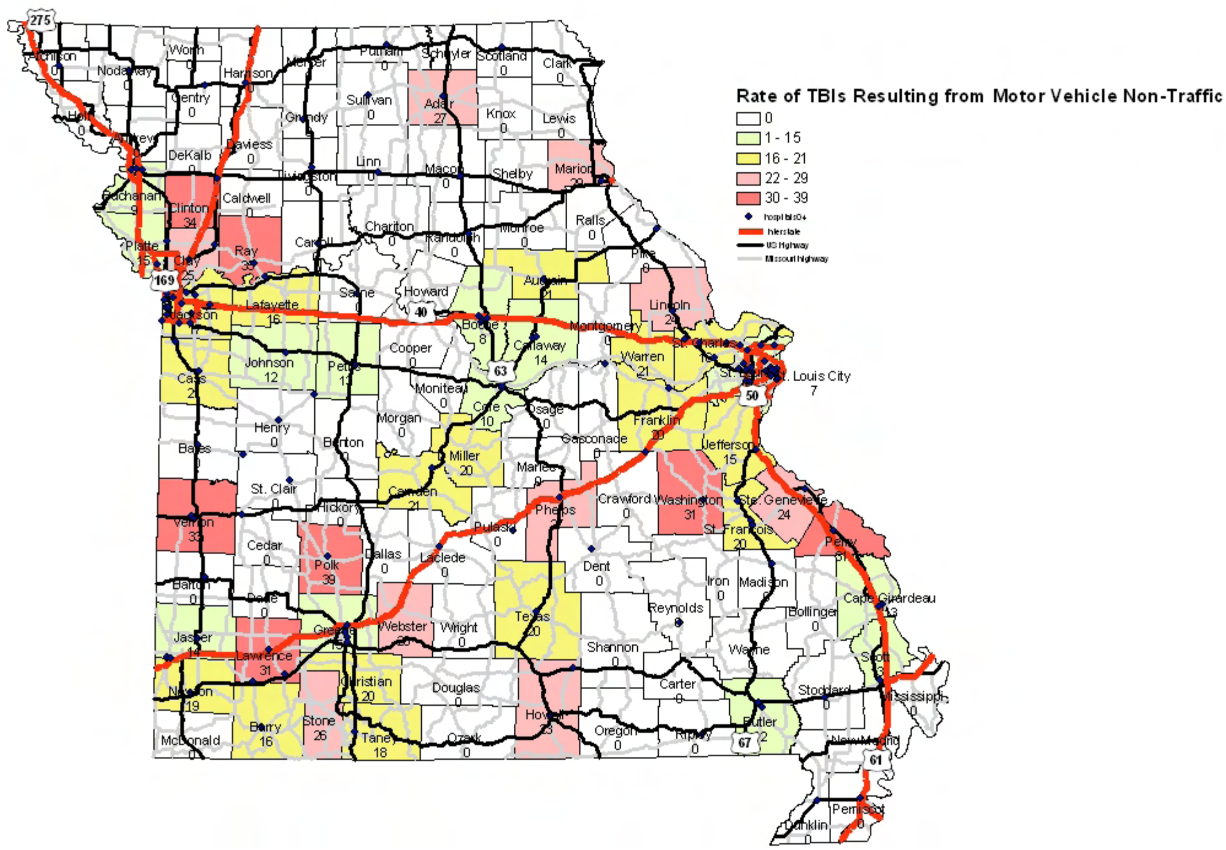


**Map 19. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Struck by/Against By Missouri Counties, 1999-2003**



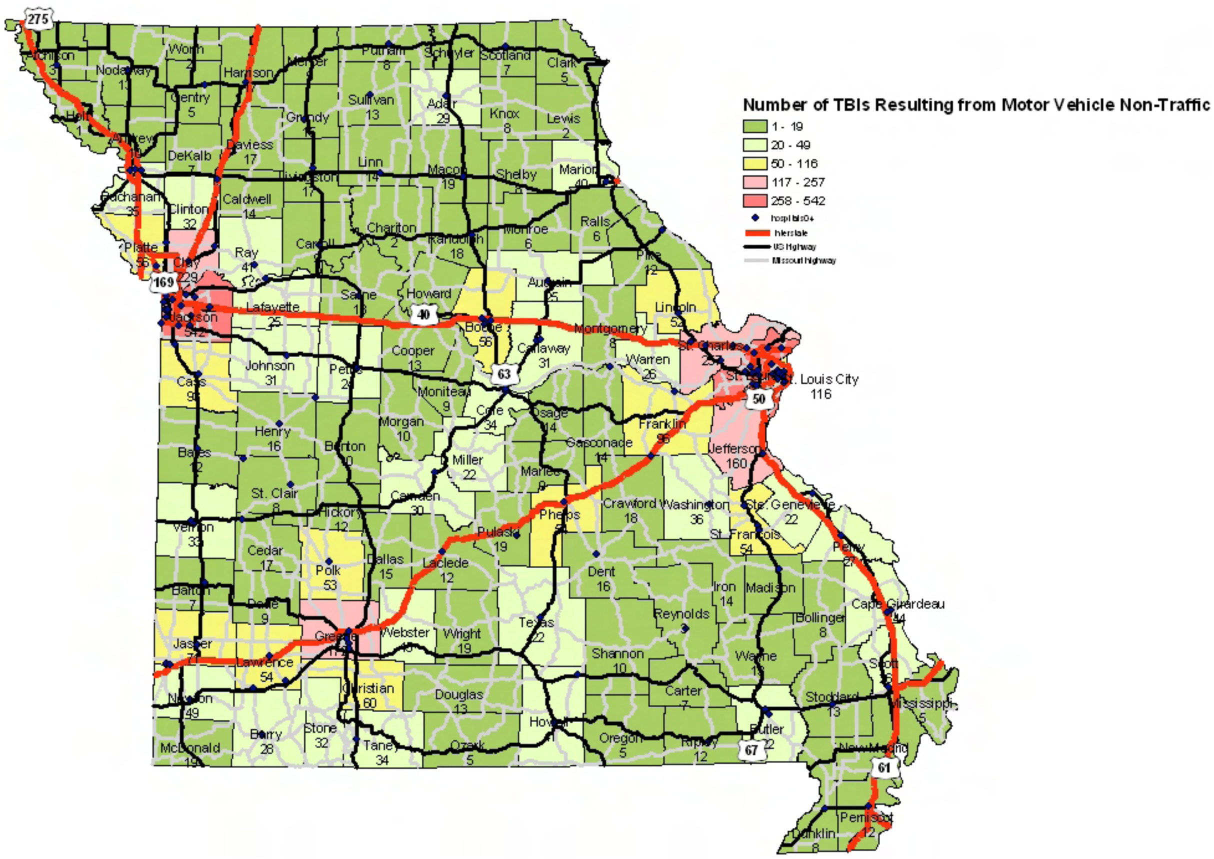

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 20. Traumatic Brain Injuries Resulting from Motor Vehicle Non-Traffic Crashes: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



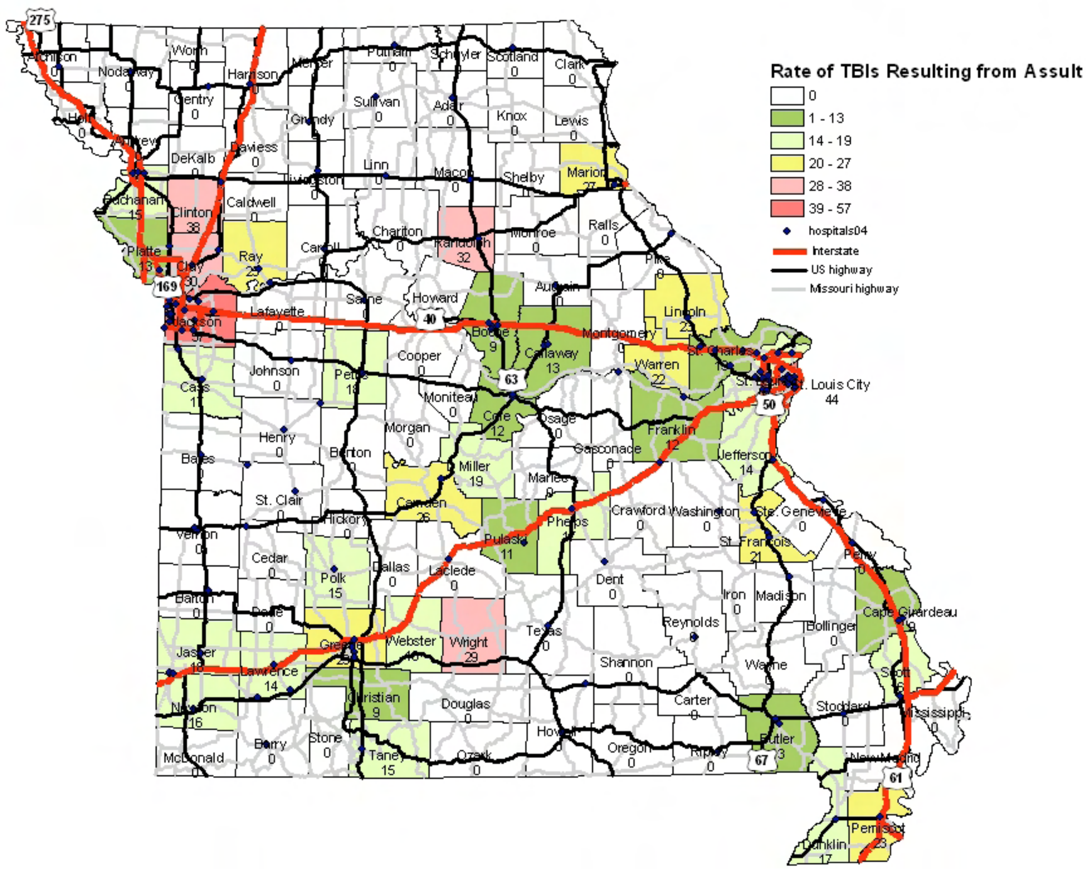

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 21. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Motor Vehicle Non-Traffic Crashes By Missouri Counties, 1999-2003**



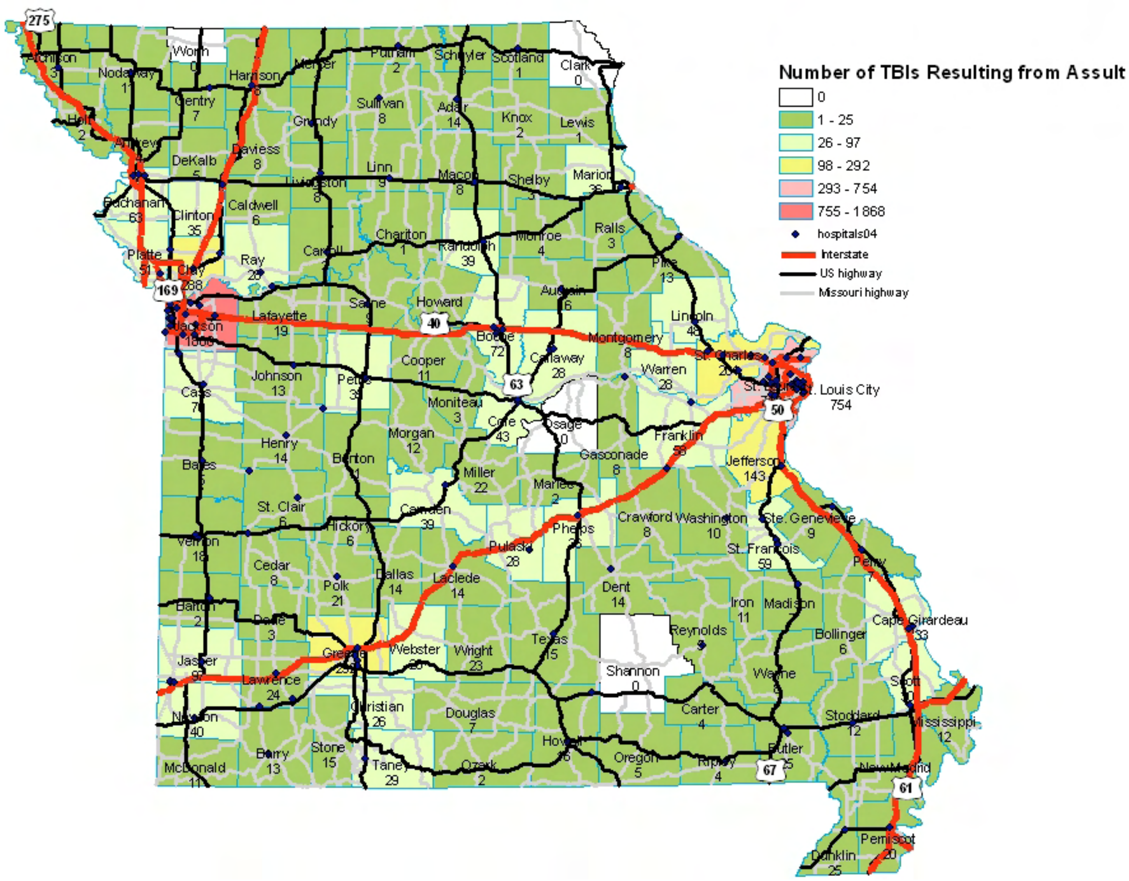

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 22. Traumatic Brain Injuries Resulting from Assault: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



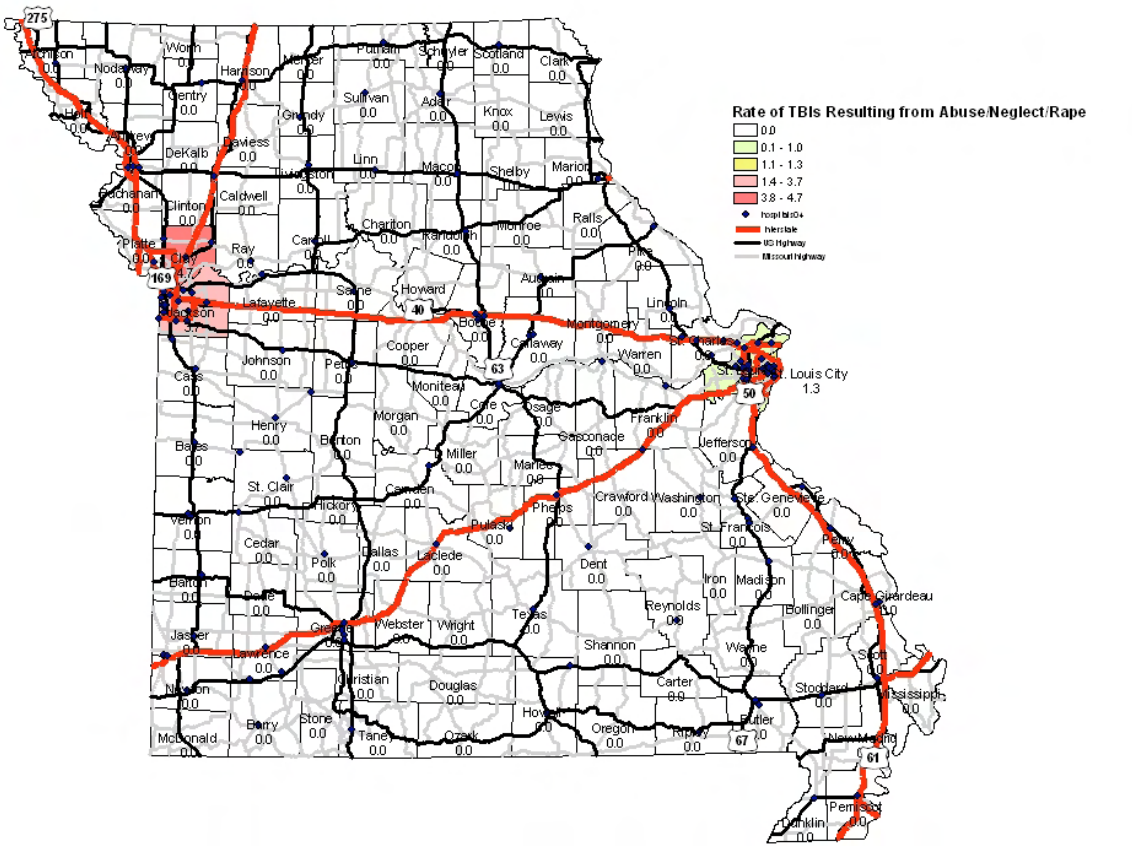

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 23. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Assault by Missouri Counties, 1999-2003**



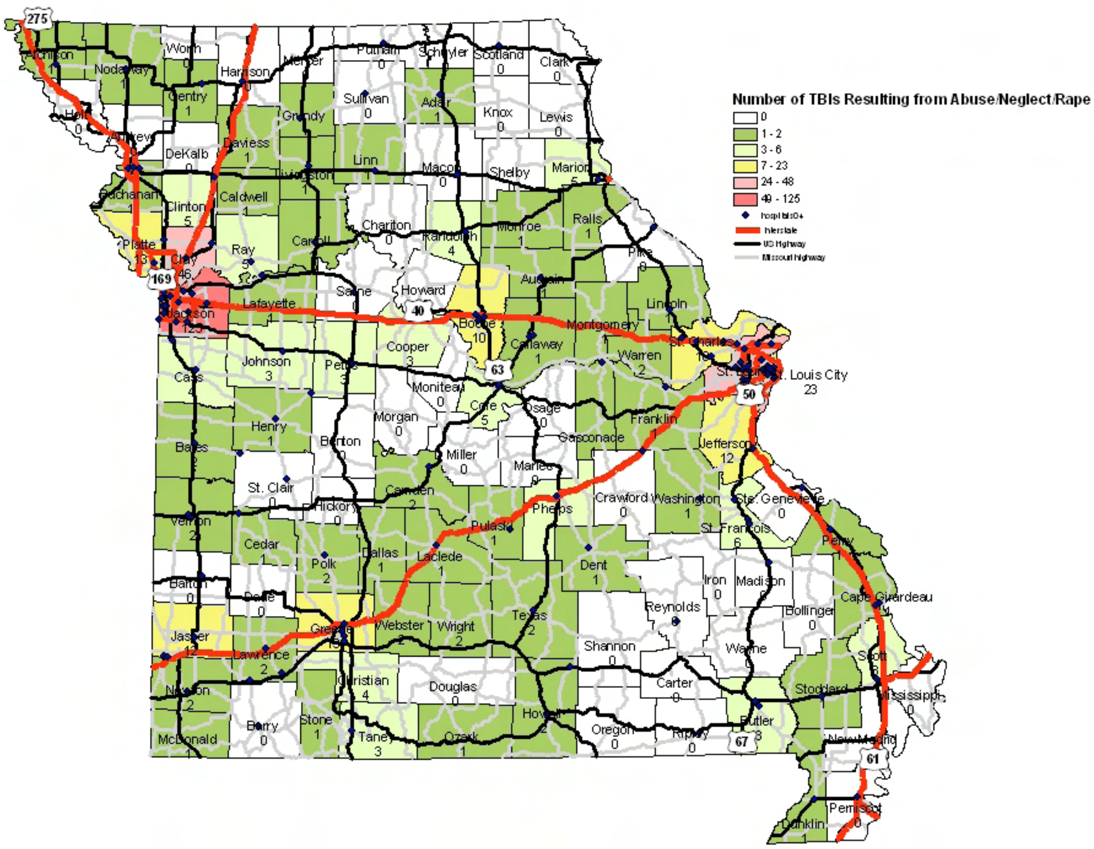

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 24. Traumatic Brain Injuries Resulting from Abuse/Neglect/Rape: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



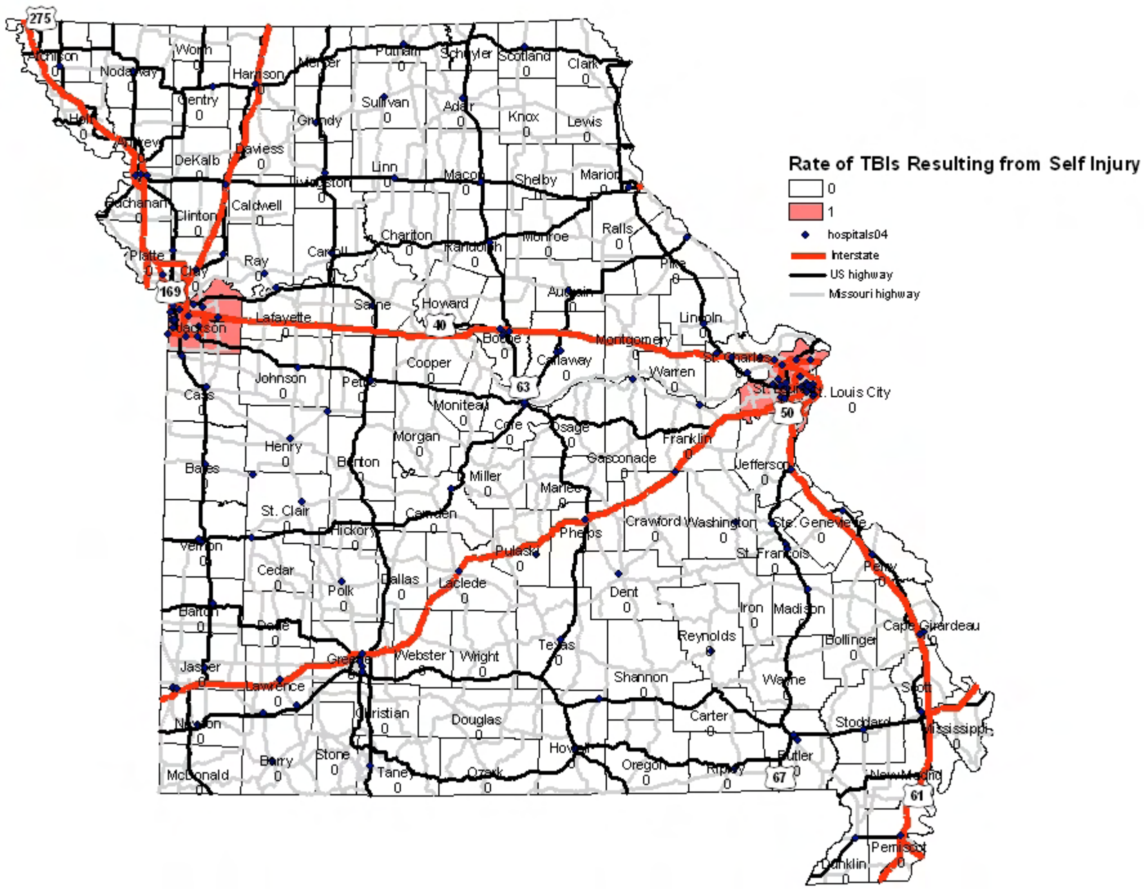

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 25. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Abuse/Neglect/Rape By Missouri Counties, 1999-2003**



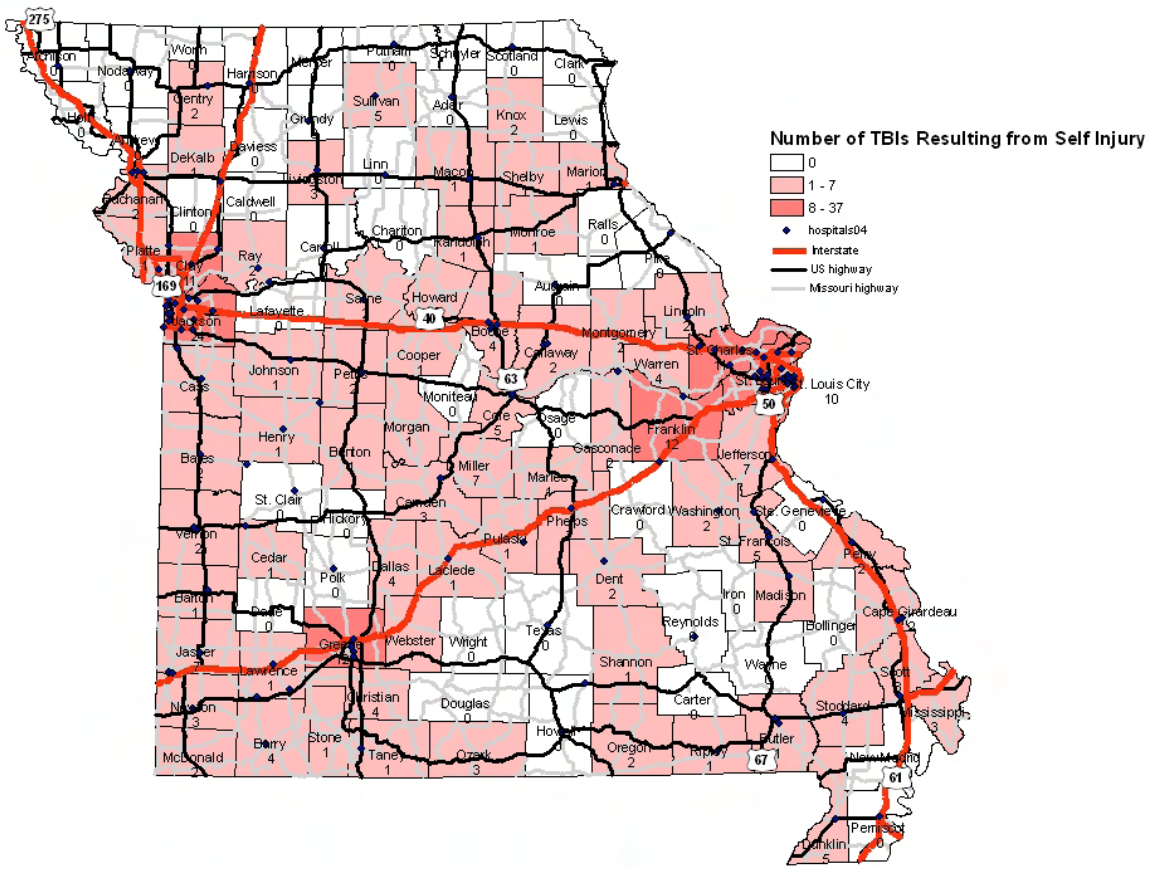

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 26. Traumatic Brain Injuries Resulting from Self-Injury: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



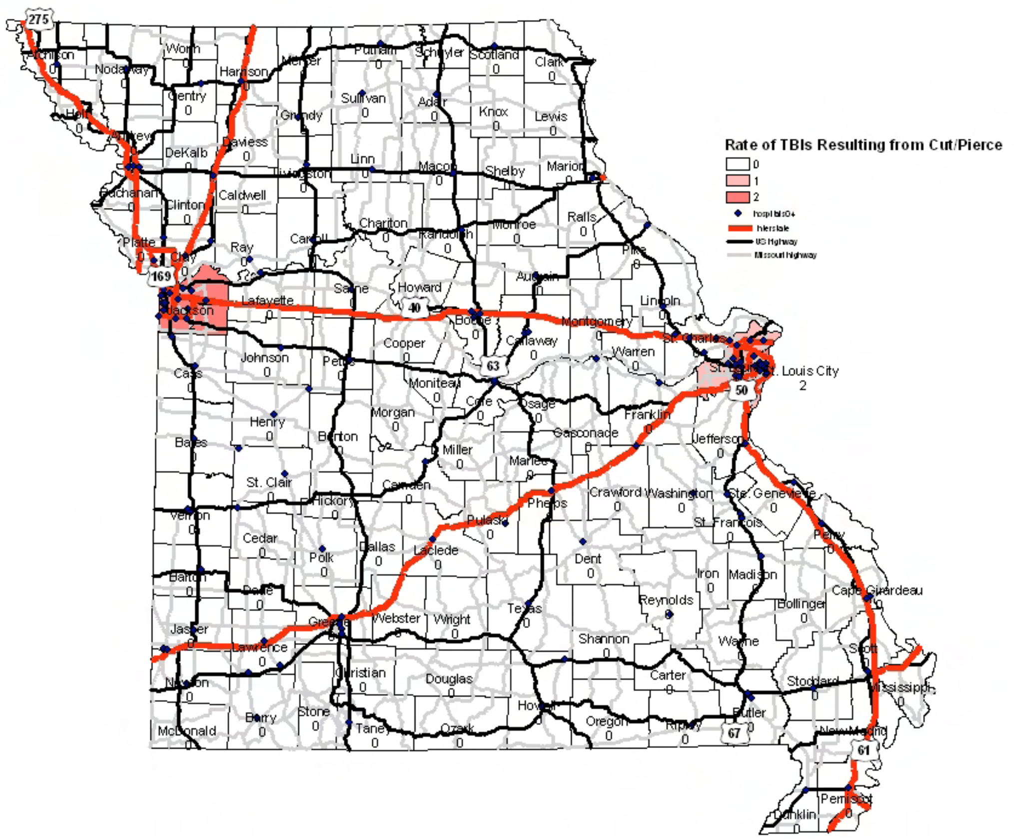

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 27. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Self-Injury by Missouri Counties, 1999-2003**



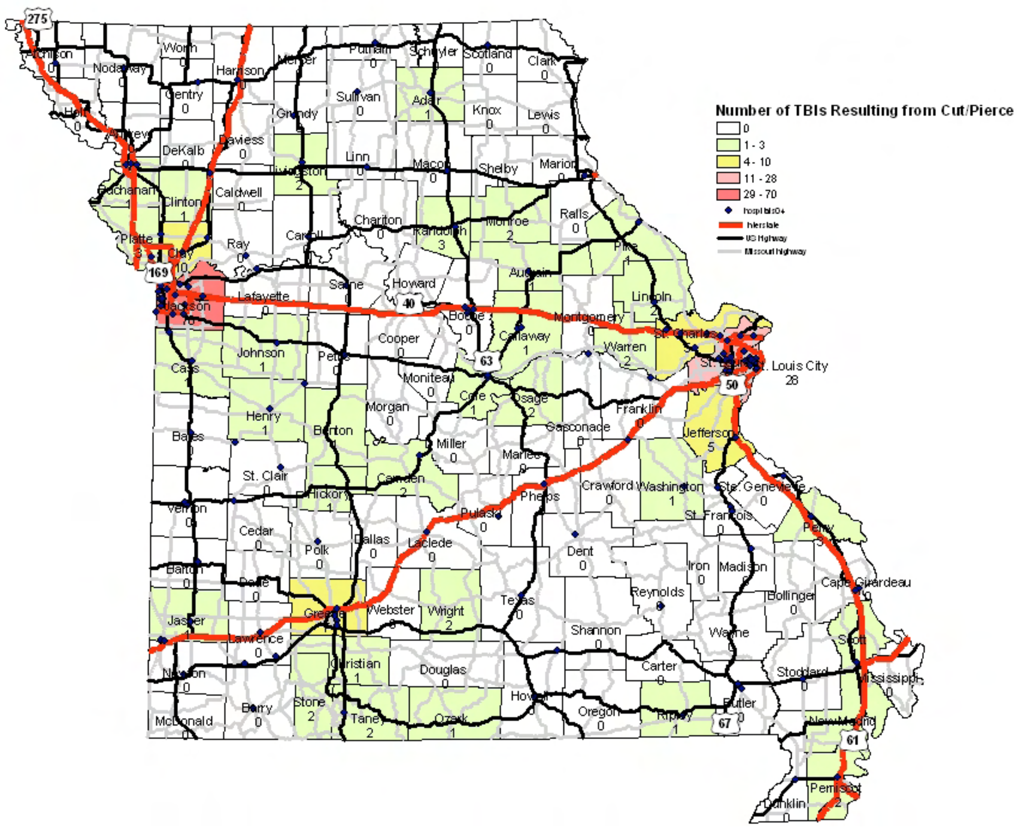

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, [http://www.dhss.mo.gov/InjuryMICA/](http://www.dhss.mo.gov/InjuryMICA/)

**Map 28. Traumatic Brain Injuries Resulting from Cut/Pierce: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



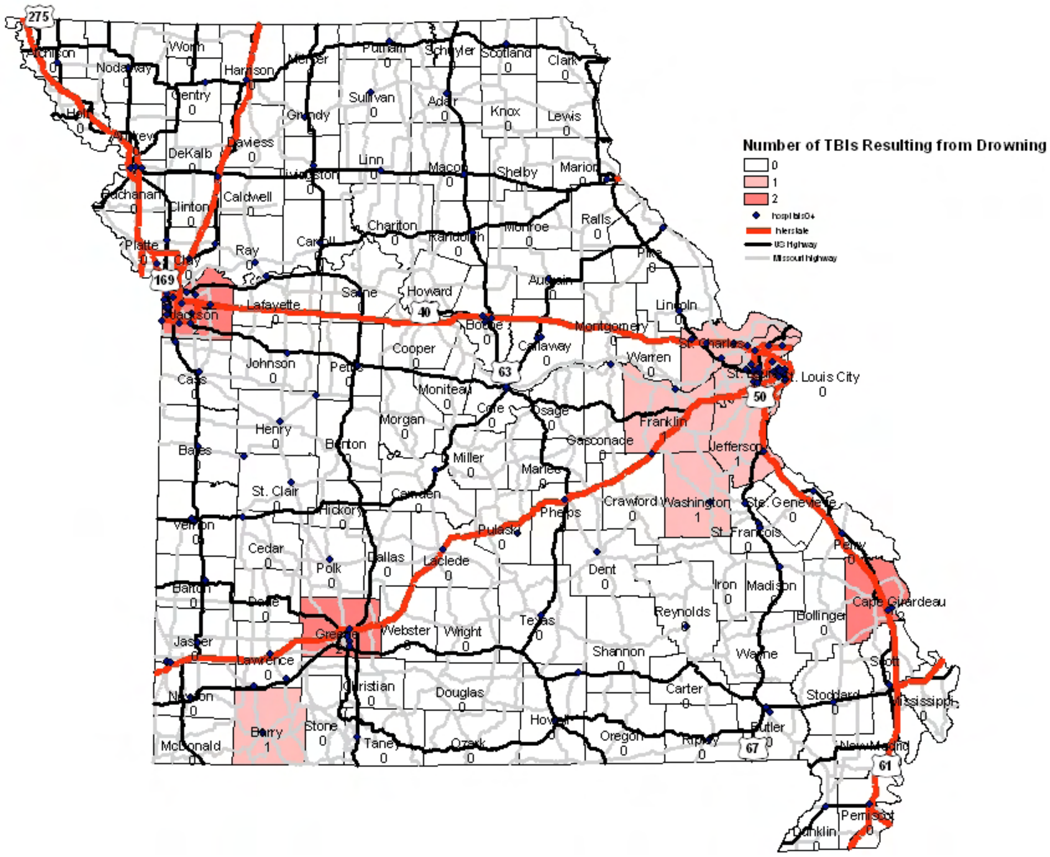

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 29. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Cut/Pierce By Missouri Counties, 1999-2003**



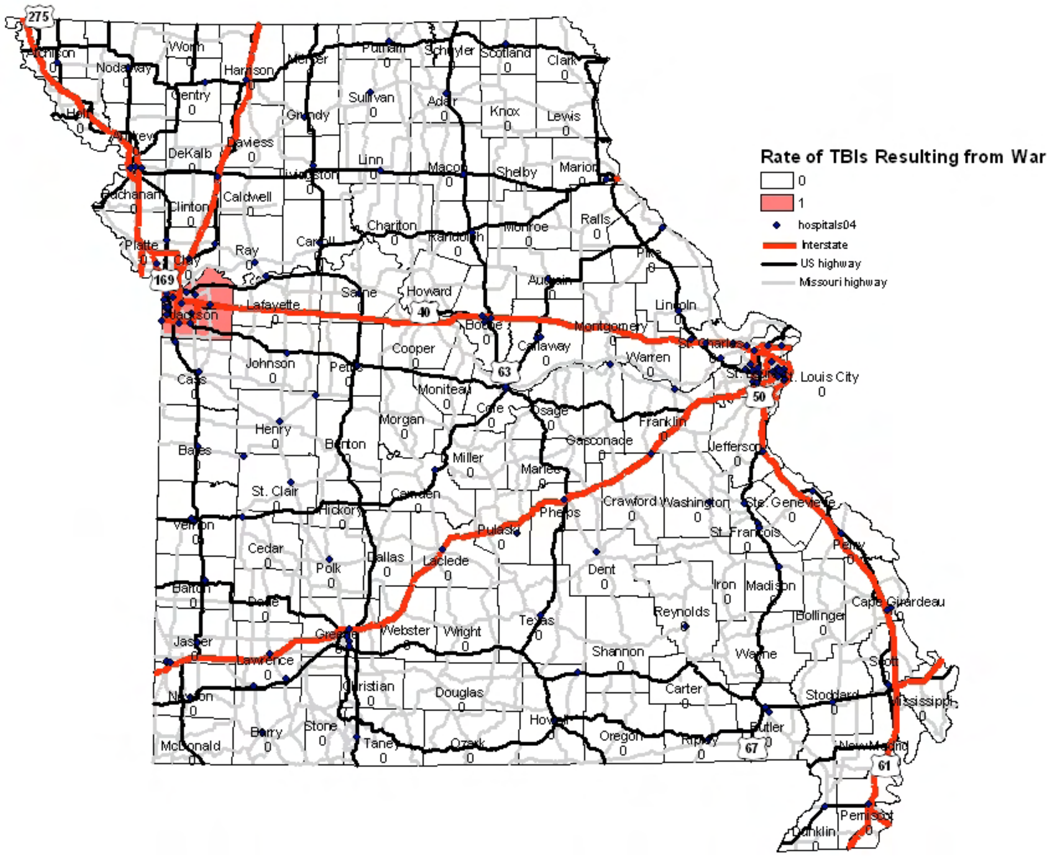

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 30. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Drowning By Missouri Counties, 1999-2003**



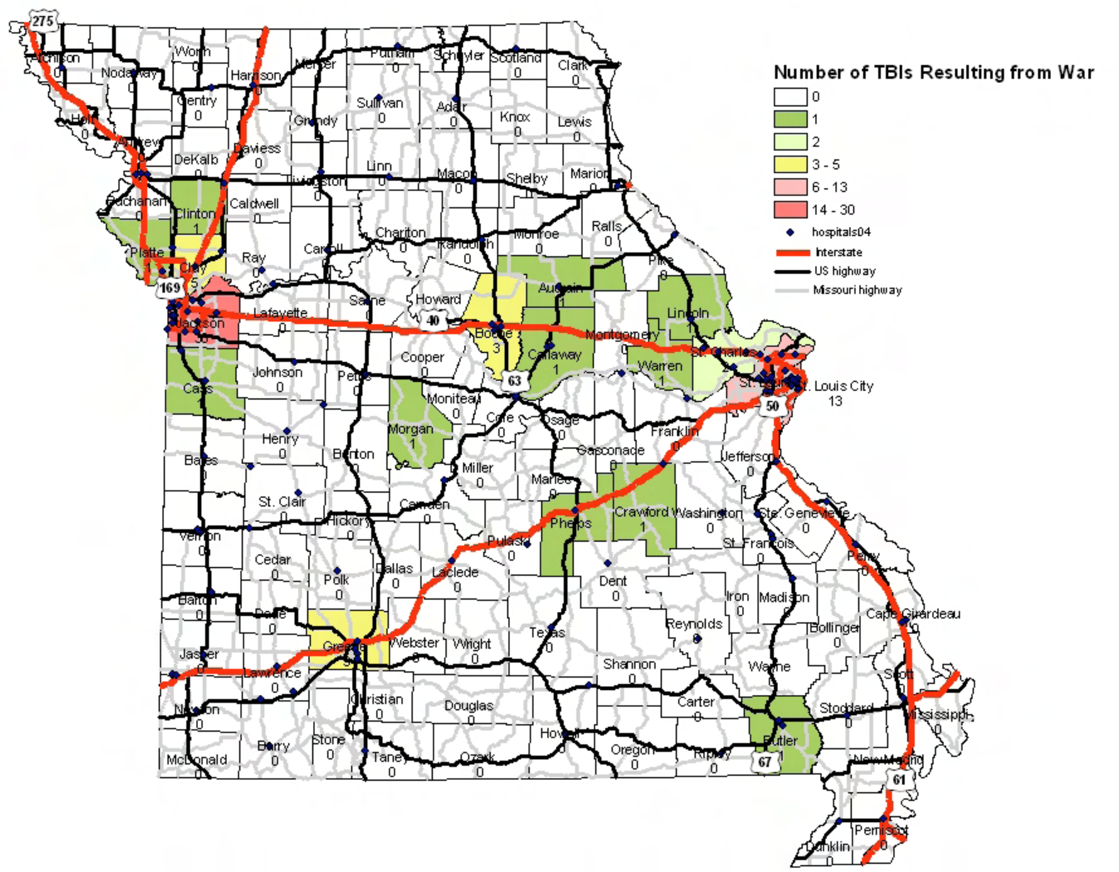

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 31. Traumatic Brain Injuries Resulting from War: ED Visits and Hospitalizations Combined Rates per 100,000 by Missouri Counties, 1999-2003**



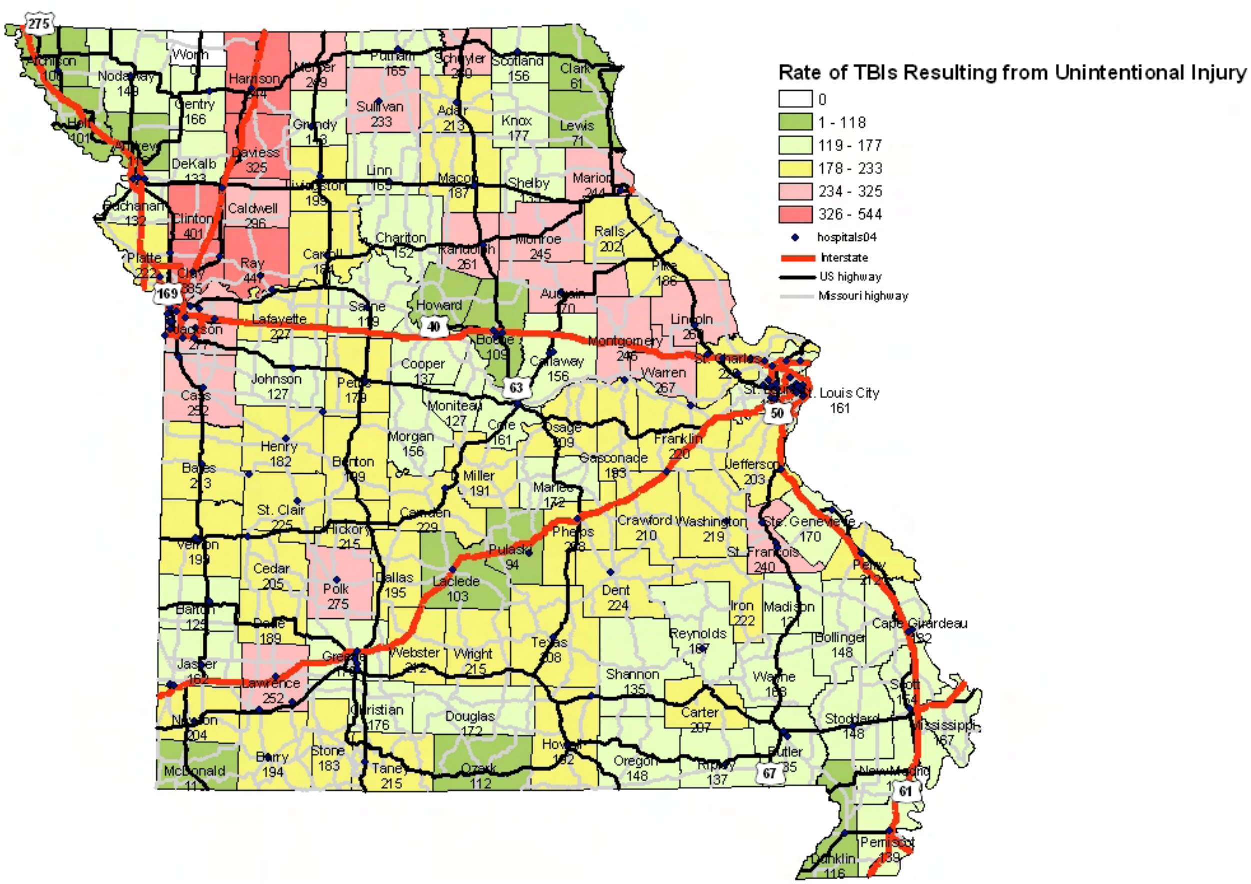

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 32. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from War by Missouri Counties, 1999-2003**



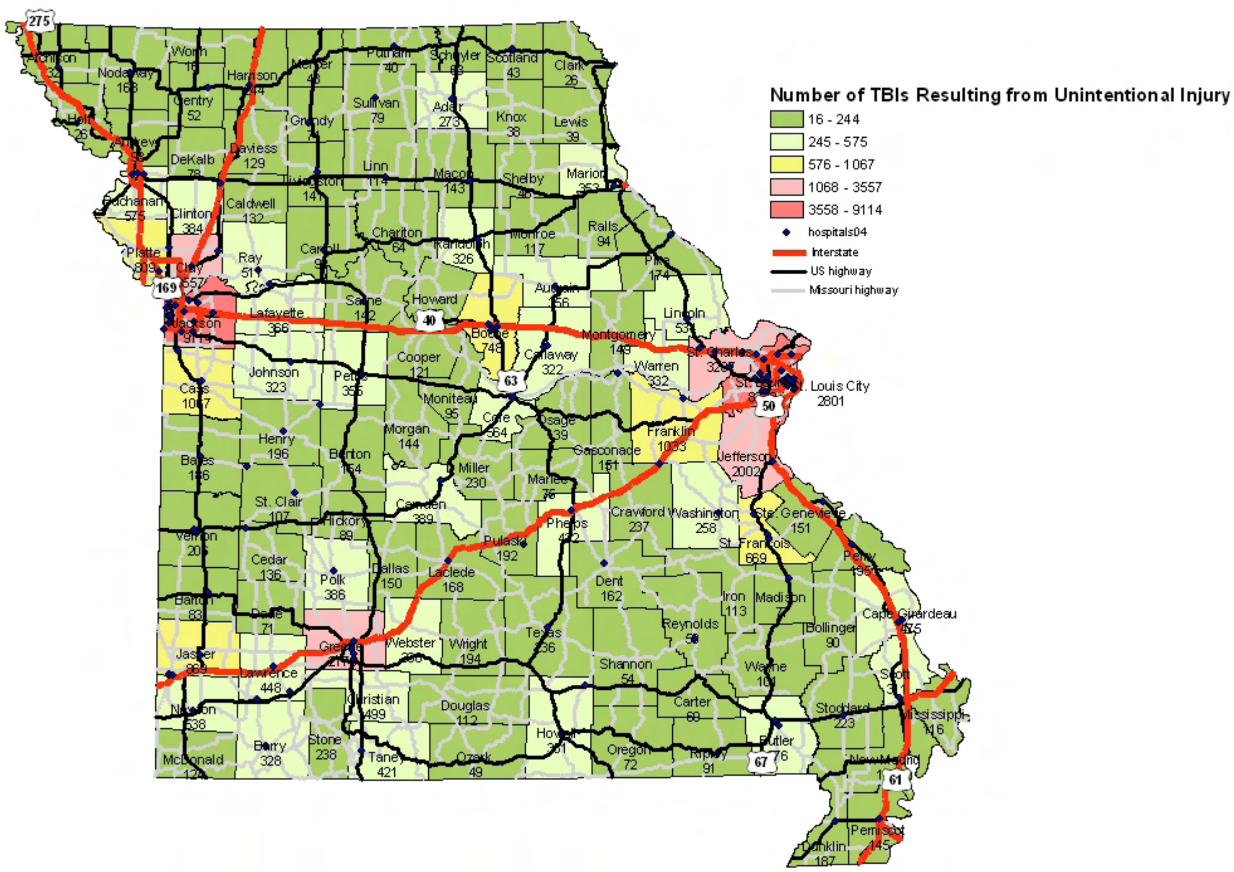

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 33. Traumatic Brain Injuries Resulting from Unintentional Injury: ED Visits and Hospitalizations Combined Rates per 100,000 by Missouri Counties, 1999-2003**



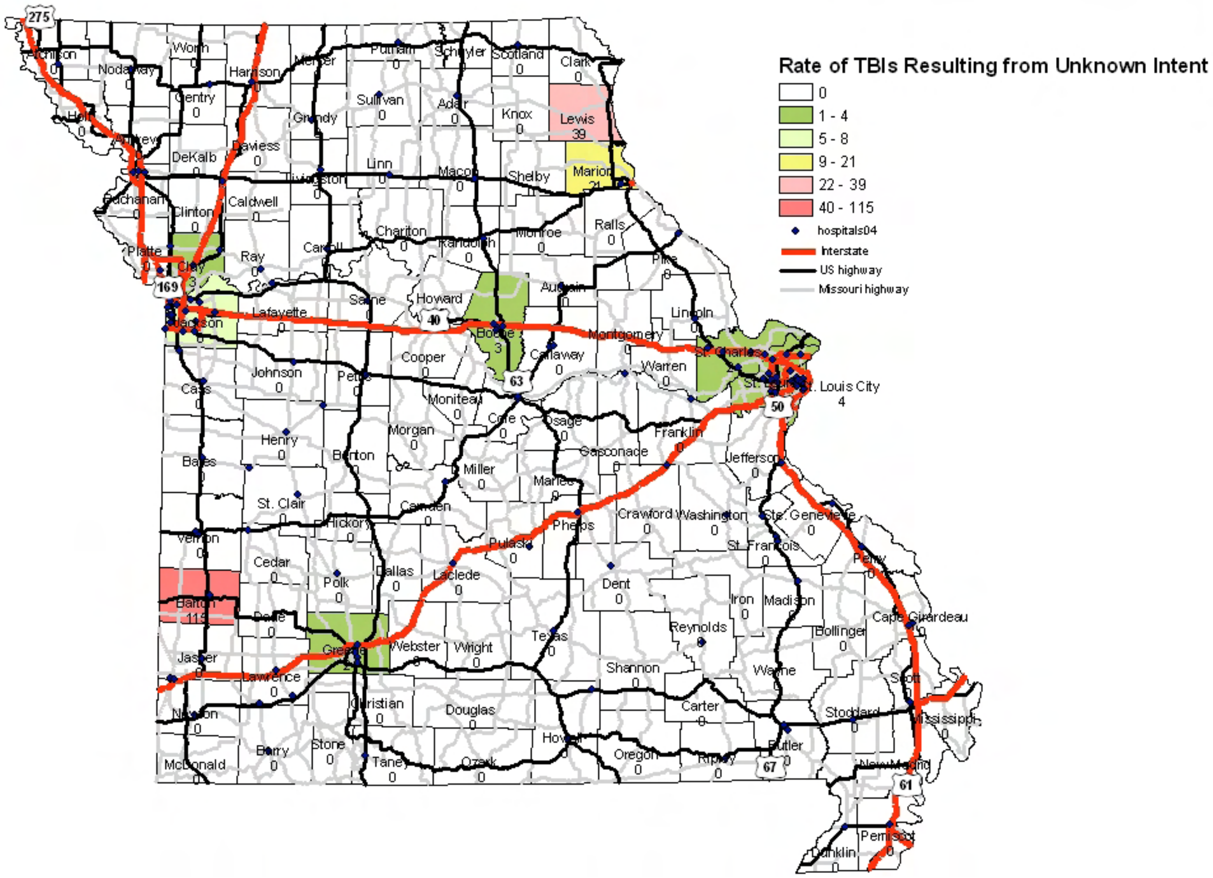

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 34. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Unintentional Injury by Missouri Counties, 1999-2003**



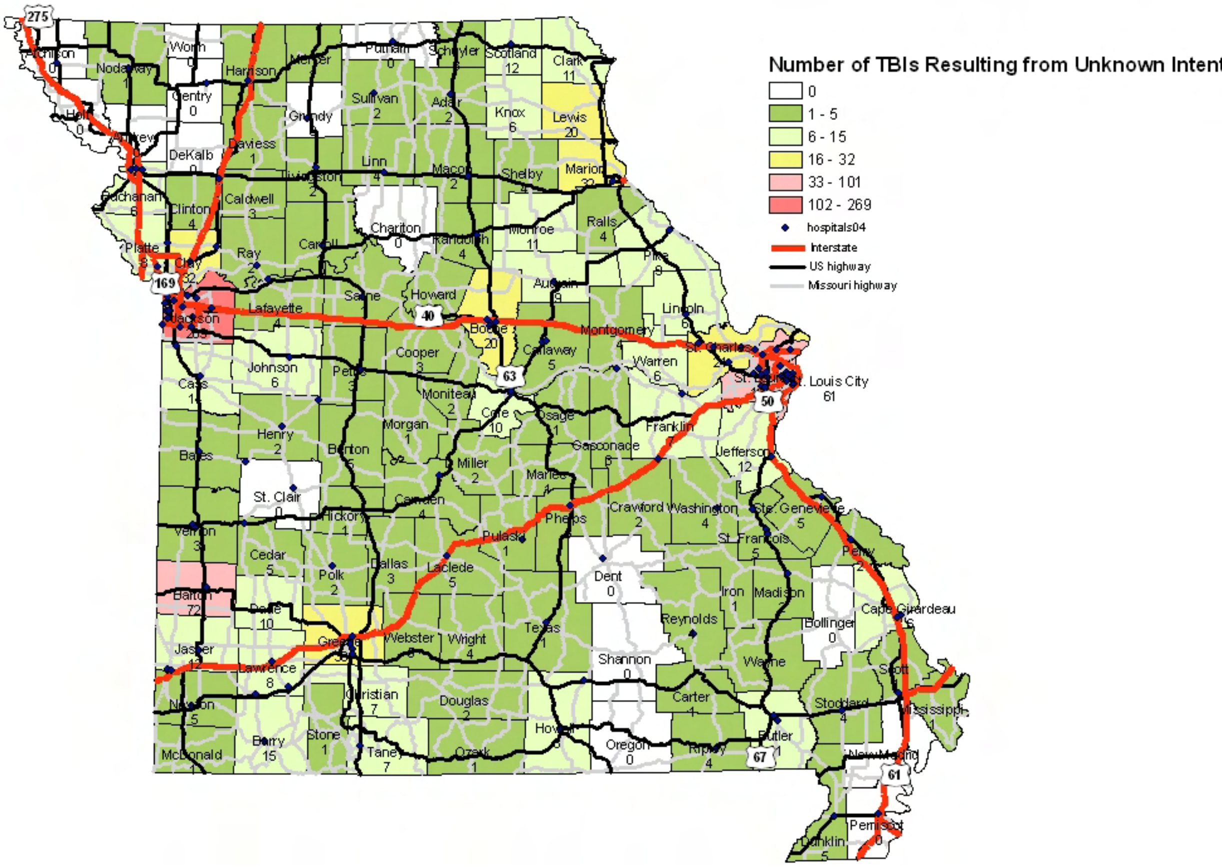

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 35. Traumatic Brain Injuries Resulting from Unknown Intent: ED Visits and Hospitalizations Combined Rates per 100,000 by Missouri Counties, 1999-2003**



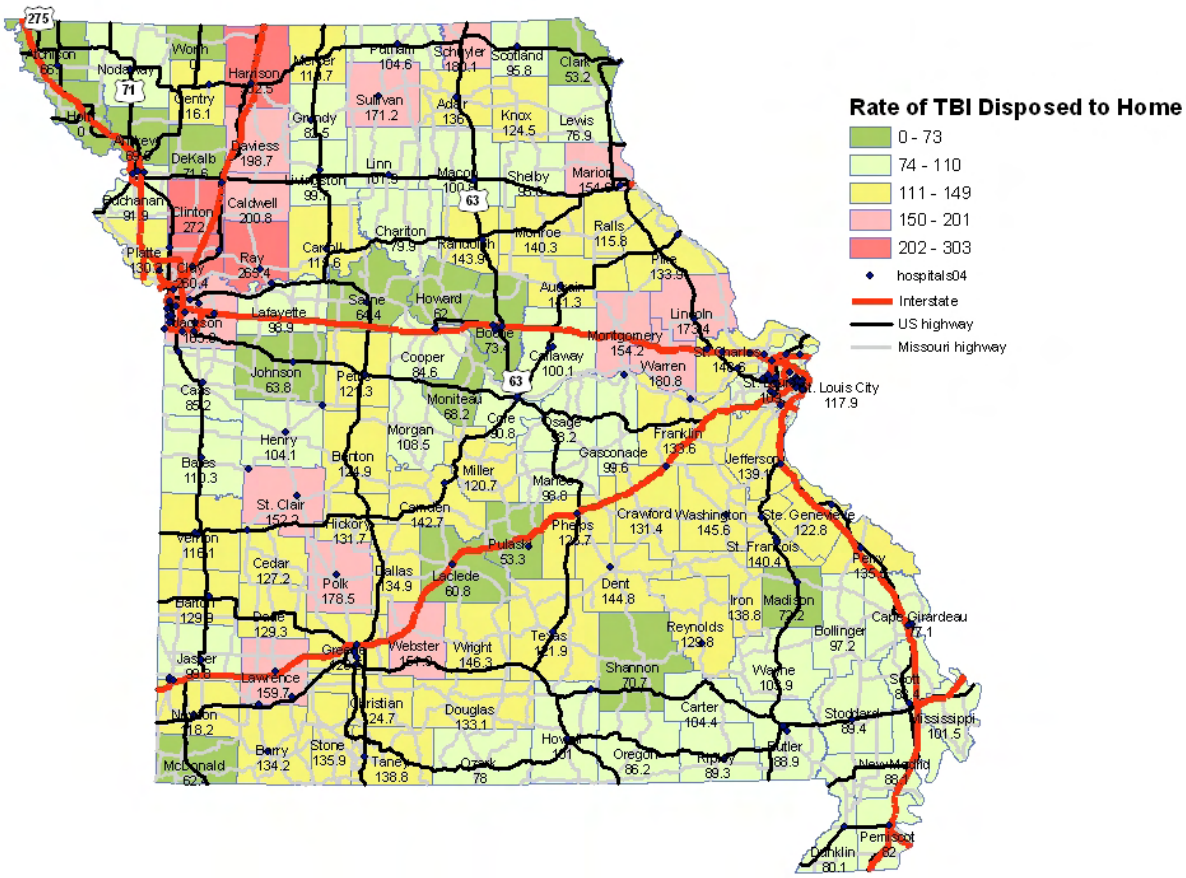

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 36. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Resulting from Unknown Intent by Missouri Counties, 1999-2003**



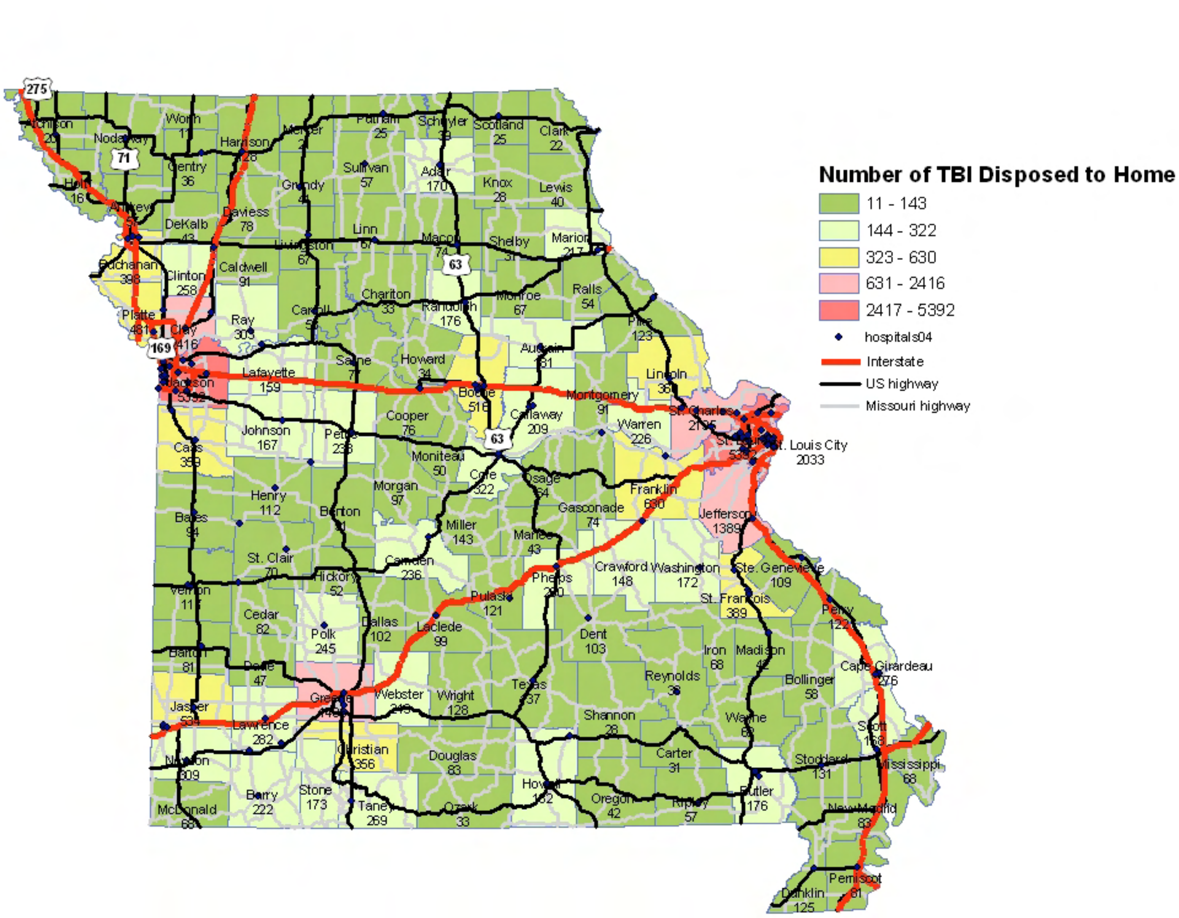

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 37. Traumatic Brain Injuries Disposed to Home: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



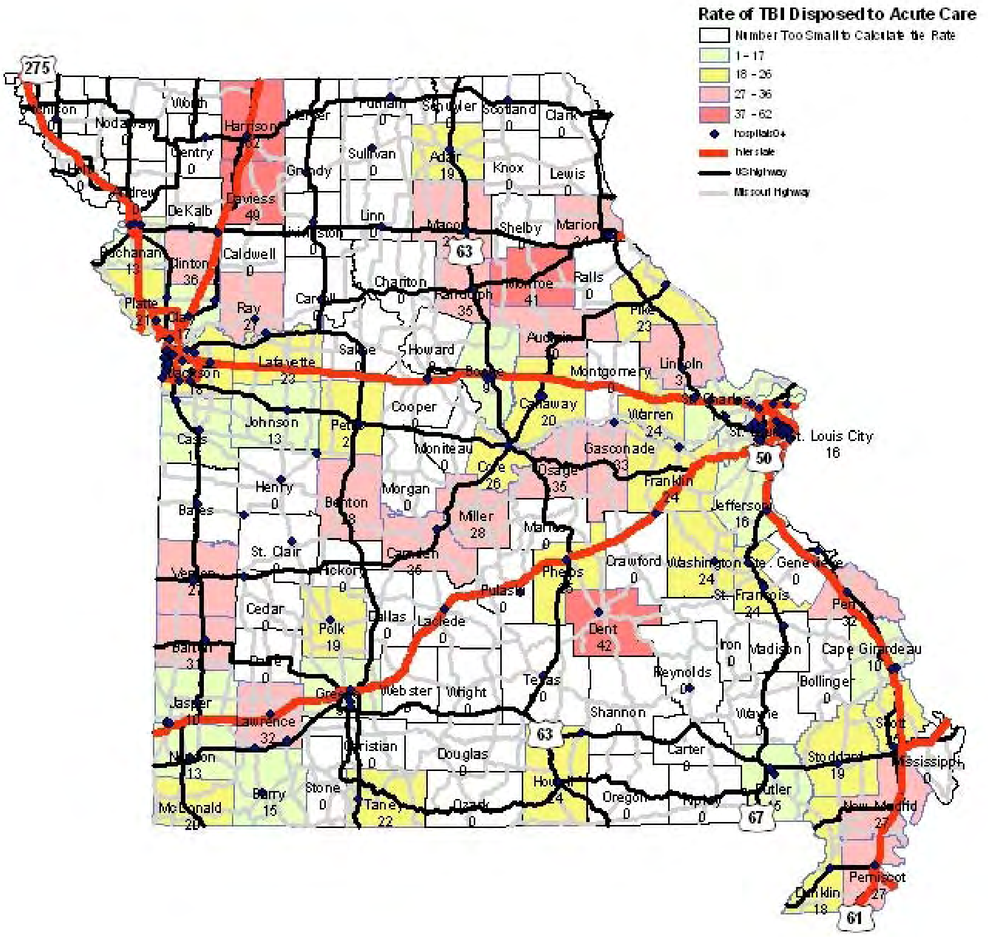

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 38. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Disposed to Home By Missouri Counties, 1999-2003**



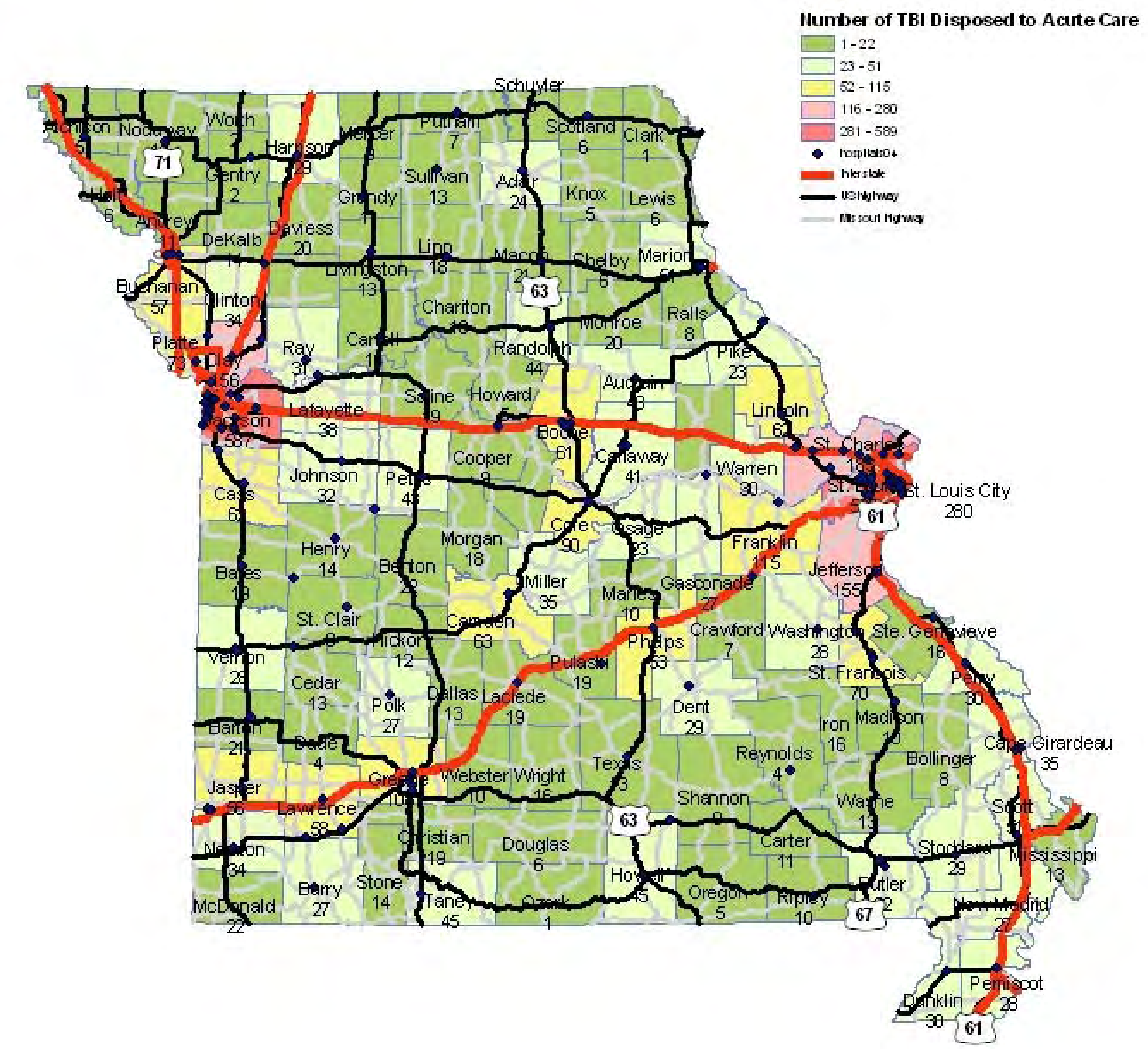

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 39. Traumatic Brain Injuries Disposed to Acute Care: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



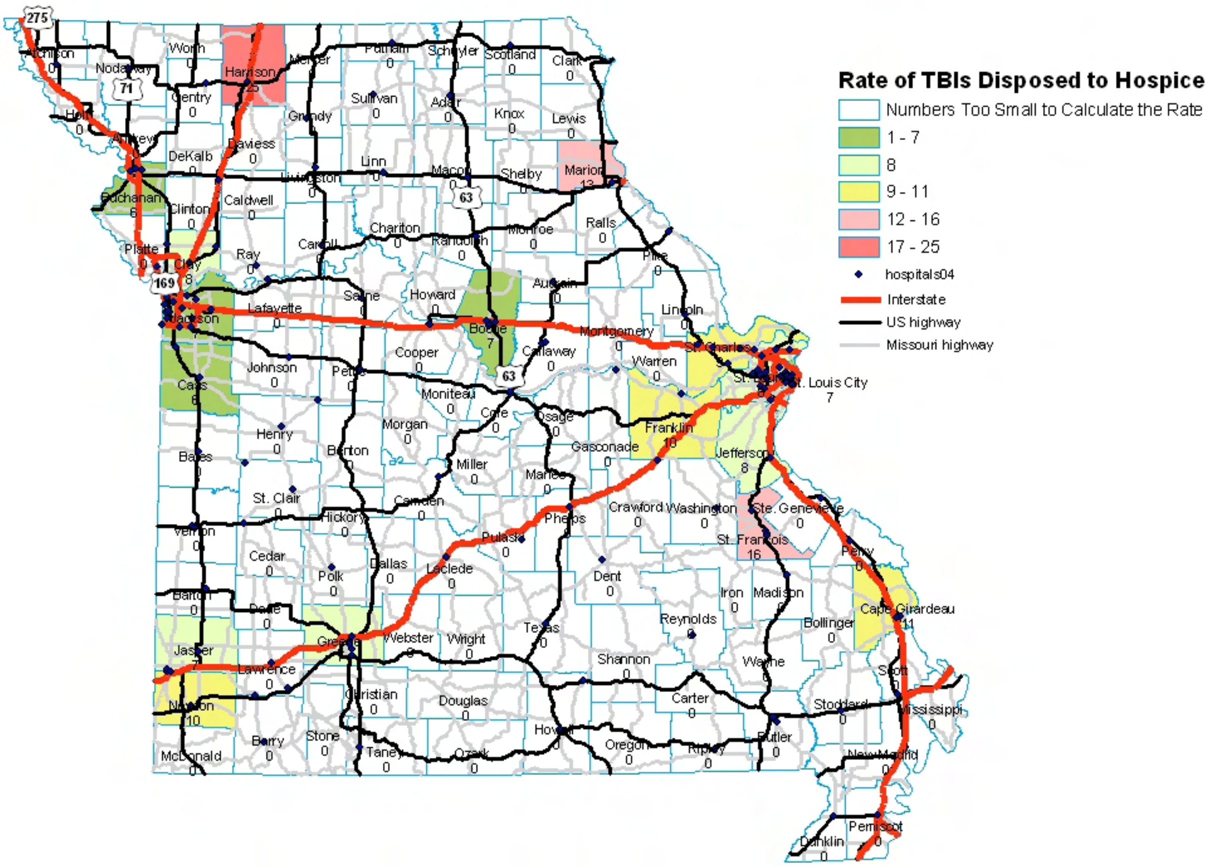

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

## Map 40. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Disposed to Acute Care By Missouri Counties, 1999-2003



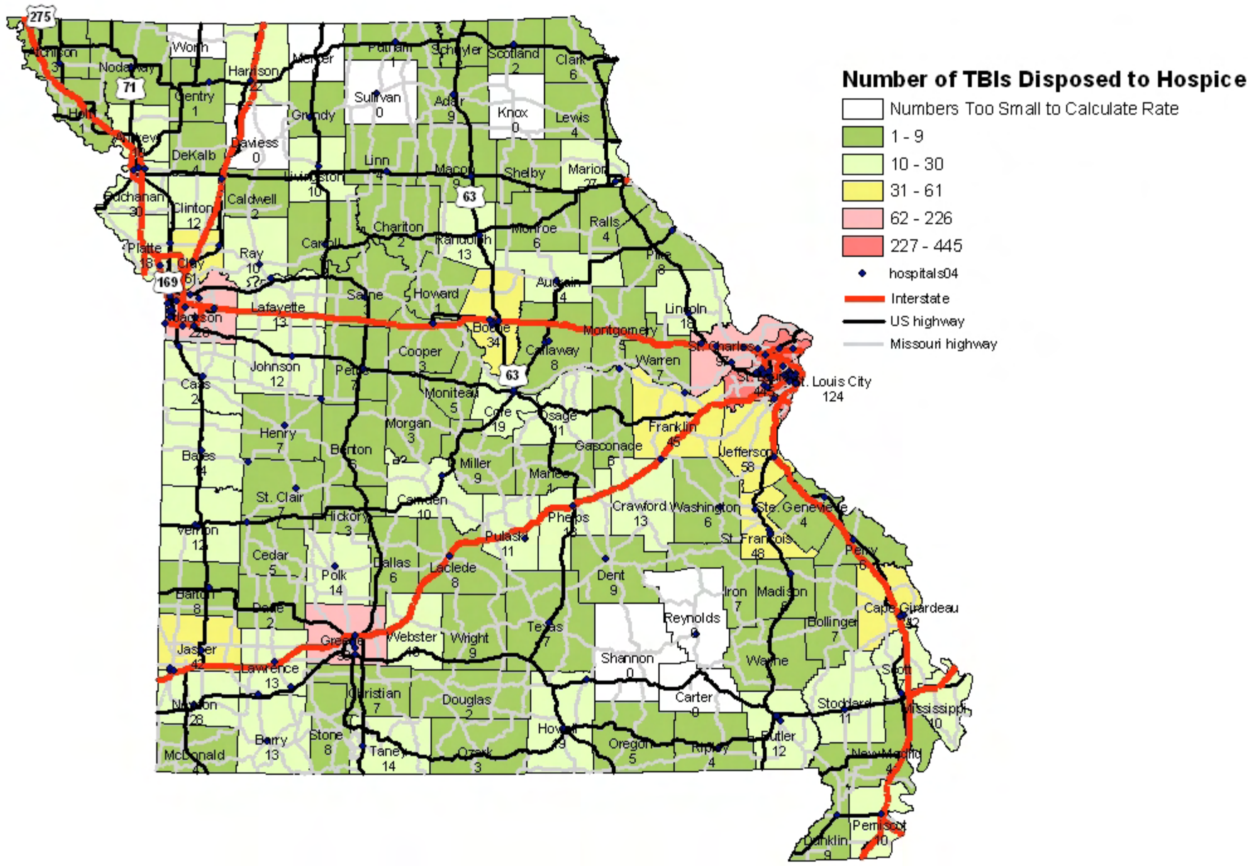

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 41. Traumatic Brain Injuries Disposed to Skilled Nursing Facility, Intermediate Care Facility, or Hospice: ED Visits and Hospitalizations Combined Rates per 100,000 By Missouri Counties, 1999-2003**



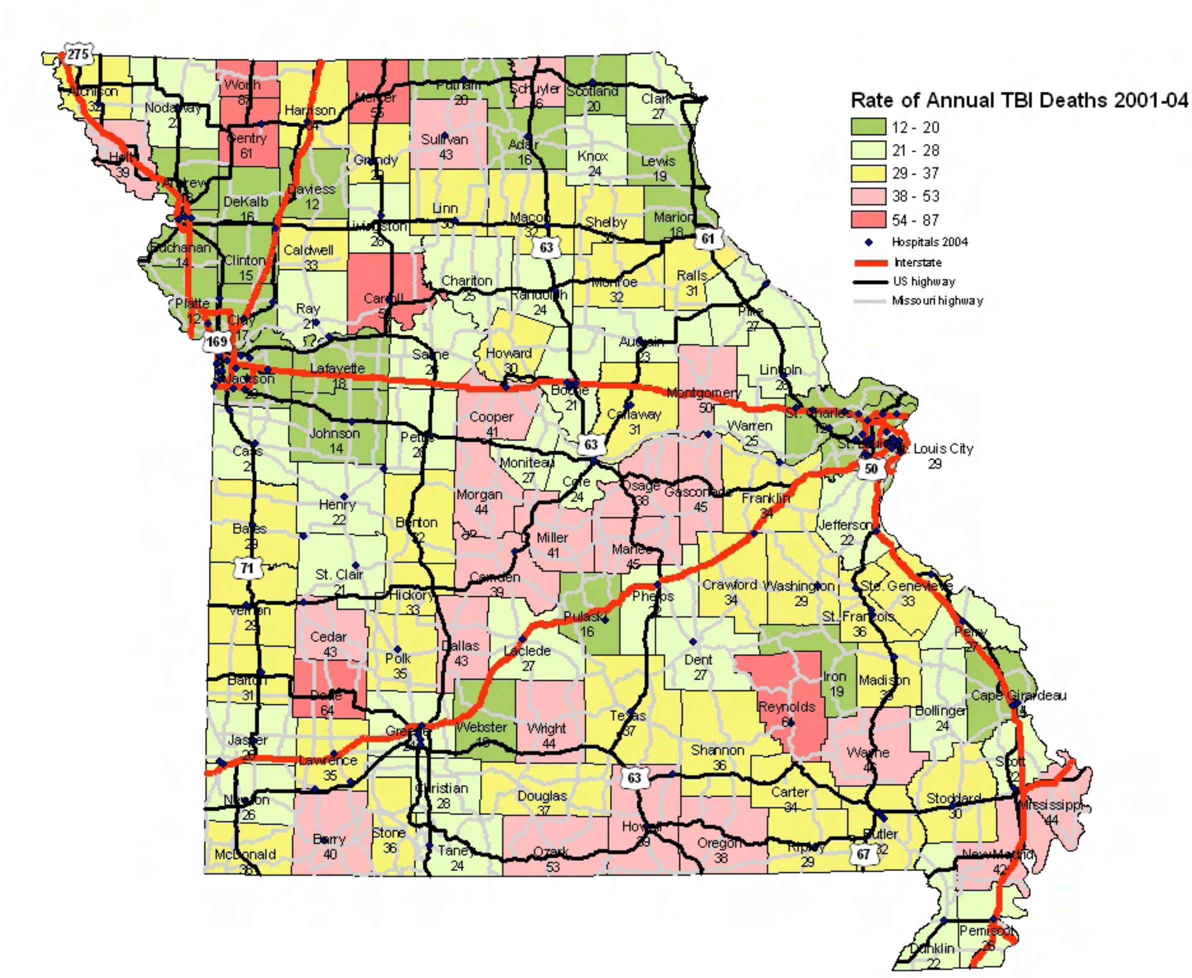

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 42. Number of ED Visits and Hospitalizations Combined for Traumatic Brain Injuries Disposed to Skilled Nursing Facility, Intermediate Care Facility, or Hospice By Missouri Counties, 1999-2003**



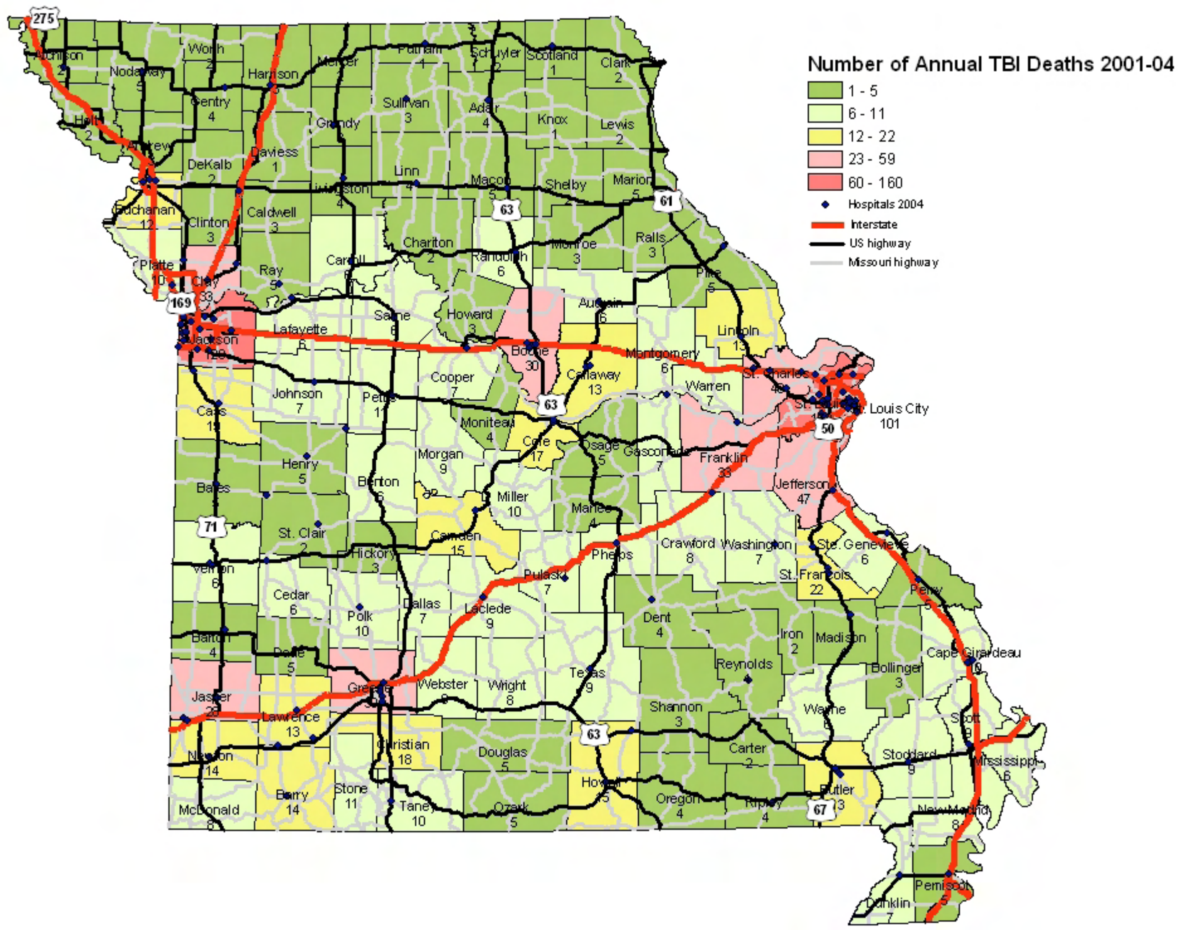

Source: Missouri Department of Health and Senior Services, Missouri Information for Community Assessment (MICA): Injury 1999-2003, http://www.dhss.mo.gov/InjuryMICA/

**Map 43. Annual Deaths Resulting from Traumatic Brain Injuries: Rates per 100,000 by Missouri Counties, 2001-2004**



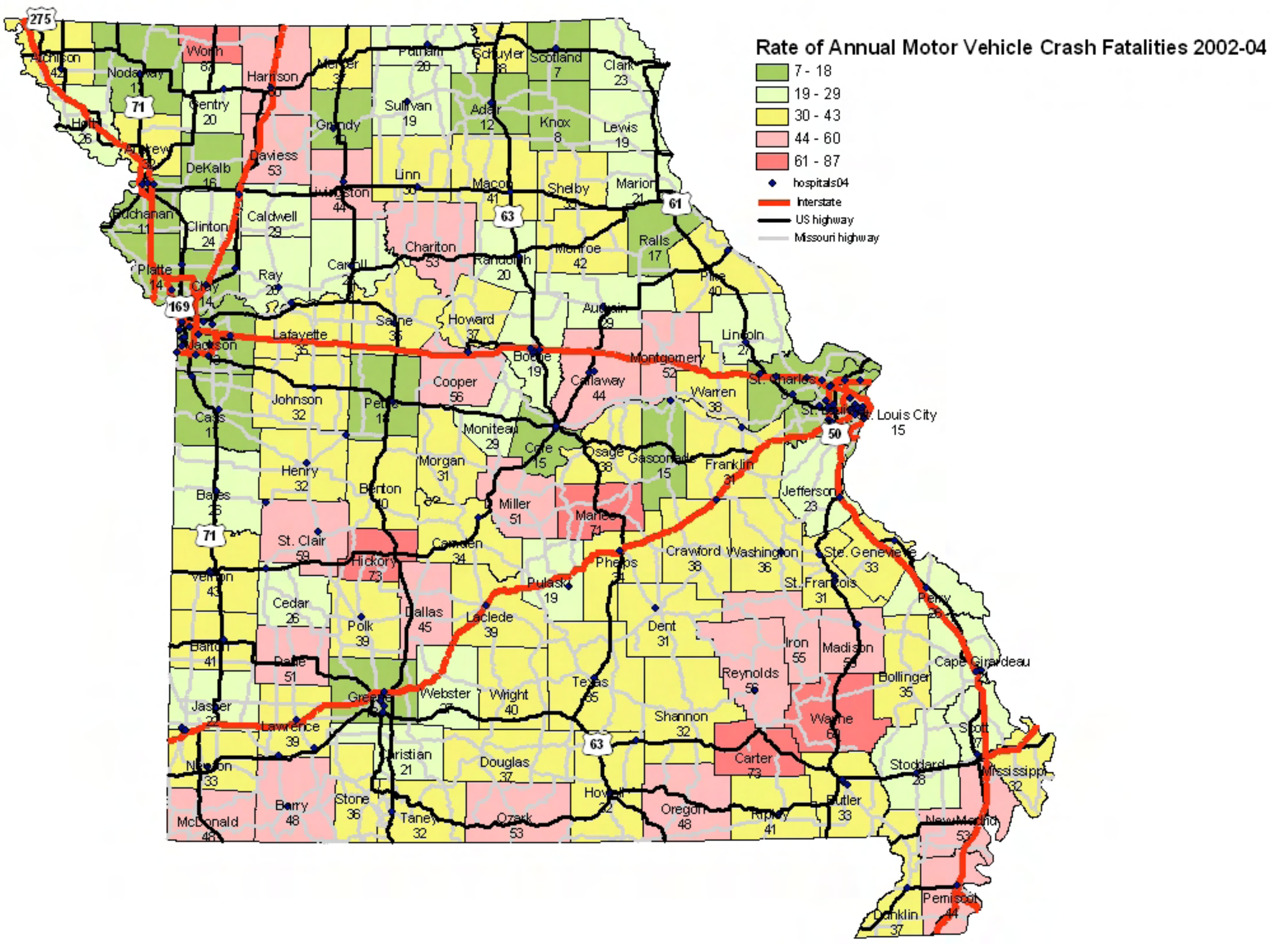

Source: Missouri Department of Health and Senior Services, Vital Statistics 2001-04.

**Map 44: Number of Annual Deaths Resulting from Traumatic Brain Injuries by Missouri Counties, 2001-2004**



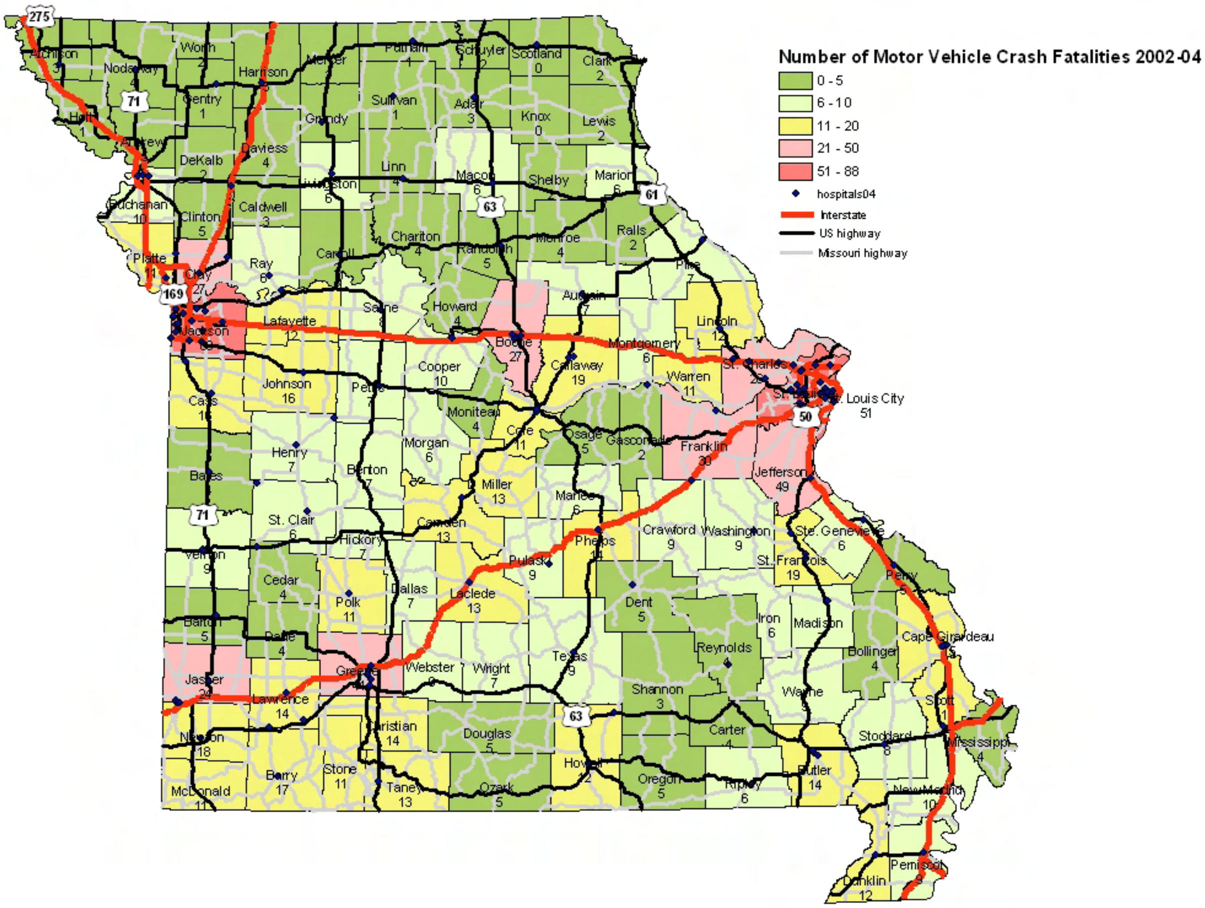

Source: Missouri Department of Health and Senior Services, Vital Statistics 2001-04

**Map 45: Annual Motor Vehicle Crash Fatalities: Rate per 100,000 Residents by Missouri Counties, 2002-2004**



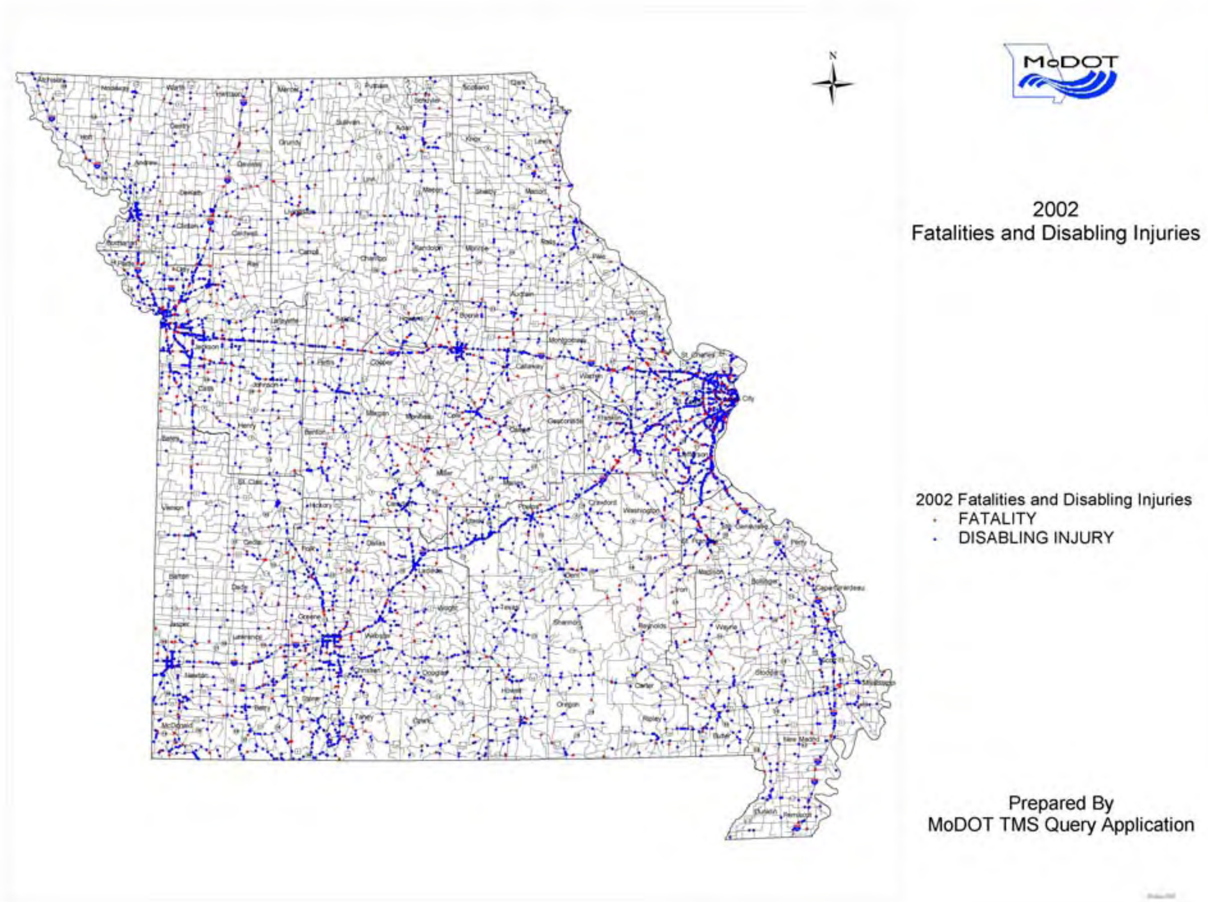

Source: Missouri Department of Transportation, 2002-04.

**Map 46: Number of Annual Motor Vehicle Crash Fatalities by Missouri Counties, 2002-2004**

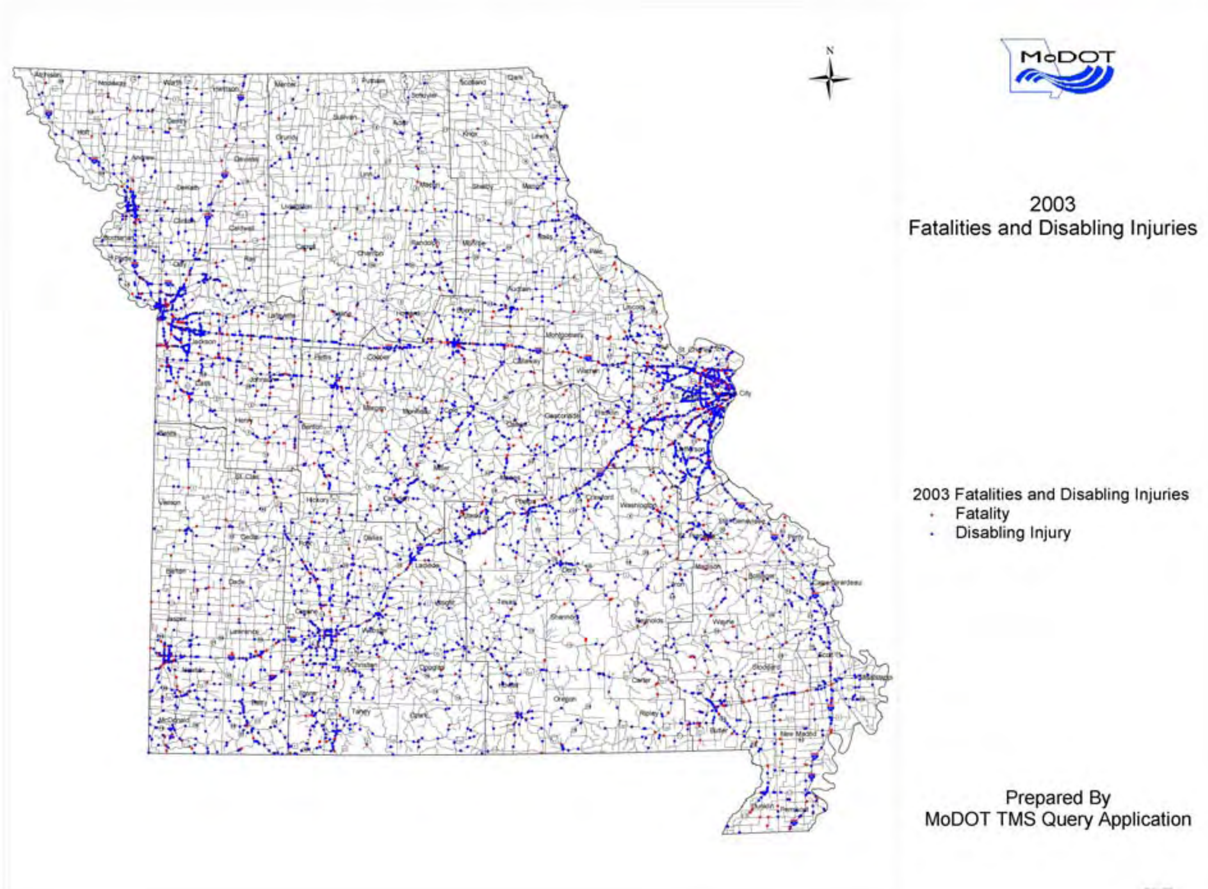



Source: Missouri Department of Transportation, 2002-04.

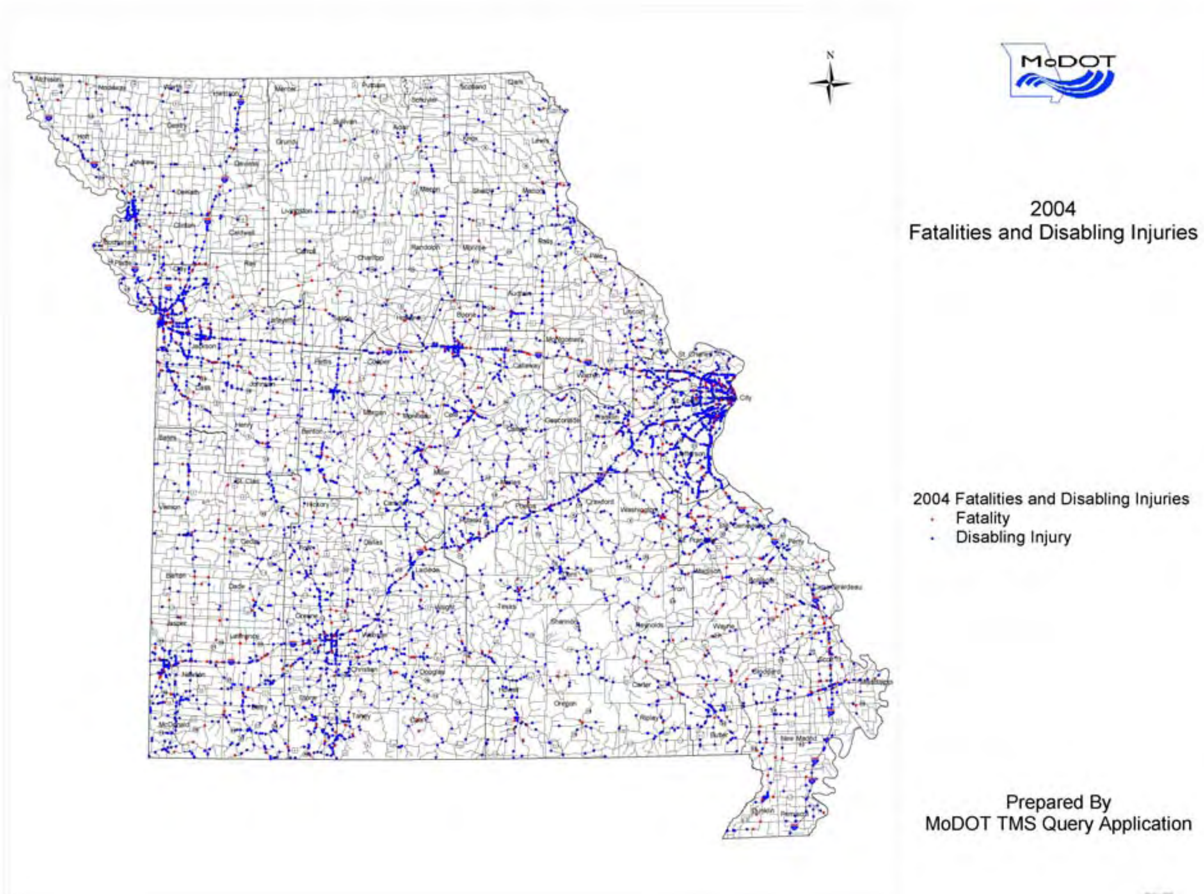
**Map 47. Number of Motor Vehicle Crash Fatalities and Disabling Injuries by Missouri Counties, 2002**



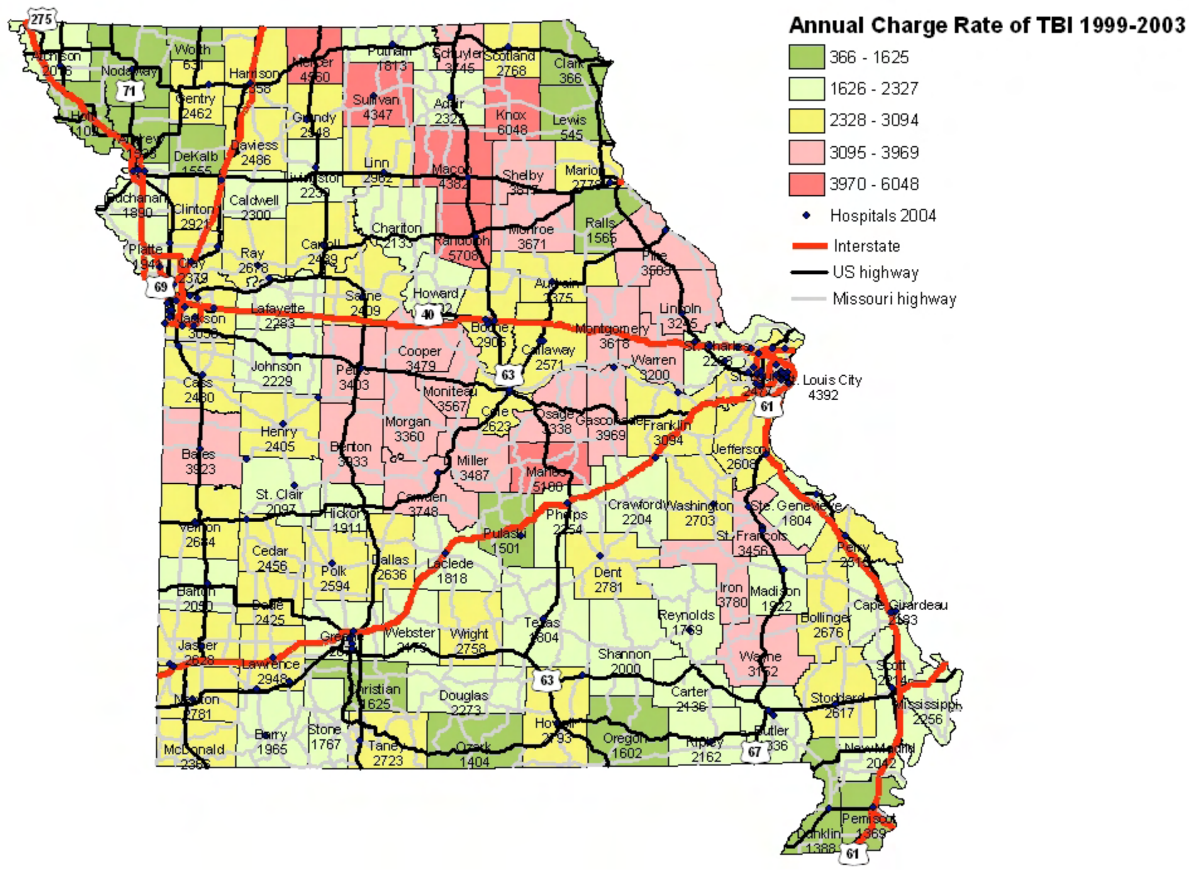
**Map 48. Number of Motor Vehicle Crash Fatalities and Disabling Injuries by Missouri Counties, 2003**



**Map 49. Number of Motor Vehicle Crash Fatalities and Disabling Injuries by Missouri Counties, 2004**

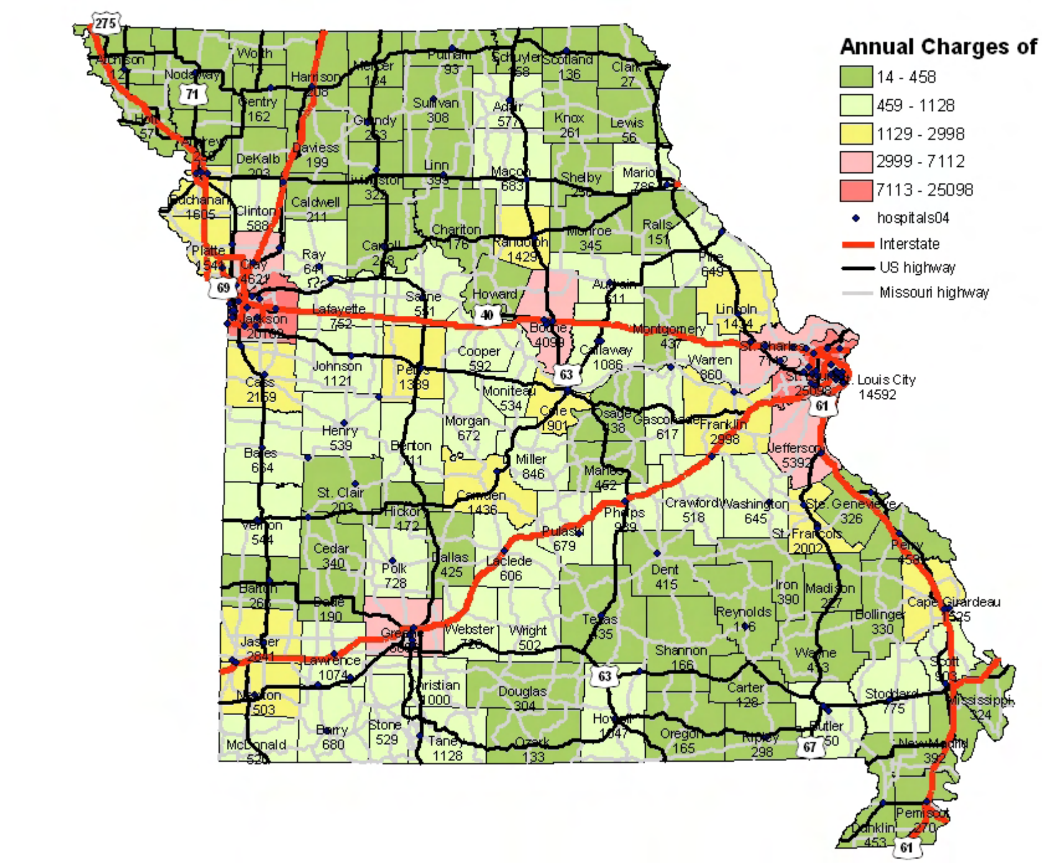


**Map 50: Annual Charges for Traumatic Brain Injuries by Missouri Counties: ED Visits and Hospitalizations Combined Rates per 100,000, 1999-2003**



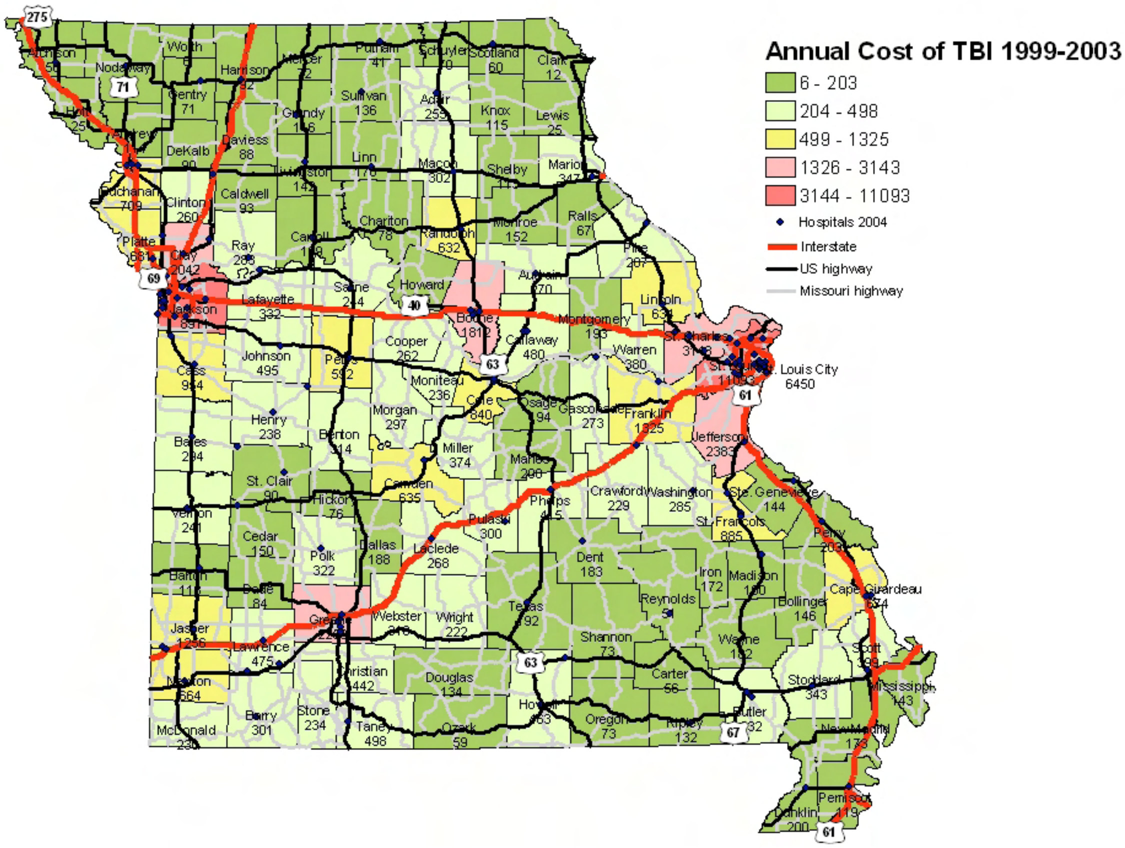

Source: Missouri Department of Health and Senior Services, Patient Abstract System, 1999-2003.

**Map 51. Annual ED Visits and Hospitalizations Combined Charges for Traumatic Brain Injuries by Missouri Counties, 1999-2003**



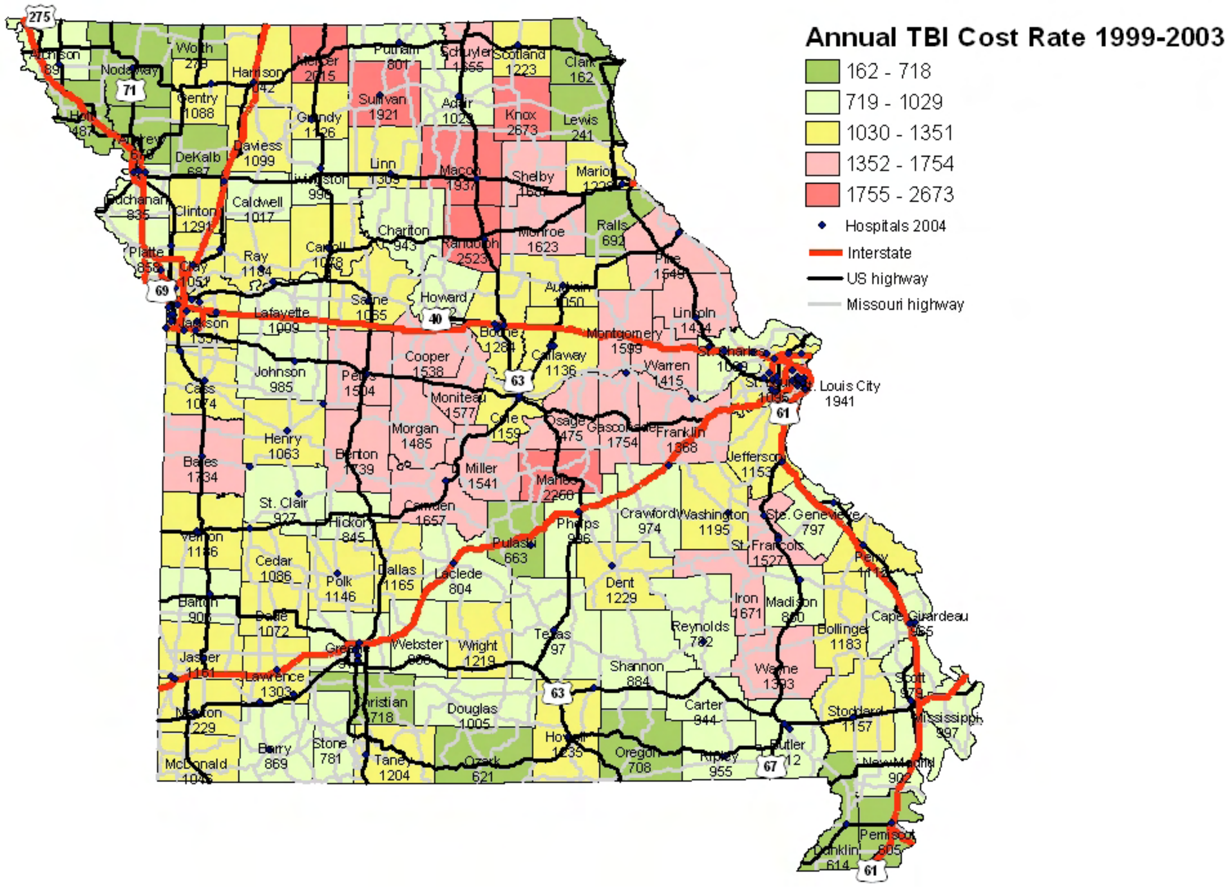

Source: Missouri Department of Health and Senior Services, Patient Abstract System, 1999-2003.

**Map 52: Annual Cost of Traumatic Brain Injuries by Missouri Counties: ED Visits and Hospitalizations Combined Rates per 100,000, 1999-2003**




Source: Missouri Department of Health and Senior Services, Patient Abstract System, 1999-2003.

**Map 53: Annual ED Visits and Hospitalizations Combined Cost of Traumatic Brain Injuries by Missouri Counties, 1999-2003**




Source: Missouri Department of Health and Senior Services, Patient Abstract System, 1999-2003.

APPENDIX 5

| Direct Cost of Traumatic Brain Injury by Missouri Counties, 1999-2003* | | | | |
|---|---|---|---|---|
| County | Annual TBI CHARGES** | Annual TBI COST*** | Annual TBI CHARGES: Rate per 100,000 of Population**** | Annual TBI COST: Rate per 100,000 of Population**** |
| Missouri | $152,103,957 | $67,229,949 | $2,666,393 | $1,178,546 |
| Adair | $576,956 | $255,014 | $2,327,373 | $1,028,699 |
| Andrew | $257,729 | $113,916 | $1,532,917 | $677,549 |
| Atchison | $126,736 | $56,017 | $2,016,163 | $891,144 |
| Audrain | $610,812 | $269,979 | $2,375,222 | $1,049,848 |
| Barry | $680,459 | $300,763 | $1,964,998 | $868,529 |
| Barton | $266,494 | $117,790 | $2,050,108 | $906,148 |
| Bates | $664,379 | $293,655 | $3,922,648 | $1,733,810 |
| Benton | $710,997 | $314,261 | $3,933,378 | $1,738,553 |
| Bollinger | $329,570 | $145,670 | $2,675,515 | $1,182,578 |
| Boone | $4,099,411 | $1,811,939 | $2,904,870 | $1,283,953 |
| Buchanan | $1,604,570 | $709,220 | $1,889,753 | $835,271 |
| Butler | $750,202 | $331,589 | $1,836,300 | $811,645 |
| Caldwell | $210,679 | $93,120 | $2,300,241 | $1,016,706 |
| Callaway | $1,085,653 | $479,859 | $2,571,115 | $1,136,433 |
| Camden | $1,435,666 | $634,564 | $3,748,279 | $1,656,740 |
| Cape Girardeau | $1,525,158 | $674,120 | $2,182,663 | $964,737 |
| Carroll | $247,561 | $109,422 | $2,439,263 | $1,078,154 |
| Carter | $127,620 | $56,408 | $2,136,252 | $944,223 |
| Cass | $2,158,901 | $954,234 | $2,430,265 | $1,074,177 |
| Cedar | $339,847 | $150,212 | $2,455,895 | $1,085,506 |
| Chariton | $175,972 | $77,780 | $2,132,732 | $942,668 |
| Christian | $1,000,497 | $442,220 | $1,624,948 | $718,227 |
| Clark | $27,145 | $11,998 | $365,842 | $161,702 |
| Clay | $4,620,812 | $2,042,399 | $2,378,833 | $1,051,444 |
| Clinton | $588,216 | $259,992 | $2,920,637 | $1,290,922 |
| Cole | $1,900,684 | $840,102 | $2,623,297 | $1,159,497 |
| Cooper | $591,714 | $261,538 | $3,478,829 | $1,537,642 |
| Crawford | $518,329 | $229,102 | $2,204,437 | $974,361 |
| Dade | $190,252 | $84,092 | $2,425,142 | $1,071,913 |
| Dallas | $424,814 | $187,768 | $2,636,465 | $1,165,317 |
| Daviess | $198,965 | $87,943 | $2,485,820 | $1,098,732 |
| De Kalb | $203,106 | $89,773 | $1,554,819 | $687,230 |

Sources: Missouri Department of Health and Senior Services; Population Estimates 2003, U.S. Census Bureau.
Haddix et al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Weighted average of charges for the years 1999-2003 for ED visits and hospitalizations.
***Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et al. in March 2001.
****Rate were calculated per 100,000 of Missouri population by county for the year 2003.

| Direct Cost of Traumatic Brain Injury by Missouri Counties, 1999-2003* | | | | |
|---|---|---|---|---|
| County | Annual TBI **CHARGES**** | Annual TBI **COST***** | Annual TBI **CHARGES**: Rate per 100,000 of Population**** | Annual TBI **COST**: Rate per 100,000 of Population**** |
| Dent | $414,925 | $183,397 | $2,780,810 | $1,229,118 |
| Douglas | $303,758 | $134,261 | $2,273,128 | $1,004,723 |
| Dunklin | $453,289 | $200,354 | $1,388,158 | $613,566 |
| Franklin | $2,998,293 | $1,325,245 | $3,094,054 | $1,367,572 |
| Gasconade | $616,890 | $272,666 | $3,969,182 | $1,754,379 |
| Gentry | $161,654 | $71,451 | $2,461,983 | $1,088,197 |
| Greene | $5,096,182 | $2,252,512 | $2,073,599 | $916,531 |
| Grundy | $262,755 | $116,138 | $2,548,296 | $1,126,347 |
| Harrison | $208,157 | $92,005 | $2,357,917 | $1,042,200 |
| Henry | $539,288 | $238,365 | $2,405,494 | $1,063,229 |
| Hickory | $172,063 | $76,052 | $1,910,750 | $844,552 |
| Holt | $56,721 | $25,070 | $1,102,440 | $487,279 |
| Howard | $170,279 | $75,263 | $1,701,599 | $752,107 |
| Howell | $1,047,497 | $462,994 | $2,793,399 | $1,234,682 |
| Iron | $389,542 | $172,178 | $3,779,762 | $1,670,655 |
| Jackson | $20,161,505 | $8,911,385 | $3,056,056 | $1,350,777 |
| Jasper | $2,840,647 | $1,255,566 | $2,627,504 | $1,161,357 |
| Jefferson | $5,392,412 | $2,383,446 | $2,607,726 | $1,152,615 |
| Johnson | $1,120,566 | $495,290 | $2,229,450 | $985,417 |
| Knox | $260,742 | $115,248 | $6,048,296 | $2,673,347 |
| Laclede | $605,916 | $267,815 | $1,818,148 | $803,622 |
| Lafayette | $752,146 | $332,449 | $2,282,620 | $1,008,918 |
| Lawrence | $1,073,983 | $474,700 | $2,948,395 | $1,303,191 |
| Lewis | $55,736 | $24,635 | $545,040 | $240,908 |
| Lincoln | $1,434,428 | $634,017 | $3,244,798 | $1,434,201 |
| Linn | $398,717 | $176,233 | $2,962,235 | $1,309,308 |
| Livingston | $322,090 | $142,364 | $2,238,756 | $989,530 |
| Macon | $682,543 | $301,684 | $4,381,735 | $1,936,727 |
| Madison | $226,879 | $100,281 | $1,922,056 | $849,549 |
| Maries | $451,602 | $199,608 | $5,108,043 | $2,257,755 |
| Marion | $785,911 | $347,373 | $2,778,152 | $1,227,943 |
| Mcdonald | $519,801 | $229,752 | $2,365,634 | $1,045,610 |
| Mercer | $163,973 | $72,476 | $4,559,866 | $2,015,461 |
| Miller | $845,735 | $373,815 | $3,486,846 | $1,541,186 |

Sources: Missouri Department of Health and Senior Services.
Population Estimates 2003, U.S. Census Bureau.
Haddix et al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Weighted average of charges for the years 1999-2003 for ED visits and hospitalizations.
***Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et al. in March 2001.
****Rate were calculated per 100,000 of Missouri population by county for the year 2003.

| Direct Cost of Traumatic Brain Injury by Missouri Counties, 1999-2003* | | | | |
|---|---|---|---|---|
| County | Annual TBI **CHARGES**** | Annual TBI **COST***** | Annual TBI **CHARGES**: Rate per 100,000 of Population**** | Annual TBI **COST**: Rate per 100,000 of Population**** |
| Mississippi | $324,493 | $143,426 | $2,255,620 | $996,984 |
| Moniteau | $533,873 | $235,972 | $3,567,479 | $1,576,826 |
| Monroe | $344,929 | $152,459 | $3,671,017 | $1,622,590 |
| Montgomery | $436,653 | $193,001 | $3,618,275 | $1,599,278 |
| Morgan | $672,030 | $297,037 | $3,360,149 | $1,485,186 |
| New Madrid | $391,750 | $173,153 | $2,041,745 | $902,451 |
| Newton | $1,502,692 | $664,190 | $2,781,063 | $1,229,230 |
| Nodaway | $294,170 | $130,023 | $1,352,942 | $598,000 |
| Oregon | $165,015 | $72,937 | $1,601,936 | $708,056 |
| Osage | $438,354 | $193,752 | $3,337,550 | $1,475,197 |
| Ozark | $133,363 | $58,947 | $1,404,122 | $620,622 |
| Pemiscot | $270,099 | $119,384 | $1,369,045 | $605,118 |
| Perry | $458,381 | $202,604 | $2,515,121 | $1,111,683 |
| Pettis | $1,338,758 | $591,731 | $3,402,700 | $1,503,993 |
| Phelps | $939,331 | $415,184 | $2,254,322 | $996,410 |
| Pike | $648,798 | $286,769 | $3,503,418 | $1,548,511 |
| Platte | $1,540,583 | $680,937 | $1,940,525 | $857,712 |
| Polk | $728,344 | $321,928 | $2,593,724 | $1,146,426 |
| Pulaski | $679,255 | $300,231 | $1,500,984 | $663,435 |
| Putnam | $93,336 | $41,254 | $1,813,050 | $801,368 |
| Ralls | $151,038 | $66,759 | $1,564,673 | $691,586 |
| Randolph | $1,429,489 | $631,834 | $5,707,682 | $2,522,795 |
| Ray | $640,718 | $283,197 | $2,677,914 | $1,183,638 |
| Reynolds | $116,411 | $51,454 | $1,768,890 | $781,849 |
| Ripley | $297,893 | $131,669 | $2,161,623 | $955,438 |
| Saline | $551,293 | $243,672 | $2,408,760 | $1,064,672 |
| Schuyler | $157,626 | $69,671 | $3,744,986 | $1,655,284 |
| Scotland | $135,757 | $60,005 | $2,767,736 | $1,223,339 |
| Scott | $902,968 | $399,112 | $2,214,297 | $978,719 |
| Shannon | $165,846 | $73,304 | $1,999,832 | $883,926 |
| Shelby | $255,807 | $113,067 | $3,816,876 | $1,687,059 |
| St Charles | $7,111,920 | $3,143,469 | $2,282,893 | $1,009,039 |
| St Clair | $202,947 | $89,703 | $2,096,782 | $926,777 |

Sources: Missouri Department of Health and Senior Services; Population Estimates 2003, U.S. Census Bureau. Haddix et al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Weighted average of charges for the years 1999-2003 for ED visits and hospitalizations.
***Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et al. in March 2001.
****Rate were calculated per 100,000 of Missouri population by county for the year 2003.

| Direct Cost of Traumatic Brain Injury by Missouri Counties, 1999-2003* | | | | |
|---|---|---|---|---|
| County | Annual TBI **CHARGES**** | Annual TBI **COST***** | Annual TBI **CHARGES**: Rate per 100,000 of Population**** | Annual TBI **COST**: Rate per 100,000 of Population**** |
| St Francois | $2,001,838 | $884,812 | $3,455,675 | $1,527,408 |
| St Louis City | $14,592,146 | $6,449,729 | $4,392,275 | $1,941,385 |
| St Louis County | $25,098,301 | $11,093,449 | $2,477,320 | $1,094,976 |
| Ste Genevieve | $326,332 | $144,239 | $1,803,538 | $797,164 |
| Stoddard | $775,456 | $342,752 | $2,617,485 | $1,156,929 |
| Stone | $529,023 | $233,828 | $1,766,885 | $780,963 |
| Sullivan | $307,742 | $136,022 | $4,346,645 | $1,921,217 |
| Taney | $1,127,518 | $498,363 | $2,723,277 | $1,203,688 |
| Texas | $435,419 | $192,455 | $1,803,574 | $797,180 |
| Vernon | $544,307 | $240,584 | $2,683,565 | $1,186,136 |
| Warren | $859,652 | $379,966 | $3,200,254 | $1,414,512 |
| Washington | $645,471 | $285,298 | $2,702,524 | $1,194,516 |
| Wayne | $412,630 | $182,382 | $3,152,254 | $1,393,296 |
| Webster | $719,626 | $318,075 | $2,172,522 | $960,255 |
| Worth | $14,321 | $6,330 | $630,898 | $278,857 |
| Wright | $501,545 | $221,683 | $2,757,862 | $1,218,975 |
| Missing | $313,382 | $138,515 | | |

Sources: Missouri Department of Health and Senior Services; Population Estimates 2003, U.S. Census Bureau.
Haddix et al. 2003 (Cost-to-Charge Ratio).
*Five years (1999-2003) annual charges were adjusted for inflation by CPI Medical Care.
**Weighted average of charges for the years 1999-2003 for ED visits and hospitalizations.
***Cost is estimated based on Cost-to-Charge ratio of 0.442 for Missouri, calculated by Haddix et al. in March 2001.
****Rate were calculated per 100,000 of Missouri population by county for the year 2003.

## APPENDIX 6

**Relative Risk and 95% Confidence Intervals (CI) for Selected Preventive Factors in Missouri**

| Risk Factor | Vehicle | Relative Risk | 95% Lower CI | 95% Upper CI |
|---|---|---|---|---|
| Alcohol Use on sustaining a TBI | Car and Pickup | 4.87 | 4.66 | 5.09 |
| | Motorcycle | 2.12 | 1.69 | 2.65 |
| No Helmet on sustaining a TBI | ATV | 2.96 | 1.36 | 6.45 |
| | Motorcycle | 2.65 | 2.13 | 3.31 |
| | Bicycle | 1.83 | 1.23 | 2.73 |
| No Seatbelt on surviving TBI | Car and Pickup | 3.93 | 3.32 | 4.65 |
| Alcohol Use on surviving TBI | Motorcycle | 2.04 | 1.24 | 3.36 |
| | Car and Pickup | 1.86 | 1.57 | 2.20 |
| No Helmet on surviving TBI | Motorcycle | 1.33 | 0.75 | 2.35 |

Source: Missouri Department of Health and Senior Services, *Injury MICA – 1993, 1996, 1999, 2001, and 2003*, Jefferson City, Missouri