

Comparison of Intentional Deaths (Suicide) and Unintentional Motor Vehicle Traffic Deaths with and without Traumatic Brain Injury as an Underlying Cause by State and By Year Across Selected Demographic, Economic and Geographical Characteristics—Unites States 1999-2010

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INTRODUCTION

Injuries are a leading cause of death for all age groups. Injury intent parses into (a) unintentional and (b) intentional injuries. In 2010 across all ages, unintentional injuries (accidents) were the 5th leading cause of death and intentional injuries (suicide) were the 10th leading cause of death, as shown in Table 1. Fatal unintentional injuries include multiple types but Motor Vehicle Traffic (MVT) deaths are the most common.

Both unintentional and intentional injuries theoretically should have high rates of traumatic brain injury (TBI), yet there is very little literature to support this. Additionally, some MVT deaths are assumed to be suicides but there is no clear indication as to how many. There are known effects of the economy on suicide and some research indicates that there are links between MVT deaths and the economy, although the results are mixed and most studies are over 15 years old. Injury should also vary by state and by level of urbanism.

Table 1: Top Ten Leading Causes of Death in the United States in 2010

Cause
#1 Diseases of heart
#2 Malignant neoplasms
#3 Chronic lower respiratory diseases
#4 Cerebrovascular diseases
#5 Accidents (unintentional injuries)
#6 Alzheimer's disease
#7 Diabetes mellitus
#8 Influenza and pneumonia
#9 Nephritis, nephrotic syndrome and nephrosis
#10 Intentional self-harm (suicide)

Table 2: Types of Injury

Type of Injury Outcome	Injury Intent	Mechanism
Death	Unintentional	Motor Vehicle Traffic
	Intentional	Suicide

Goal of this Investigation

In this study we increase our understanding of the complex nature of injury-related death when traumatic brain injury (TBI) is present.

The original plan for the research was to address injury-related death only when the intent was unintentional and the mechanism was Motor Vehicle Traffic (MVT). As the research plans unfolded, we realized we had a unique opportunity to incorporate known research on another type of injury, that is intentional injury with self-harm. This decision was made because recent research conducted by the authors in Idaho uses many of the same variables of interest. Building on that research expanded the scope of this research without additional cost. In addition, including two injury underlying causes of death (UCDs) with TBI affords the opportunity for comparison as the number of deaths and the rate of TBI are similar across both types of injury-related death.

Given the complexity of TBI and of suicide we have chosen a multimethod, structural approach using measures of a variety of potentially related constructs to answer the following question of interest: **What is the nature of the relationship between MVT deaths and TBI across time, geography, economics, and intent of injury?**

Literature on Intentional and Unintentional Death with TBI

One study identified similarities across violent deaths (homicide, suicide, MVT deaths) in 1982.¹ Most of the economic information available on suicide and MVT deaths is mixed. Two studies found no relationship between economy and MVT deaths or suicide.^{2,3} Regardless it seems that knowledge of economic factors does not improve models of MVT deaths.⁴

A drop in motor vehicle accidents occurred during the recession of the early 1980s. At that time Wagenaar⁵ conducted research to examine the relationship between the economy and MVT accidents. He hypothesized that higher rates of unemployment would lead to less motor vehicle traffic which would in turn to a reduction in frequency of traffic crashes. As expected, he found an inverse relationship between the rate of unemployment and involvement in motor vehicle crashes. As unemployment rose there were fewer motor vehicle crashes. The specific measure of economic conditions used in the current study is the rate of unemployment. Two types of effects of the unemployment rate on crash involvement were hypothesized. First, high rates of unemployment would lead to less motor vehicle travel, which would in turn cause a reduction in frequency of traffic crashes. The chain of events was that economic uncertainty and reduced disposable income associated with high unemployment rates may cause a reduction in discretionary driving. Reduced exposure to the risk of involvement in traffic crashes is likely to reduce the aggregate number of crashes. The second hypothesized effect of unemployment on crash involvement is not mediated by vehicle miles traveled. The argument is as follows. High rates of unemployment lead to higher levels of mental stress in the population. Increased stress associated with job loss or feared job loss during a recession might cause more aggressive

¹ Paul C. Holinger, Elaine H. Klemen, Violent deaths in the United States, 1900–1975: Relationships between suicide, homicide and accidental deaths, *Social Science & Medicine*, Volume 16, Issue 22, 1982, Pages 1929-1938, ISSN 0277-9536, 10.1016/0277-9536(82)90392-6.
(<http://www.sciencedirect.com/science/article/pii/0277953682903926>)

² Donald W. Reinfurt, J. Richard Stewart, Nancy L. Weaver, The economy as a factor in motor vehicle fatalities, suicides, and homicides, *Accident Analysis & Prevention*, Volume 23, Issue 5, October 1991, Pages 453-462, ISSN 0001-4575, 10.1016/0001-4575(91)90065-D.
(<http://www.sciencedirect.com/science/article/pii/000145759190065D>)

³ Hans C. Joks, The relation between motor vehicle accident deaths and economic activity, *Accident Analysis & Prevention*, Volume 16, Issue 3, June 1984, Pages 207-210, ISSN 0001-4575, 10.1016/0001-4575(84)90014-9.
(<http://www.sciencedirect.com/science/article/pii/0001457584900149>)

⁴ Donald W. Reinfurt, J. Richard Stewart, Nancy L. Weaver, The economy as a factor in motor vehicle fatalities, suicides, and homicides, *Accident Analysis & Prevention*, Volume 23, Issue 5, October 1991, Pages 453-462, ISSN 0001-4575, 10.1016/0001-4575(91)90065-D.
(<http://www.sciencedirect.com/science/article/pii/000145759190065D>)

⁵ Wagenaar, A. C. (1984). Effects of Macroeconomic Conditions on the Incidence of Motor Vehicle Accidents. *Accident Annals & Prevention*, 16. 191-205.

driving patterns (i.e. higher threshold of acceptable risk). Unemployment, more common among young males, reduces their driving and reduces the accident rates.⁶

There is very little information about MVT deaths as a mechanism of suicide. A 2003 Australian study interviewed people with a history of suicidal behaviors and ideation. Of those who reported planning a suicide, 14.8% (19.1% of males) had planned to have a motor vehicle “accident” as the method. Nineteen (of 61) had previously attempted via MV collision.⁷

External Causes of Death by Injury with TBI

An **external cause of death**⁸ is defined as a death due to accidents and violence including environmental events, circumstances and conditions as the cause of injury, poisoning, and other adverse effects. The broad categories of death include (a) accidents, (b) suicides, (c) medical misadventures or abnormal reactions, (d) homicide, (e) legal intervention and (f) injury from war operations.

Methods for Identifying and Coding Accidental Death

The cases included in this study were external causes of death (suicide and MVT deaths) with TBI as a contributing factor. The stratification of accidental death is unintentional and intentional. MVT deaths are the largest group with TBI occurring as part of the contributing factors of death. The TBI codes apply for deaths at the time of the event and deaths as a sequela of the TBI. The codes included for TBI are the ones recommended by the CDC.⁹

Collection and Access to Death Data

Making judgments about underlying cause of death is precipitous. For example, suicide is considered an external cause of death although some may argue that the internal factor of depression is the key factor. The death data in general are variable across time. Additionally, many of the data are suppressed due to small numbers or other potential issues with confidentiality and privacy.¹⁰

Variables Chosen

Detailed information about MVT deaths with TBI is sparse in general and even more so in low population states like Idaho. There are very real and appropriate concerns about deductive

⁶ G. William Mercer, Influences on passenger vehicle casualty accident frequency and severity: Unemployment, driver gender, driver age, drinking driving and restraint device use, *Accident Analysis & Prevention*, Volume 19, Issue 3, June 1987, Pages 231-236, ISSN 0001-4575, 10.1016/0001-4575(87)90007-8. (<http://www.sciencedirect.com/science/article/pii/0001457587900078>)

⁷ Routley, Staines, Brennan, Haworth, Ozanne-Smith. 2003. Suicide and natural deaths in road traffic—Review. August, Report #216, Monash University Accident Research Center, Melbourne Australia.

⁸ World Health Organization International Disease Code-10

⁹ CDC MMWR May 6, 2011 Surveillance for Traumatic Brain Injury-Related Deaths —United States, 1997-2007 Surveillance Summaries vol 60 #5

¹⁰ Kavi Bhalla, James E Harrison, Saeid Shahraz, Lois A Fingerhut & on behalf of the Global Burden of Disease Injury Expert Group, Availability and quality of cause-of-death data for estimating the global burden of injuries, *Bulletin of the World Health Organization*, <http://www.who.int/bulletin/volumes/88/11/09-068809-ab/en/>

disclosure. Consequently, the number of people who die with TBI by MVT accident in Idaho is often reported in multi-year blocks or geographical blocks which may mix rural and urban. Data may be completely suppressed. Given these challenges, we have used some proxy variables and have compared with the paired external cause of death, suicide. The rationale for including intentional injuries in the study is twofold. First, intentional injuries are “paired” with unintentional injuries as a UCD category. Second, in Idaho we have a great deal of data on suicide from which to draw. From recent research conducted by the authors, we have much more information about the intentional cause of death though suicide. Many useful variables are shared across the UCD external causes of death for accidents.

Typically, intentional and unintentional accidents are handled separately given their very different nature. One is very much against the victim’s wishes and the other is set into motion by the victim. What is often overlooked is their shared aspect: both are injuries. Both are treated as external causes of death. Arguably, neither originates as a malignancy from within the person like cancer or heart disease, although depression can be a factor in suicide.

This study initially proposed examining the rural and urban differences between MVT deaths with and without TBI. Even with the addition of suicide with and without TBI, there were insufficient data. Economic data are also generally unavailable as they typically examine only MVT deaths or suicide or TBI alone. Studying them in combination was too challenging for the resources of this study and perhaps such data do not currently exist.

Given these challenges, the study focused on comparisons of suicide and MVT deaths with and without TBI at a more descriptive level.

METHODS

Subjects and Procedures

Study 1: Coroner Information

Individual coroners were invited to participate in discussions with the primary study author (Stamm). Because of the scope of the study, and the desire to have the discussions based on the coroner’s perceptions of injuries that could potentially include a TBI rather than only their official documentation, a small number of coroners were approached (n<10). Of those, 100% participated in the study. While the conversations were informal, coroners were given informed consent and encouraged to talk with the researcher only if they desired, and only on the content they wished to share. Coroners were also promised anonymity.

Two points were formally addressed in the conversations. The first query (1) was whether or not coroners had any thoughts or opinions regarding TBI and how it is reported on death certificates. They were encouraged to discuss cases where they suspected but could not verify a TBI involvement. The second query (2) was a detailed conversation regarding the process by which a coroner allocates causes of death and how TBI may or may not be included in a cause of death.

Study 2: Unintentional (MVT) and Intentional (Suicide) Means and TBI

For this portion of the study data were drawn from multiple archival sources. The sources are summarized below

Death Data: Data from the CDC multiple-cause-of-death public use data files were analyzed for January 1, 1999–December 31, 2010. The data used was recorded from the death certificates as submitted to the state jurisdiction by the originator of the death certificate. Fifty states and the District of Columbia (DC) were analyzed.

Other Data: As with the death data, as often as possible, data were analyzed in the time frame of January 1, 1999 to December 31, 2010. Some data are not available across all years but are included in the time span studied (e.g. coroners, food access, and use data).

Table 3: Key Data Sources by Access, Type, and Location in This Report

Source	Online Location
Idaho Department of Labor	labor.idaho.gov/dnn/idl/StatisticsResearch/tabid/673/Default.aspx
U.S. Department of Labor	Unemployment
U.S. Census Bureau Population Statistics and NAICS Data	www.census.gov
U.S. Center for Disease Control & Prevention WISQARS,	www.cdc.gov/injury/wisqars/index.html , wonder.cdc.gov
Idaho Department of Health and Welfare	Special data draw from the Division of Vital Statistics
Idaho Department of Health and Welfare	Coroners in Idaho
U.S. Center for Disease Control & Prevention WONDER	wonder.cdc.gov
U.S. Center for Disease Control & Prevention National Center for Health Statistics, Division of Vital Statistics	Various reports

Classification Codes

UCD and multiple causes of death were drawn following the CDC criteria based on codes in the *International Classification of Disease-10th Revision*.¹¹ The following codes were used to classify cases for analysis. Only data post 1998 were included in the analysis to assure comparability. Data before 1998 were classified under the *International Classification of Disease-9th Revision* and are treated separately from post 1998 data.

Table 4: Type of Accidents Considered

	Unintentional	Intentional
Type of Accident	MVT	Suicide
Cause code nested inside the accident	Injury Mechanisms and All Causes of Death associated with the accident	Injury Mechanisms and All Causes of Death associated with the accident

¹¹ An excellent summary of the coding criteria is the Data Sources for WISQARS Fatal, located at <http://www.cdc.gov/ncipc/wisqars/fatal/help/datasources.htm#6.3.1>.

Table 5: Codes Used to Identify TBI Cases

Inclusion Code Noted One or More Times	Excluded No TBI codes AND an accident code below
S00 (Superficial injury of head)	S02.2 (Fracture of nasal bones)
S01 (Open wound of head)	S02.4 (Fracture of malar and maxillary bones)
S01.0 (Open wound of scalp)	S02.5 (Fracture of tooth)
S01.1 (Open wound of eyelid and periocular area)	S02.6 (Fracture of mandible)
S01.2 (Open wound of nose)	S03 (Dislocation, sprain and strain of joints and ligaments of head)
S01.3 (Open wound of ear)	S05 (Injury of eye and orbit)
S01.4 (Open wound of cheek and temporomandibular area)	S06 (Intracranial injury)
S01.5 (Open wound of lip and oral cavity)	S08 (Traumatic amputation of part of head)
S01.7 (Multiple open wounds of head)	S09.1 (Injury of muscle and tendon of head)
S01.8 (Open wound of other parts of head)	S09.2 (Traumatic rupture of ear drum)
S01.9 (Open wound of head, part unspecified)	S10-S19 (Injuries to the neck)
S02.0 (Fracture of vault of skull)	S20-S29 (Injuries to the thorax)
S02.1 (Fracture of base of skull)	S30-S39 (Injuries to the abdomen, lower back, lumbar spine and pelvis)
S02.3 (Fracture of orbital floor)	S40-S49 (Injuries to the shoulder and upper arm)
S02.7 (Multiple fractures involving skull and facial bones)	S50-S59 (Injuries to the elbow and forearm)
S02.8 (Fractures of other skull and facial bones)	S60-S69 (Injuries to the wrist and hand)
S02.9 (Fracture of skull and facial bones, part unspecified)	S70-S79 (Injuries to the hip and thigh)
S04 (Injury of cranial nerves)	S80-S89 (Injuries to the knee and lower leg)
S06.0 (Concussion)	S90-S99 (Injuries to the ankle and foot)
S06.1 (Traumatic cerebral oedema)	T00 (Superficial injuries involving multiple body regions)
S06.2 (Diffuse brain injury)	T01 (Open wounds involving multiple body regions)
S06.3 (Focal brain injury)	T02 (Fractures involving multiple body regions)
S06.4 (Epidural haemorrhage)	T02.1 (Fractures involving thorax with lower back and pelvis)
S06.5 (Traumatic subdural haemorrhage)	T02.2 (Fractures involving multiple regions of one upper limb)
S06.6 (Traumatic subarachnoid haemorrhage)	T02.3 (Fractures involving multiple regions of one lower limb)
S06.7 (Intracranial injury with prolonged coma)	T02.4 (Fractures involving multiple regions of both upper limbs)
S06.8 (Other intracranial injuries)	T02.5 (Fractures involving multiple regions of both lower limbs)
S06.9 (Intracranial injury, unspecified)	T02.8 (Fractures involving other combinations of body regions)
S07.0 (Crushing injury of face)	T02.9 (Multiple fractures, unspecified)
S07.1 (Crushing injury of skull)	T03 (Dislocations, sprains and strains involving multiple body regions)
S07.8 (Crushing injury of other parts)	T04 (Crushing injuries involving multiple body

Inclusion Code Noted One or More Times	Excluded No TBI codes AND an accident code below
of head) S07.9 (Crushing injury of head, part unspecified) S09.7 (Multiple injuries of head) S09.8 (Other specified injuries of head) S09.9 (Unspecified injury of head) T90 (Sequelae of injuries of head) T90.0 (Sequelae of superficial injury of head) T90.1 (Sequelae of open wound of head) T90.2 (Sequelae of fracture of skull and facial bones) T90.3 (Sequelae of injury of cranial nerves) T90.4 (Sequelae of injury of eye and orbit) T90.5 (Sequelae of intracranial injury) T90.8 (Sequelae of other specified injuries of head) T90.9 (Sequelae of unspecified injury of head)	regions) T04.1 (Crushing injuries involving thorax with abdomen, lower back and pelvis) T04.2 (Crushing injuries involving multiple regions of upper limb(s)) T04.3 (Crushing injuries involving multiple regions of lower limb(s)) T04.8 (Crushing injuries involving other combinations of body regions) T04.9 (Multiple crushing injuries, unspecified) T05 (Traumatic amputations involving multiple body regions) T06 (Other injuries involving multiple body regions, not elsewhere classified) T07 (Unspecified multiple injuries) T08-T14 (Injuries to unspecified part of trunk, limb or body region) T15-T19 (Effects of foreign body entering through natural orifice) T20-T32 (Burns and corrosions) T33-T35 (Frostbite) T36-T50 (Poisoning by drugs, medicaments and biological substances) T51-T65 (Toxic effects of substances chiefly nonmedicinal as to source) T66-T78 (Other and unspecified effects of external causes) T79 (Certain early complications of trauma) T80-T88 (Complications of surgical and medical care, not elsewhere classified) T91 (Sequelae of injuries of neck and trunk) T92 (Sequelae of injuries of upper limb) T93 (Sequelae of injuries of lower limb) T94 (Sequelae of injuries involving multiple and unspecified body regions) T95 (Sequelae of burns, corrosions and frostbite) T96 (Sequelae of poisoning by drugs, medicaments and biological substances) T97 (Sequelae of toxic effects of substances chiefly nonmedicinal as to source) T98 (Sequelae of other and unspecified effects of external causes)

Stratification

Data were stratified by state, year and urbanism. Data were not stratified across age, sex or race. This was done to maximize information at a state level which is the location at which most policy and practice originates for motor vehicles and for prevention of both suicide and MVT deaths. Additionally there is good evidence to suggest that differences will exist at the state level.

Economic indicators are typically calculated at the state level.

The longitudinal data afford the opportunity to examine economic factors with their potential impact on the underlying cause of death (UCD).

Confidentially, Privacy, and How Data are Reported

The majority of data collected for this archival analysis were from the Idaho Department of Vital Statistics and from the National Center for Health Statistics. Other data were collected from other Federal agency databases. Some data were collected in conversations with Idaho county coroners. In accordance with The National Center for Health Statistics (NCHS) in an agreement with the National Association of Public Health Statistics and Information Systems (NAPHSIS), data are reported on cells only larger than 10 in order to protect individual privacy and unintentional or deductive disclosure of individuals.¹²

In years where there are few data, the data were combined across a multiyear block in order for the data to be analyzable across states. As much as possible the primary variable was state, necessitating collapsing across year or other variables. Additional information about decision rules regarding the unit of data can be found below in the Analytic Method section.

Analytic Methods

Study 1: Coroner Study

The original plan was to identify a subgroup of cases and link those with qualitative interviews with Idaho coroners. Due to multiple reasons this plan was unfeasible. The core reason for not being able to use this methodology was related to protection of the identity of decedents. Thus, an alternative method was undertaken in which informal interviews were conducted and these data were integrated with national data on coroner reporting. During the conversations the researcher took notes which were then organized based on similarities and differences.

Algorithms were developed for decision processes in determining the primary cause of death and the various methods for determining where, or if, the TBI would be mentioned.

¹² The National Center for Health Statistics (NCHS) in an agreement with the National Association of Public Health Statistics and Information Systems (NAPHSIS) has implemented a new, more restrictive rule for reporting National Vital Statistics System (NVSS) state- and county-level death data for years 2008 and later, in order to avoid inadvertent disclosure of cases. Therefore, the Office of Statistics and Programming, NCIPC has modified WISQARS to accommodate the new data suppression rule; i.e., no figure, including totals, should be less than 10 in tabulations for sub-national geographic areas, regardless of the number of years combined with the data from 2008 and later. Tabulations, charts, and maps produced by WISQARS using only NVSS death data for years prior to 2008 are not affected by this new rule.

Study 2: Death by Unintentional and Intentional External Forces with TBI

Data were gathered from the multiple sources discussed in the Introduction section of this paper. The data were cleaned when necessary and reorganized into data sets that could be utilized for the study. In a few cases adjustments to the metrics were necessary and are noted in the results below. When data seemed particularly unstable they were excluded from the analysis. For example, death data with large amounts of suppressed or unreliable data were excluded from statistical analyses. They were included in tabular and some visual presentation of data in order to demonstrate the level or quality of available data. These too are noted in the results section. Finally, any data that were judged to have any risk for deductive disclosure were either removed from the analyses or combined with other data even when there was a loss to the statistical or data visualization quality. As with other adjustments these are noted below. If data were adjusted statistically to prevent deductive disclosure or other confidentiality or privacy concerns, then the data are presented in such a way that the patterns of the information is conveyed as accurately as possible. For example, in some cases data were smoothed or were presented without explicit metrics or case labels.

RESULTS AND DISCUSSION

STUDY 1: REVIEW OF COUNTY CORONER CHARACTERISTICS 1999 TO 2013

A Qualitative Discussion on Establishing and the Accuracy of Recording Underlying Causes of Death

Nationally coroners typically conduct death investigations, often called a medicolegal investigation, for unattended death with no obvious cause, accidental death, suicide and homicide. Under Idaho Code Title 19, Chapter 43, Section 194301 the coroner must investigate “deaths as a result of violence, whether apparently homicide, suicidal, or accidental. They must also investigate deaths that occur under suspicious or circumstances or deaths not attended by a physician so that the cause of death cannot be certified by a physician.”

These data are drawn from informal discussions with a small number of coroners who were interested in sharing their thoughts on the process of being a coroner addressing the UCDs for external deaths. One of the most important points raised by discussions with the coroners is one of the core issues in the entire field of death reporting. Coroners reported that the most critical part of determining cause of death—even in uncontested deaths—is discerning the immediate cause of death and the chain of events that led to that immediate cause. As expected, coroners indicated that what they understood or believed to have happened and what they reported to the Idaho Bureau of Health Statistics and Vital Records were the same. However, when encouraged to speak about their thought processes, not just their official conclusions, coroners related situations when they had considered TBI but were unable to find any information to support including it. Like most jurisdictions across the US, Idaho coroners’ offices do not have sufficient funds to conduct supplemental investigation for accidental death when there is an obvious cause of death and no clear indications that further investigation should be conducted. Coroners pointed out they could only go on the actual facts that they had after investigation, not on what they thought might have happened.

Training, Attitudes, Local Culture and Other Conditions

A variety of issues have the potential to impact the causes of death. For example, attitudes toward suicide have changed in the past decade and recording a death as suicide is not as socially difficult as it was in the past. Some jurisdictions may have different investigative resources. Some coroners are physicians with pathology training. Others have law enforcement backgrounds or have worked as funeral directors. Funding and training background have an impact on the length and depth of a death investigation.

Time Post Trauma and Determining TBI

Coroners discussed how they arrived at the primary and secondary causes of death. Like the coroners and medical examiners discussed in the papers cited above, there seemed to be clinical nuances in the algorithms they use to discern multiple causes of death. All reported that if a person died of an injury that would likely have caused a TBI, and that very little time passed between the lethal event and the time of death, there would probably insufficient information to separate the TBI from the overall injury. For example, if a person sustained massive injuries as a result of a car crash, and they were taken to a medical facility where they died very soon thereafter, the cause of death are the injuries sustained in the crash. In the case of TBI, it is far harder to tell if one has occurred than compared to loss of limb. If a person never regained consciousness and died soon after the accident, it would be difficult to determine from among the multiple traumas to the victim whether there was a TBI.

Idaho Coroner Characteristics

In Idaho a coroner is typically elected although may be appointed. They must be at least 21 years of age, have lived in the county for at least one year and agree to complete 8 hours of training in coroner law or death investigation or similarly suitable topic.

Coroners may be elected to sequential 4-year terms. In Idaho approximately one third of the coroners now in place were in their jobs in 2003. Most county coroners are men but an increasing number of coroners are women. The increase in female coroners was 150% from 2003 to 2013.

Table 6: Change in Coroners across Idaho’s 44 Counties 2003 and 2013

	Number of Coroners	Percent of Coroners
No Change	>12	Approx. 30%
Change	28	Actual 63%
Data Not Available	<5	Approx. 10%

Table 7: Sex of Idaho County Coroners 2003 and 2013 with Percent Change

	2003		2012		2003-2013
	Number	Percent	Number	Percent	Percent Change Based on Actual Numbers
Male	>37	>80%	34	75%	-26%
Female	<5	<14%	10	25%	150%

STUDY 2: COMPARISON OF MVT DEATHS TO SUICIDE ACROSS TBI

Suicide and MVT Deaths

In this section information will be presented by individual concept and then grouped. The first set is MVT deaths, suicide, and then suicide and MVT deaths.

Suicide and MVT deaths were examined by year and by state. The pattern of suicides and MVT deaths from 1999 to 2010 show an inverse relationship crossing at 2009. Prior to 2009, MVT deaths outnumbered suicide and after 2009, suicide outnumbered MVT deaths. This pattern can be seen in Idaho and is also apparent at the national level although not as dramatic.

Table 8: Total Idaho Suicide and MVT Deaths by Year 1999-2010

	Suicide	MVT Deaths
1999	181	257
2000	167	263
2001	210	246
2002	202	281
2003	217	273
2004	236	235
2005	228	264
2006	222	275
2007	223	259
2008	252	228
2009	304	222
2010	290	199

The following figure shows the change of pattern between the two types of accidental deaths.

Figure 1: Total Idaho Suicide and MVT Deaths by Year 1999-2010

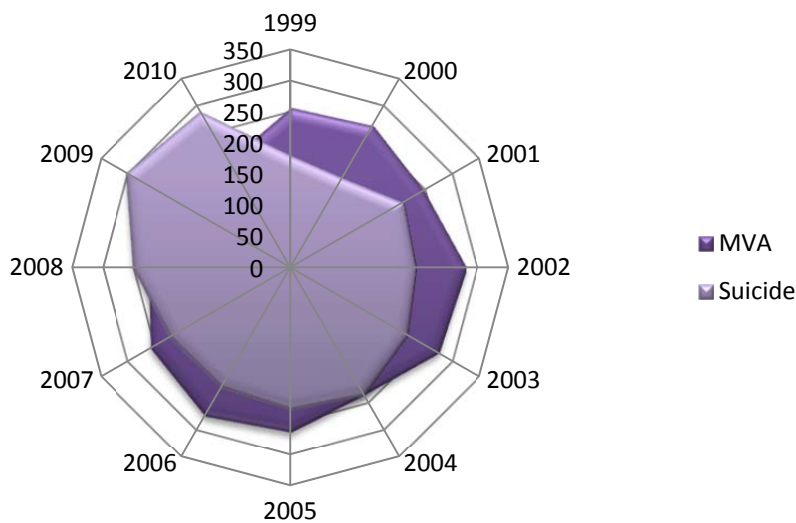


Figure 2: Total Idaho Suicide and MVT Deaths by Year 1999-2010

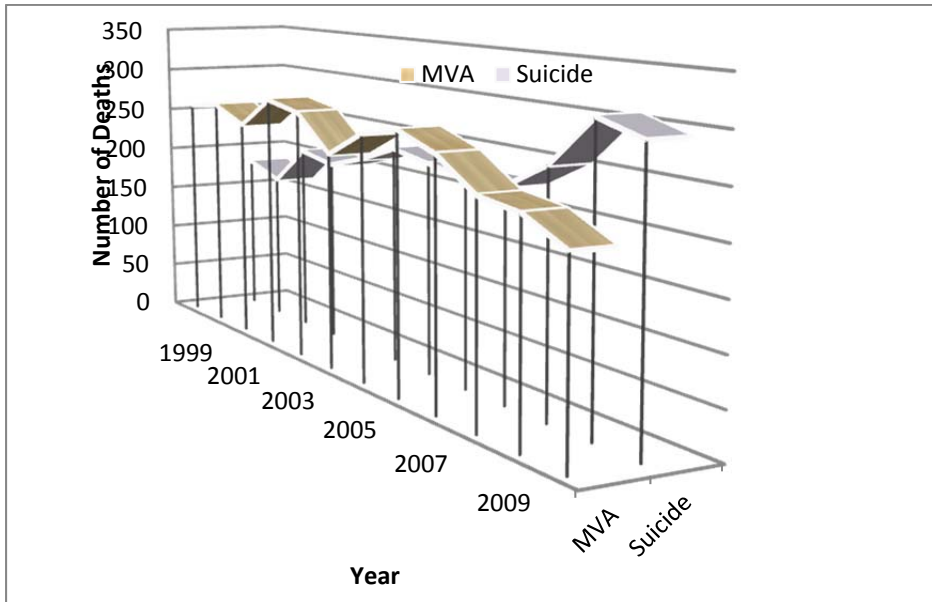


Table 9: Total U.S. Suicide and MVT Deaths by Year 1999-2010

	Suicide	MVT Deaths
1999	29,199	42,401
2000	29,350	43,354
2001	30,622	43,788
2002	31,655	45,380
2003	31,484	44,757
2004	32,439	44,933
2005	32,637	45,343
2006	33,300	45,316
2007	34,598	43,945
2008	36,035	39,790
2009	36,909	36,216
2010	38,364	35,332

The following figure shows the change of pattern between the two types of injury: unintentional MVT deaths and intentional suicide deaths.

Figure 3: Total U.S. Suicide and MVT Deaths by Year 1999-2010

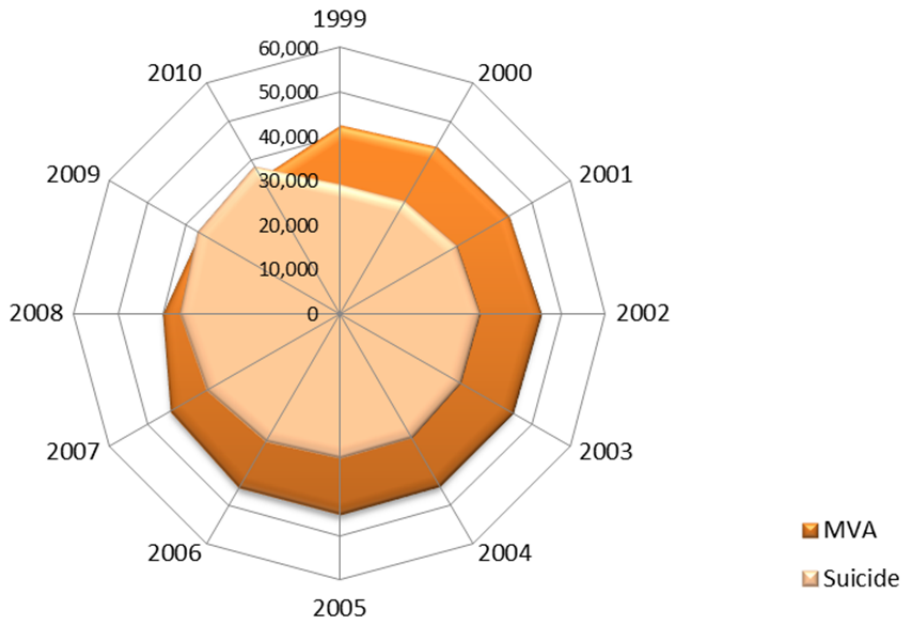


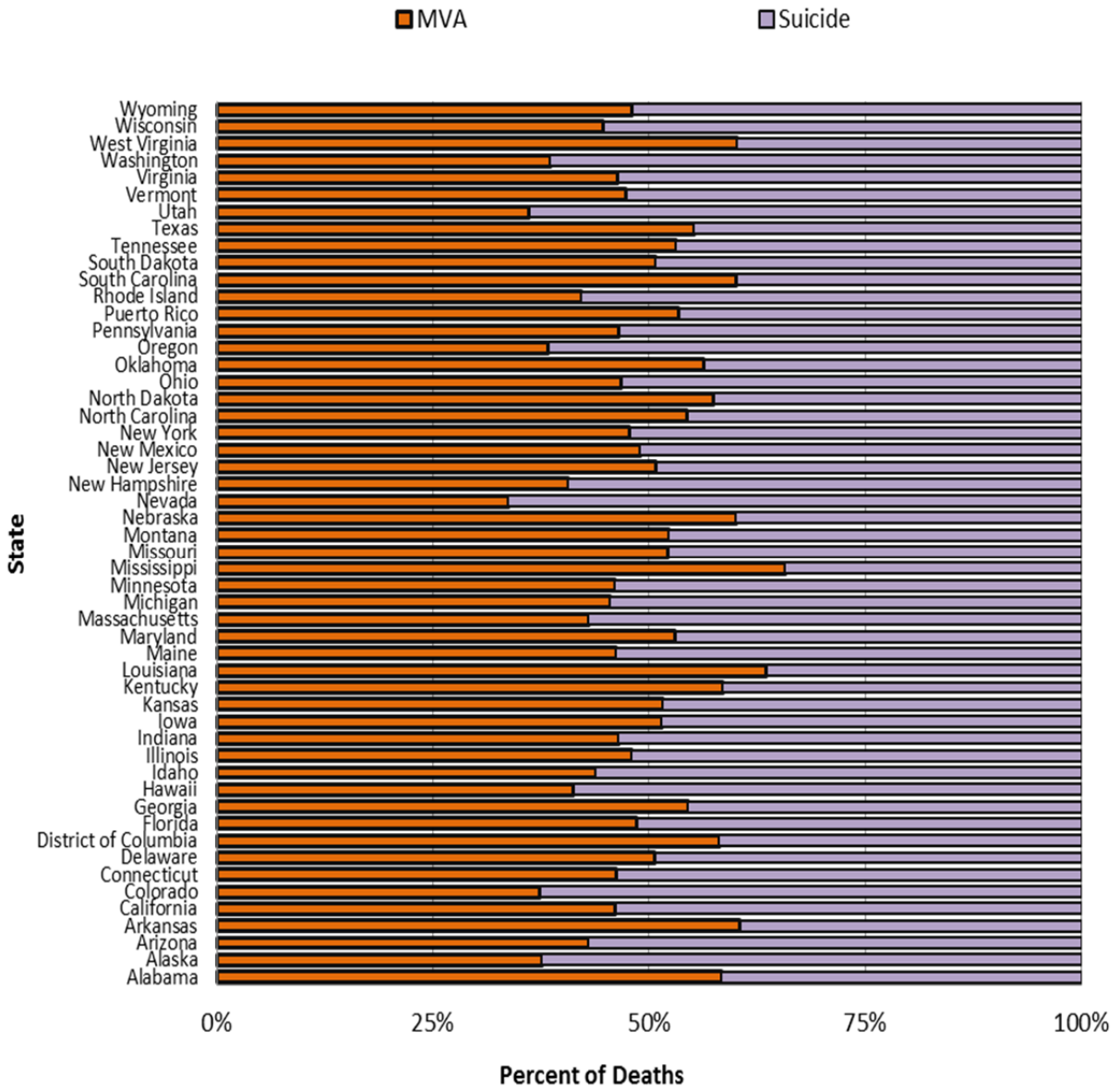
Table 10: Suicide and MVT Deaths per 100,000 by State 1999-2010

	MVT Deaths	Suicide
Alaska	11.9	19.8
Arizona	12.2	16.2
Arkansas	22.2	14.5
California	8.8	10.3
Colorado	11.1	18.6
Connecticut	7.4	8.6
Delaware	12.1	11.8
District of Columbia	6.1	4.4
Florida	13.8	14.6
Georgia	14	11.7
Hawaii	9.2	13.1
Idaho	15.9	20.4
Illinois	8.3	9
Indiana	11.1	12.8
Iowa	12.6	11.9
Kansas	14.6	13.7
Kentucky	18.9	13.4
Louisiana	19	10.9
Maine	12.1	14.1
Maryland	10.6	9.4

	MVT Deaths	Suicide
Massachusetts	5.8	7.7
Michigan	9.5	11.4
Minnesota	9.2	10.8
Mississippi	25.3	13.2
Missouri	15.5	14.2
Montana	23.3	21.3
Nebraska	14.1	9.4
Nevada	9.7	19.1
New Hampshire	8	11.7
New Jersey	6.4	6.2
New Mexico	17.7	18.5
New York	6.3	6.9
North Carolina	14.8	12.4
North Dakota	19.3	14.3
Ohio	8.7	9.9
Oklahoma	20	15.5
Oregon	10	16.1
Pennsylvania	10.6	12.2
Puerto Rico	9.4	8.2
Rhode Island	7.8	10.7
South Carolina	19.7	13.1
South Dakota	16.7	16.2
Tennessee	16.5	14.6
Texas	14.4	11.7
United States	11.7	11.8
Utah	9.9	17.5
Vermont	11.7	13
Virginia	10.3	11.9
Washington	8.4	13.4
West Virginia	20.1	13.3
Wisconsin	10.1	12.5
Wyoming	19.4	21

The proportion of suicide and MVT deaths is different across states. The table below shows the proportion of total deaths by suicide and by MVT across states.

Figure 4: Proportion of Deaths across Suicide and MVT Accidental Deaths



MVT Deaths, Suicide and TBI

It is difficult to study an injury and UCD of TBI in Idaho due to the small numbers. Maps are one way to grasp the situation in that they show both the counties with sufficient deaths that they can be reported and provide a true sense of the rural and sparsely populated parts of the state where rates per 100,000 are at a minimum unreliable and in many ways unreportable due to the risk of unintentional disclosure.

Figure 5: Death Rates per 100,000 for MVT Deaths with TBI as a UCD

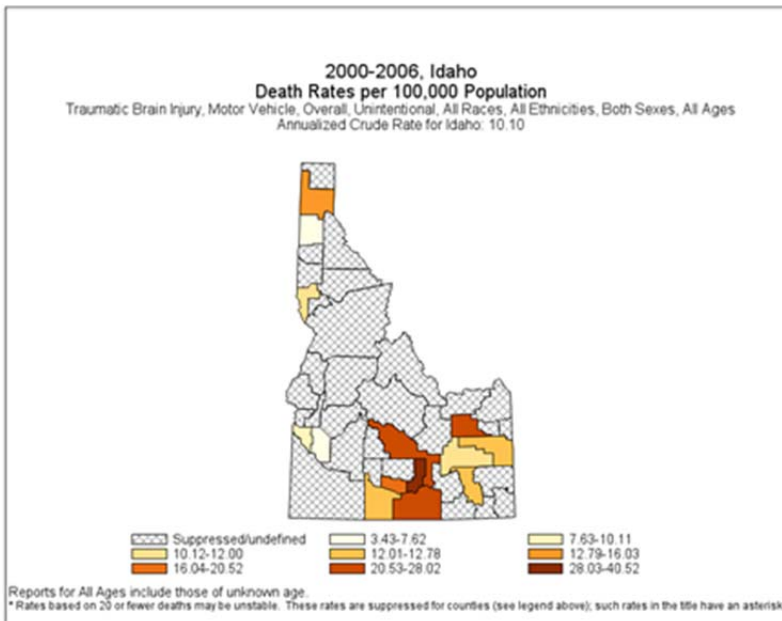
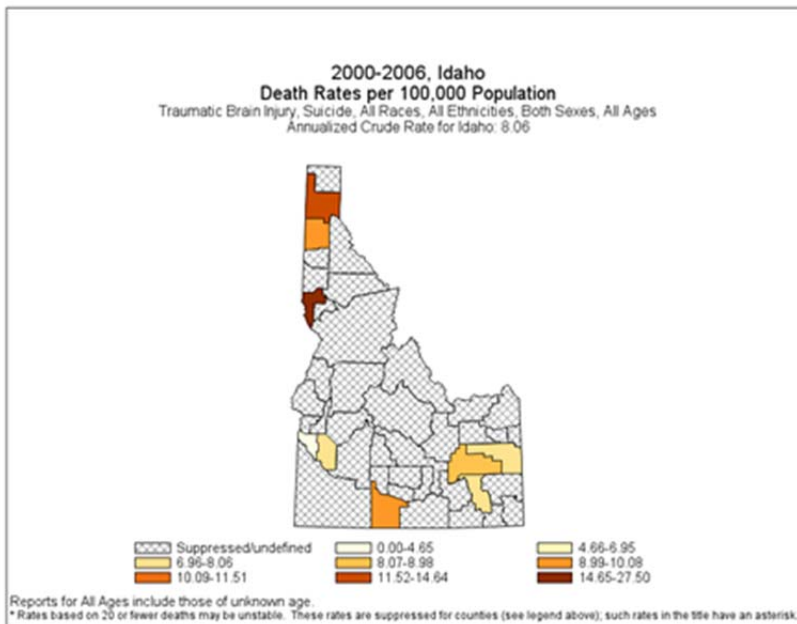
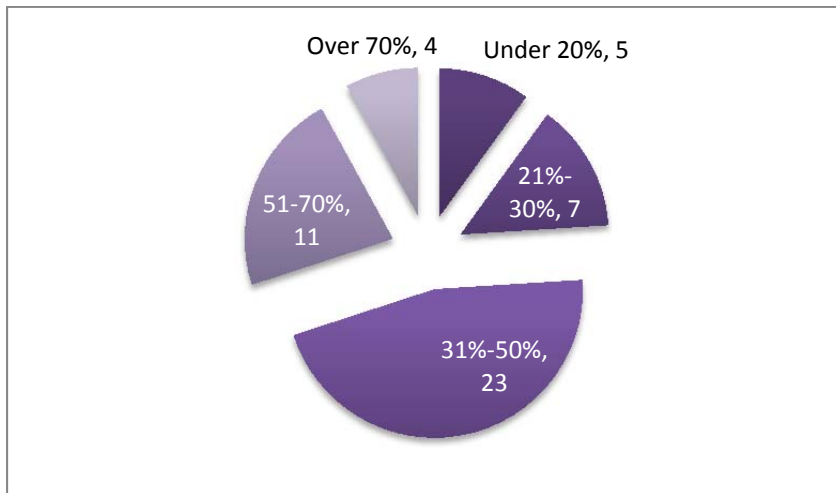


Figure 6: Death Rates per 100,000 for Suicide with TBI as a UCD



Half of Idaho counties (n=23) have MVT deaths that include TBI ranging between 30 and 50 percent. The number of counties that have rates between 51% and 70% is also large (n=11). Few counties (n=9) have less than 30% of MVT deaths and few counties (n=5) have rates over 70% (n=4) that do not include TBI.

Figure 7: Number of Idaho Counties by Percent of MVT Deaths that Include TBI



When considering the pattern of all MVT deaths and all suicide across time there is a significant inverse relationship across time. As suicide increases, MVT deaths decrease. A Multivariate Analysis of Variance was conducted using suicide and MVT deaths counts by year by state. The analysis reinforces the fact that the relationships between suicide and MVT deaths are complex. Individually neither MVT deaths nor suicide was significantly different over time. However, taken together across time, there was a significant difference in suicide and MVT deaths, with MVT deaths decreasing and suicide increasing over time (Wilks' Lambda 6.508_{22,1198} <.001; partial eta squared .107, observed power 1.0).

Adding the variable TBI has an effect on the analysis. As with suicide and MVT deaths across time, MVT deaths-TBI and suicide-TBI are significantly different but the differences are more pronounced over time. The main effect of the analysis is significant (Wilks' Lambda 7.149_{44,2285.927} <.001; partial eta squared .116, observed power 1.0).

Suicide with MVT Deaths as the Mechanism of Injury

The research on Motor Vehicle Traffic (MVT) as the cause of death for intentional (suicide) injury is scant and often based on interviews with suicide attempters. As previously noted, the literature is older with the majority of papers published prior to 1999 when there were major changes in the organization of the UCD to align with the ICD 10. As a result, papers that use data collected prior to 1998 cannot be compared directly with results from data collected after 1998. While the ICD codes are used internationally and thus the classification of the judgments of the UCD of coroners and their counterparts in various countries in the world would theoretically be comparable, the values, medical procedures and cultural aspects that underlie the coroner's assessment may not be comparable. Additionally, suicide means is closely related to the methods available. The options for individuals in different cultures internationally likely reflect different cultural beliefs.

In light of these issues, comparing suicide with the means being MVT from the existing research is difficult at best.

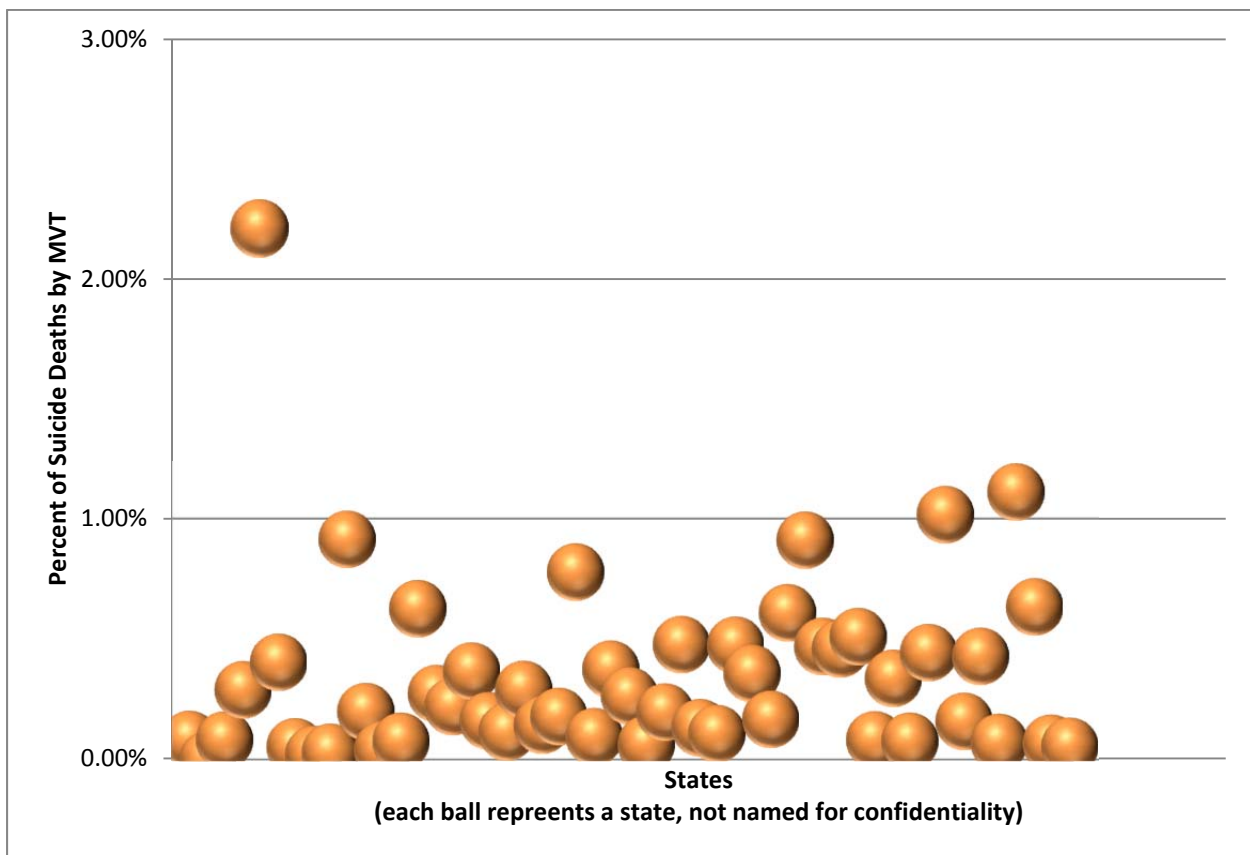
For this study we utilized data comparing intent (unintentional MVT deaths, intentional suicide) with TBI as an external cause of death. This is an imprecise methodology and the numbers are very small. Extreme caution should be used in interpreting these results. In viewing the original

data it was clear that it could not be analyzed by state and by year. As with other analyses with small numbers per cell, we chose to collapse the data across years and not across locations.

The small numbers precluded any meaningful statistical tests comparing across years or across states. However, a graphical analysis yielded interesting information including clusters of similar rates (see Figure 8). States were intentionally ranked by rate per 100,000. Thus, it is not possible to tell from this graph which state ranked in what order. The crude rate per 100,000 was used because of the small numbers of people, which made an age-adjusted rate less reliable.

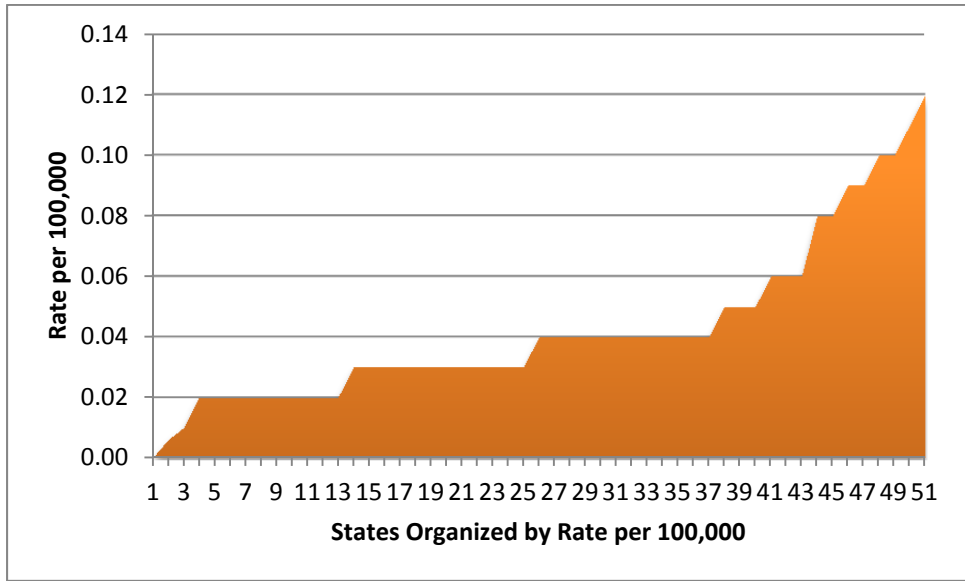
Figure 8 below shows the pattern of percent of deaths by MVT. Each ball represents a state but the states are intentionally not named. Figure 9 shows states grouped into four categories by percent of deaths.

Figure 8: Estimated Suicides by MVT 1999-2010



When viewed by rates per 100,000 people a stair-step pattern emerges. The abrupt steps are an artifact of the available data that only takes the rate to two decimal places; however, the pattern itself is important in that it highlights a categorical type of organization of the data.

Figure 9: Crude Rate per 100,000 for Suicide by MVT, Ranked by Rate per 100,000 people



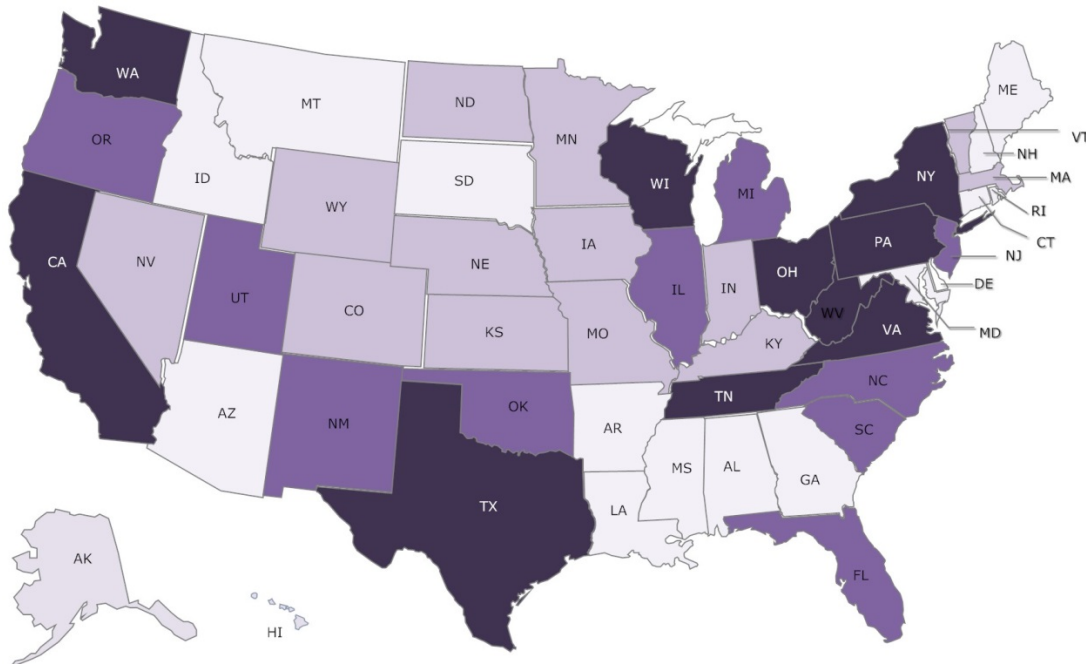
As can be seen in the graph, there are thresholds at 0.02, 0.03 and 0.04 people per 100,000. Below 0.02 and above 0.04 there was variability across states. The stair steps were accentuated by using two decimal places for each state. Table 11 below shows states aggregated into three groups of low (0.03 and below), medium (0.03 to 0.05) and high (0.50 and higher). This was done in order to prevent accidental or deductive disclosure of the cases.

Table 11: Rate per 100,000 of Suicide Death by MVT by State

Low 0.00 to 0.03	Medium 0.03 to 0.05	High 0.05 and above
AR	KY	MT
CT	MA	AZ
GA	NC	DC
LA	NJ	DE
MD	RI	FL
MI	TN	IL
MO	UT	IN
NY	VA	MI
PA	WV	MN
AK		NH
AL		OH
MD		CO
OK		KS
PA		ME
		NM
		WA
		WI
		WY

The following map shows the categorizations of low, medium and high rates of suicide by MVT when a TBI is included as an UCD.

Figure 10: Categorical Organization of States into Low, Medium and High Suicide by MVT with TBI



State by State Comparisons of Rates and Ranks of Suicide and MVT Deaths

There are clusters of states that have high rates of suicide and MVT deaths. The following section shows ranks based on an average rate per 100,000 for 1999-2010 inclusive for MVT deaths, suicide, MVT deaths with TBI, and suicide with TBI. As can be seen from the data, some states are particularly high in all categories. Idaho is in the top 10 for suicide, MVT deaths-TBI, and suicide-TBI. However, Idaho ranks 16th for MVT deaths.

Table 12: Rank per 100,000 State by State Comparison of Suicide and MVT Deaths with MVT Deaths-TBI and Suicide-TBI, 1999-2010

State	Suicide	MVT Deaths	Suicide-TBI	MVT Deaths-TBI
Alabama	24	5	14	10
Alaska	1	31	2	49
Arizona	8	17	7	26
Arkansas	14	4	12	5
California	43	41	42	42
Colorado	6	28	11	21
Connecticut	47	46	45	51
Delaware	34	25	38	34
District of Columbia	51	48	49	45
Florida	15	18	19	27
Georgia	38	21	27	16

State	Suicide	MVT Deaths	Suicide-TBI	MVT Deaths-TBI
Hawaii	39	45	48	47
Idaho	7	16	6	8
Illinois	46	42	44	38
Indiana	26	27	31	33
Iowa	35	26	40	22
Kansas	23	19	29	19
Kentucky	18	11	15	13
Louisiana	33	8	20	11
Maine	20	29	24	24
Maryland	45	38	43	50
Massachusetts	48	51	51	48
Michigan	36	37	37	40
Minnesota	42	40	41	41
Mississippi	27	1	18	1
Missouri	22	14	23	7
Montana	2	3	3	3
Nebraska	40	23	39	12
Nevada	4	24	4	43
New Hampshire	28	44	32	37
New Jersey	49	49	50	46
New Mexico	5	7	5	31
New York	50	50	47	44
North Carolina	29	15	28	14
North Dakota	21	20	25	9
Ohio	37	39	34	32
Oklahoma	10	12	10	15
Oregon	9	32	8	28
Pennsylvania	31	33	35	36
Rhode Island	44	47	46	39
South Carolina	30	6	22	4
South Dakota	13	9	26	6
Tennessee	16	10	13	17
Texas	41	22	33	35
Utah	11	35	16	18
Vermont	17	34	17	29
Virginia	32	36	30	23
Washington	19	43	21	25
West Virginia	12	13	9	30
Wisconsin	25	30	36	20
Wyoming	3	2	1	2

An average rank across all four categories was used to identify an overall rank. This measure should be used cautiously as it combines overlapping categories. The averages were created this

way due to the fact that there was variability in the injury intent with and without TBI. Considering injury intent only based on the presence or absence of TBI did not factor in the variability across intent and TBI. Nonetheless it should be considered only to gain an overall sense of the issues across states.

Table 13: Mean Rank across Injury Intent with and without TBI across States

Ordered by Rank		Alphabetically Ordered	
Wyoming	1	Alabama	8
Montana	2	Alaska	23
Arkansas	3	Arizona	12
Idaho	4	Arkansas	3
Mississippi	5	California	42
Oklahoma	6	Colorado	16
New Mexico	7	Connecticut	47
Alabama	8	Delaware	35
South Dakota	9	District of Columbia	49
Tennessee	10	Florida	21
Kentucky	11	Georgia	28
Arizona	12	Hawaii	46
South Carolina	13	Idaho	4
West Virginia	14	Illinois	43
Missouri	15	Indiana	32
Colorado	16	Iowa	34
Louisiana	17	Kansas	25
North Dakota	18	Kentucky	11
Nevada	19	Louisiana	17
Oregon	20	Maine	26
Florida	21	Maryland	45
Utah	22	Massachusetts	51
Alaska	23	Michigan	40
North Carolina	24	Minnesota	41
Kansas	25	Mississippi	5
Maine	26	Missouri	15
Vermont	27	Montana	2
Georgia	28	Nebraska	31
Washington	29	Nevada	19
Wisconsin	30	New Hampshire	38
Nebraska	31	New Jersey	50
Indiana	32	New Mexico	7
Virginia	33	New York	48
Iowa	34	North Carolina	24
Delaware	35	North Dakota	18
Texas	36	Ohio	39
Pennsylvania	37	Oklahoma	6

Ordered by Rank	
New Hampshire	38
Ohio	39
Michigan	40
Minnesota	41
California	42
Illinois	43
Rhode Island	44
Maryland	45
Hawaii	46
Connecticut	47
New York	48
District of Columbia	49
New Jersey	50
Massachusetts	51

Alphabetically Ordered	
Oregon	20
Pennsylvania	37
Rhode Island	44
South Carolina	13
South Dakota	9
Tennessee	10
Texas	36
Utah	22
Vermont	27
Virginia	33
Washington	29
West Virginia	14
Wisconsin	30
Wyoming	1

Below are four maps showing the relative deaths per 100,000 across the four variables rank ordered: MVT deaths, suicide, MVT deaths with TBI, and suicide with TBI.

Figure 11: Map of Rates per 100,000 for Overall MVT Deaths, 1999-2010

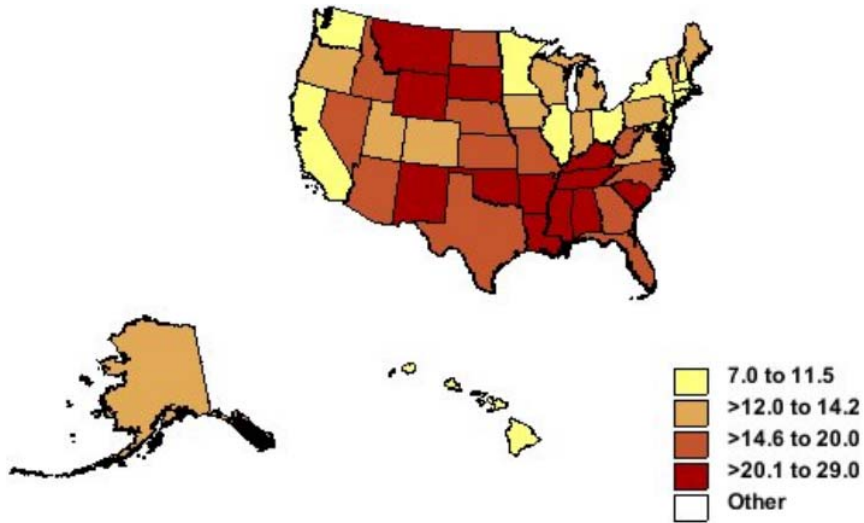


Figure 12: Map of Rates per 100,000 for Overall Suicide, 1999-2010

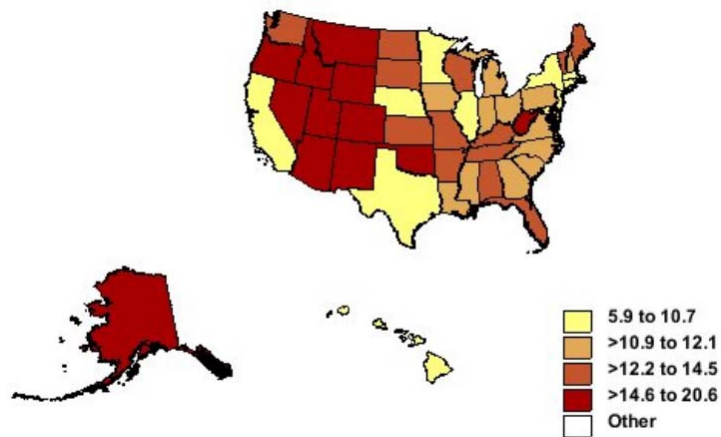


Figure 13: Map of Rates per 100,000 for MVT Deaths with TBI 1999-2010

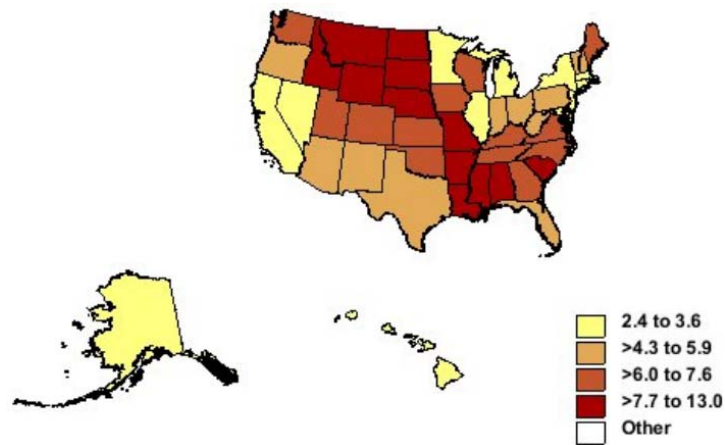
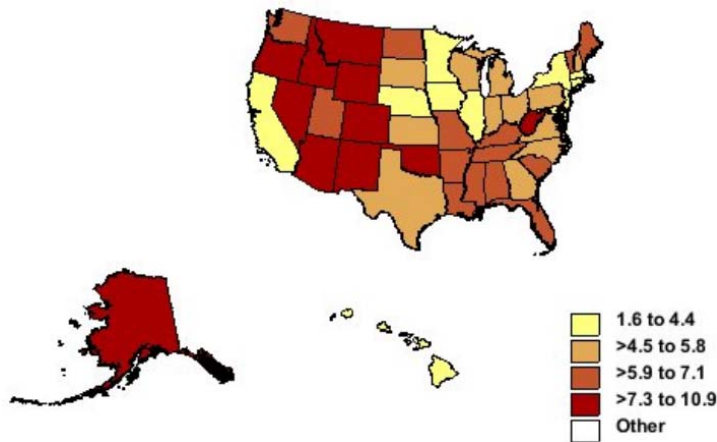


Figure 14: Map of Rates per 100,000 for Suicide with TBI, 1999-2010



ECONOMICS OF SUICIDE AND MVT DEATHS WITH AND WITHOUT TBI

There are no specific data comparing suicide and MVT deaths with and without TBI. To estimate these costs, the WISQARS economic report system was used for MVT deaths and for suicide with a base year of 2005. A ten year average of percent of suicide and MVT deaths that include TBI was used as a factor to estimate the costs.

Table 14: Percent of U.S. Death by Suicide and by MVT that include TBI as UCD, 1999 to 2010

	Number of Deaths	Death with TBI	% with TBI
Suicide	2,732	1,432	52.4%
MVT deaths	3,002	1,494	49.8%

Using these percentages it can be estimated that \$152,520,996 of the total MVT death costs of \$306,267,000 include TBI as a UCD. Similarly, about half (\$152,520,966) of the costs of suicide (\$239,107,000) are suicides with TBIs. However, these estimates are overly general and do not take into account the possibility that medical care for a fatality when there is a TBI is higher than without. Alternately, the presence of a TBI may increase the speed of death thereby reducing medical costs. Because this analysis focused on State by State comparisons, age was not factored in. The age of a person at time of death drives the overall costs because of the work loss costs. Younger people have more years to work and thus these deaths are particularly financially costly.

Table 15: Costs of U.S. Death by Suicide and MVT Deaths with Estimated Total Costs of MVT Deaths with TBI and Suicide with TBI

		Intent	Intent	Intent	Intent
Deaths and Type of Cost		MVT deaths	Suicide	Estimate of MVT deaths with TBI	Estimate of Suicide with TBI
Deaths		254	228	126	119
Medical Cost	Average	\$8,360	\$2,332		
	Total	\$2,207,000	\$532,000	\$1,099,086	\$281,960
Work Loss Cost	Average	\$1,151,741	\$1,046,384		
	Total	\$304,060,000	\$238,575,000	\$151,421,880	\$129,403,080
Combined Cost	Average	\$1,160,101	\$1,048,715		
	Total	\$306,267,000	\$239,107,000	\$152,520,966	\$125,292,068

CONCLUSIONS

Deaths by suicide and by MVT are similar in prevalence. However, one receives more attention from a public health perspective. There are multiple organizations that focus only on motor vehicle safety. The Federal government regulates safety designs for vehicles. Significant progress has been made in the past 20 years of motor vehicle safety design such as airbags. Most States allocate funds for motor vehicle safety campaigns. Seat belt laws, child safety seats and cell-phone use are examples of public health benefits of regulatory actions. Suicide has not received similar attention either in overall prevention or in safety such as has been recommended in suicide prevention in bridge design.¹³ One explanation is the stigma associated with intentional injury when compared to unintentional injury. Social marketing campaigns could focus on stigma reduction and increasing the awareness of suicide in comparison to MVT deaths. It could be that discussing suicide prevalence and lethality would lead to a better understanding of the breadth of the impact of suicide.

Better coding of TBI could also contribute to understanding how to address suicide. A suicide attempt is a major risk factor for a second attempt. Impulsivity is also a risk factor. Impulsivity is a potential outcome of a traumatic brain injury. The theoretical question can be raised as to whether a TBI sustained by MVT accident or a previous suicide attempt added in some way to the vulnerability of the person who died by suicide. As improvements are made in collecting and organizing UCD it may be possible to rule in or out a link between suicide, MVT deaths, and

¹³ Fleming, A. & Blaustein, M. (2009). Suicide from the Golden Gate Bridge. *The American Journal of Psychiatry*, 166, 1111-1116.

TBI. If there are links, addressing the TBI could reduce the risk of suicide attempts or completions.

There is scant literature on the prevalence of using a motor vehicle as a mechanism of a suicide death. This study showed major differences state-by-state in the use of motor vehicles for suicide. Examining characteristics of the States could help with state-level prevention. In some cases lessons learned in states with low rates could be applied in prevention efforts in other states. However, some differences may be outside of the control of prevention campaigns. For example, Alaska has a very high suicide rate but a very low rate of suicide death by MVT. It is possible that this low rate is related more to the lack of roads in many areas of Alaska than to something that can be changed by public health activity.

Intentional and unintentional accidents are similar in prevalence, yet it is likely that people would estimate motor vehicle accidents to be far more common than suicide. It is likely that stigma toward suicide and mental illness is a major cause of underestimating the commonness of suicide. Even though people are directly affected, cultural prohibitions may make it easier to talk about MVT deaths than suicide, bringing to light one more piece of evidence that suicide affects many more people than society recognizes.