



TRAUMATIC BRAIN INJURY IN THE UNITED STATES

Emergency Department Visits,
Hospitalizations, and Deaths



Traumatic Brain Injury in the United States

Emergency Department Visits, Hospitalizations, and Deaths

Prepared by

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Some thoughts about traumatic brain injury (TBI) data...

...People are uneducated about traumatic brain injury. They don't recognize it when it happens to them or their loved ones; they don't know the extent of the public health problem....

This is my dream for people who will sustain a traumatic brain injury:

....At the time the TBI is diagnosed,...the injured person receives information about the consequences of traumatic brain injury and sources of education and support.

....All traumatic brain injuries will be counted, including mild TBIs. The Centers for Disease Control and Prevention will develop a methodology to count even me, a person with TBI who was not admitted to a hospital or died.

...Without accurate data, how can we begin to address the problem?...

*Presented by a TBI survivor
to the Congressional Brain Injury Task Force
June 27, 2001*

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Executive Summary

Background and Purpose of the Report

Traumatic brain injury (TBI) is an important public health problem in the United States. Because the problems that result from TBI, such as those of thinking and memory, are often not visible, and because awareness about TBI among the general public is limited, it is frequently referred to as the “silent epidemic.”

Population-based data on TBI in the United States are critical to understanding the impact of the TBI epidemic on the American people. This report presents basic data about emergency department (ED) visits, hospitalizations, and deaths for the years 1995 through 2001. ED data, which represent approximately 80% of TBIs, are included for the first time in a detailed Centers for Disease Control and Prevention (CDC) report. These data answer a wide range of important questions about how many TBIs occur each year in the United States, who is affected, and how these TBIs occur. The report is intended as a reference for policy makers, service providers, educators, researchers, advocates, and others interested in knowing more about the impact of TBI in the United States.

Highlights of the Results

Each year in the United States:

- At least 1.4 million people sustain a TBI. Of them, about 50,000 die, 235,000 are hospitalized, and 1.1 million are treated and released from an ED.

- Approximately 475,000 TBIs occur among children ages 0 to 14 years; ED visits account for more than 90% of the TBIs in this age group.
- Adults age 75 years or older have the highest rates of TBI-related hospitalization and death.
- In almost every age group, TBI rates are higher for males than for females.
- Motor vehicle–traffic causes result in the greatest number of TBI-related hospitalizations.
- Falls are the leading cause of TBI; rates are highest for children ages 0 to 4 years and for adults age 75 years or older.

Conclusion

An estimated 1.4 million TBI-related deaths, hospitalizations, and ED visits occur in the United States each year. An estimated 80,000 to 90,000 people with TBI experience permanent disability from their injury. Thus, TBI prevention to reduce the incidence of TBIs, improved acute care and rehabilitation to reduce the likelihood of TBI-related disability, and increased access to services for those who do not fully recover must continue to be national priorities.

Introduction

Background

Traumatic brain injury (TBI) is an important public health problem in the United States. Because the problems that result from TBI, such as those of thinking and memory, are often not visible, and because awareness about TBI among the general public is limited, it is frequently referred to as the “silent epidemic.”

Population-based data on TBI in the United States are critical to understanding the impact of the TBI epidemic on the American people. A previous CDC report, *Traumatic Brain Injury in the United States: A Report to Congress*,¹ provided useful data about TBI. It included information about TBI-related deaths and hospitalizations, but it did not describe TBIs of patients who were treated and released from the emergency department (ED). ED visits account for about 80% of TBIs and include a large number of mild TBIs. The term “mild” TBI refers to those in which the injury to the brain itself is diagnosed as mild at the time the person is initially evaluated. Most people recover from a mild TBI, but some have serious long-term consequences. For this reason, more data are needed about mild TBIs, including those seen in the ED.²

Purpose of the Report

Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths presents basic data on the incidence of TBI. It goes beyond previous reports by including ED visits, and answers a wide range of important questions about how many TBIs occur each year in the United States, who is affected, and how these TBIs occur. These data can answer questions such as “Do men sustain TBIs more often than women? Are children more likely to have a TBI than adults? How important are motor vehicles as a cause of TBI among older adults?”

This report is intended as a reference for policy makers, service providers, educators, researchers, advocates, and others interested in knowing more about the impact of TBI in the United States. This important information can be used to document the need for TBI prevention, to identify priorities for research, and to support the need for services among those living with TBI-related disability.

Contents and Organization

This report describes TBI-related ED visits, hospitalizations, and deaths in the United States for the years 1995 through 2001. Average annual numbers of TBIs per year and annual rates are reported. The numbers show the magnitude of the problem, but the rates are also important. Rates show how a certain group is affected by TBI by relating the number of TBIs to the size of the population. For example, a relatively small number of TBIs occurring in a small population (e.g., persons ages 75 years and older) would result in a higher TBI rate than if the same number of TBIs occurred in a larger population (e.g., persons ages 25 to 34 years).

The report findings are organized into two main sections. The Overview summarizes and interprets some key findings. The Appendixes present more detailed data tables, along with a description of the methods and limitations.

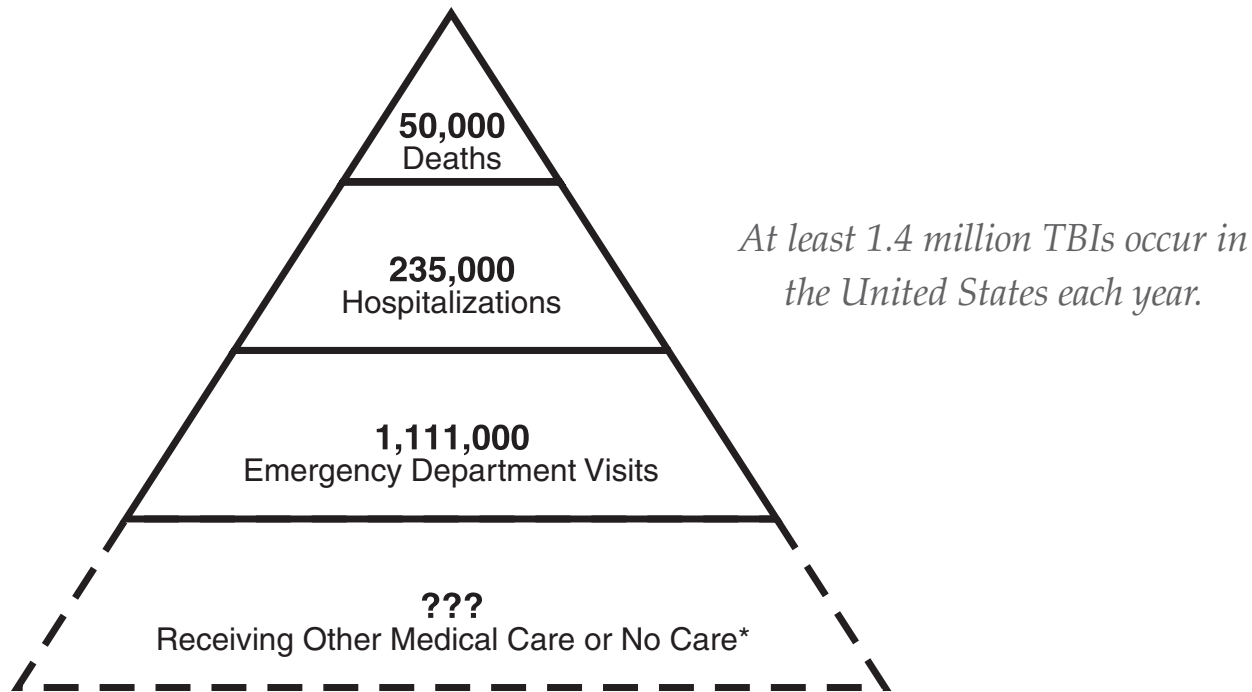
For More Information

If you have questions about the report, please e-mail staff at the Centers for Disease Control and Prevention: dardinfo@cdc.gov.

Overview

Overview of TBI in the United States: A Summary of Findings

Figure 1. Average Annual Number of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths, United States, 1995–2001



* Data for this category are not included in this report. See "Limitations" in the Appendix for more detail (page 49).

From 1995 to 2001, an average of 1.4 million TBIs occurred in the United States each year. Of them, most (79.6%) were ED visits, followed by hospitalizations (16.8%) and deaths (3.6%) (Table 1, page 17).

TBI by Age: Comparing the Numbers

Table A. Average Annual Numbers* of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths, by Age Group, United States, 1995–2001

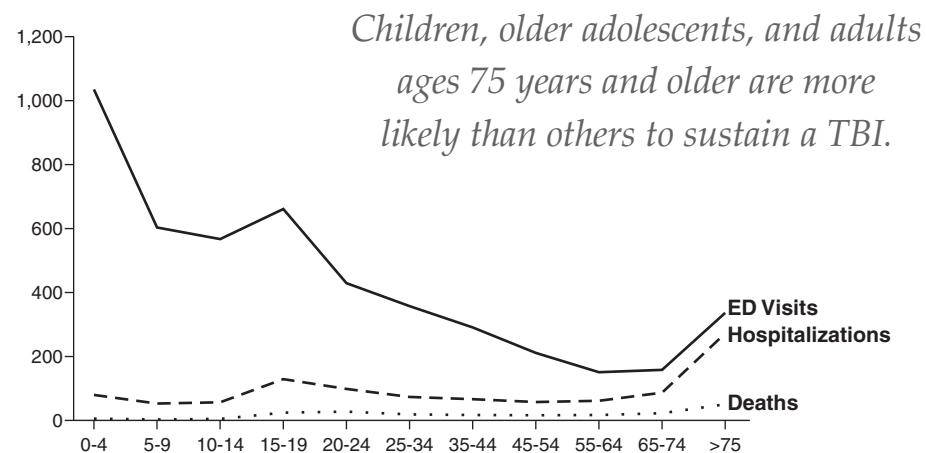
<u>Age Group</u>	<u>ED Visits</u>	<u>Hospitalizations</u>	<u>Deaths</u>	<u>Total</u>
Children (0–14 years)	435,000	37,000	2,685	475,000
Older Adults (65 years and older)	83,000	60,000	12,283	155,000

* The numbers for ED visits and hospitalizations were rounded to the nearest thousand per National Center for Health Statistics (NCHS) methods; thus sums may not add to rounded totals.

An average of 475,000 TBIs occurred each year among children ages 0 to 14 years, while 155,000 occurred among older adults (ages 65 years and older). ED visits accounted for a larger proportion of TBIs among children (91.5%) than among older adults (53.6%) (Table 1, page 17).

TBI by Age: Comparing the Rates

Figure 2. Average Annual Traumatic Brain Injury-Related Rates for Emergency Department Visits, Hospitalizations, and Deaths, by Age Group, United States, 1995–2001



Very young children ages 0 to 4 years had the highest rate of TBI-related ED visits (1,035.0 per 100,000 population), followed by older adolescents ages 15 to 19 years (661.1 per 100,000). However, the highest rates of TBI-related hospitalization and death occurred among adults age 75 years or older (272.1 per 100,000 and 50.6 per 100,000, respectively) (Table 1, page 17).

TBI by Sex: Comparing the Numbers

Table B. Average Annual Numbers* of Traumatic Brain Injury–Related Emergency Department Visits, Hospitalizations, and Deaths, by Sex, United States, 1995–2001

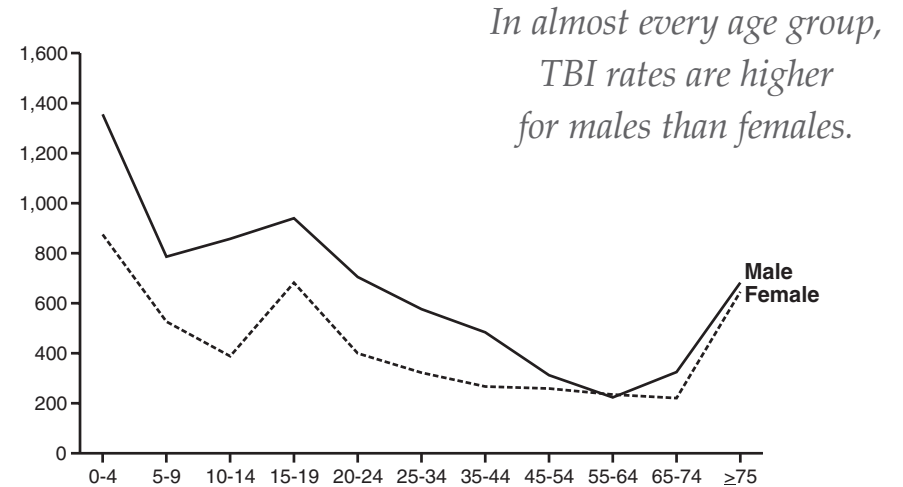
<u>Sex</u>	<u>ED Visits</u>	<u>Hospitalizations</u>	<u>Deaths</u>	<u>Total</u>
Male	652,000	146,000	36,922	835,000
Female	459,000	89,000	12,978	561,000

* The numbers for ED visits and hospitalizations were rounded to the nearest thousand per National Center for Health Statistics (NCHS) methods; thus sums may not add to rounded totals.

An average of 835,000 TBIs occurred each year among males compared with 561,000 among females. Overall, approximately 1.5 times as many TBIs occurred among males as among females.

TBI by Sex: Comparing the Rates

Figure 3. Average Annual Traumatic Brain Injury-Related Rates for Emergency Department Visits, Hospitalizations, and Deaths, by Age Group and Sex, United States, 1995–2001



Males from 0 to 4 years of age had the highest rate for TBI-related deaths, hospitalizations, and ED visits combined (1,355.3 per 100,000). Rates were also high for females from 0 to 4 years (874.8 per 100,000), and for both males and females ages 15 to 19 years and 75 years and older (Table 3, page 22; Table 7, page 28; and Table 12, page 35).

TBI by External Cause: Comparing the Numbers

Table C. Average Annual Numbers* of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths, by External Cause, United States, 1995–2001

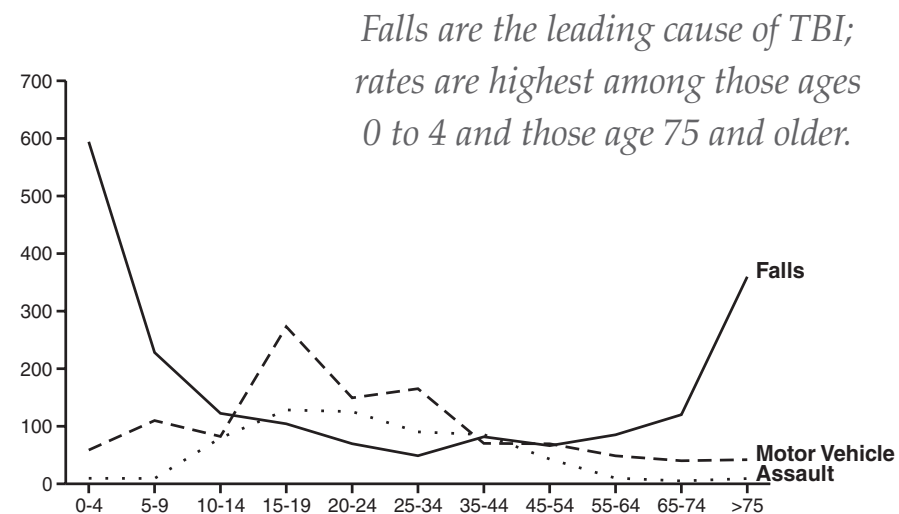
<u>Cause</u>	<u>ED Visits</u>	<u>Hospitalizations</u>	<u>Deaths</u>	<u>Total</u>
Motor Vehicle–Traffic	204,000	59,000	16,800	280,000
Falls	343,000	48,000	6,426	398,000
Assault	135,000	14,000	6,499	156,000
Struck By/Against	263,000	6,000	404	269,000
Other/Unknown	166,000	107,000	19,772	293,000

* The numbers for ED visits and hospitalizations were rounded to the nearest thousand per National Center for Health Statistics (NCHS) methods; thus sums may not add to rounded totals.

An average of 398,000 fall-related TBIs, 280,000 motor vehicle–traffic TBIs, 269,000 struck by/against events, and 156,000 assault-related TBIs occurred annually. Motor vehicle–traffic caused the greatest number of TBI-related deaths and hospitalizations; however, falls resulted in the greatest number of ED visits.

TBI by External Cause: Comparing the Rates

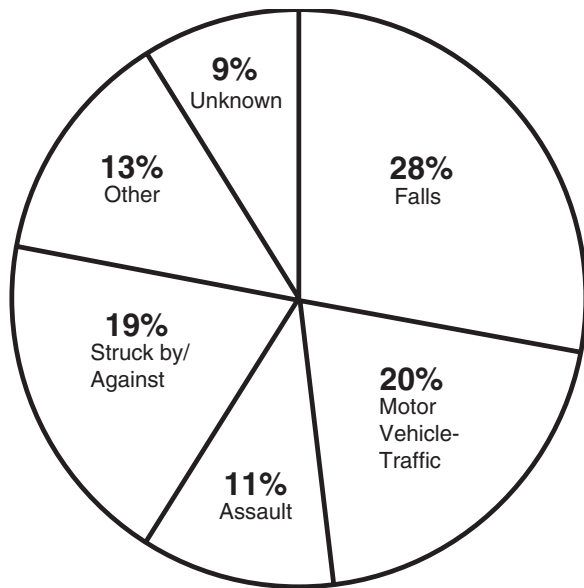
Figure 4. Average Annual Traumatic Brain Injury-Related Rates for Emergency Department Visits, Hospitalizations, and Deaths, by Age Group and External Cause, United States, 1995–2001



The rate of fall-related TBI was highest among children from 0 to 4 years (594.2 per 100,000) and adults age 75 years and older (359.8 per 100,000) (Table 5, page 24; Table 9, page 30; and Table 14, page 37). The rates for both motor vehicle–traffic and assault-related TBI were highest among adolescents ages 15 to 19 years (273.1 per 100,000 and 125.9 per 100,000, respectively).

TBI by External Cause: Comparing the Percentages

Figure 5. Percentage of Average Annual Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths, by External Cause, United States, 1995–2001



Falls were the leading cause of traumatic brain injury (28%), followed by motor vehicle-traffic (20%), struck by/against events (19%), and assaults (11%).

TBI by External Cause: Comparing the Percentages by Age Groups

Figure 6. Percentage of Average Annual Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths Among Children Ages 0 to 14 Years, by External Cause, United States, 1995–2001

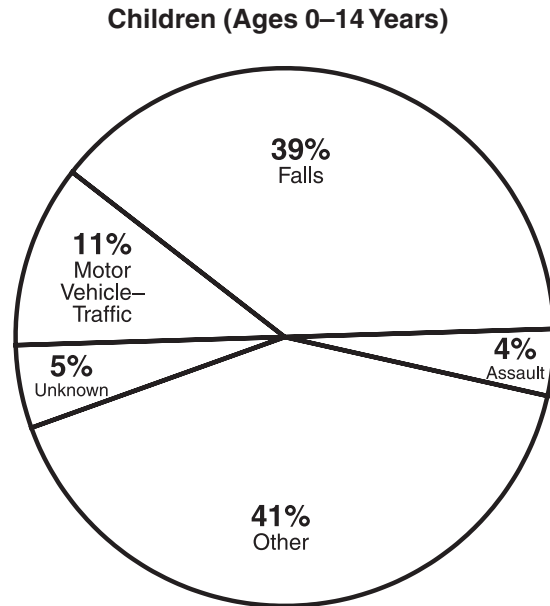
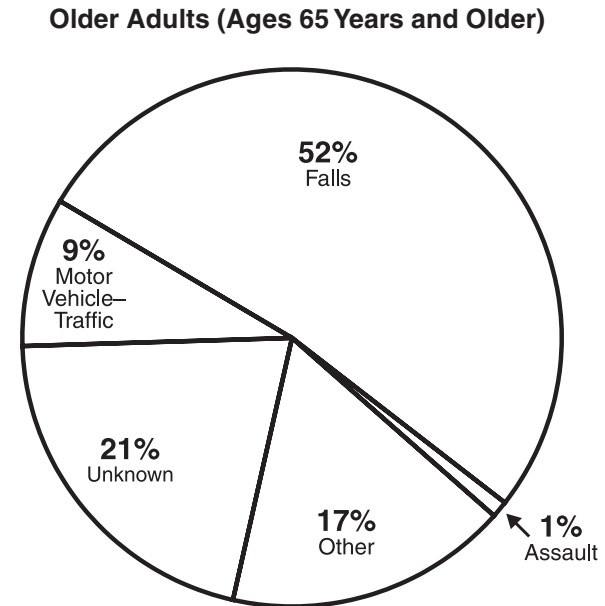


Figure 7. Percentage of Average Annual Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths Among Older Adults Ages 65 Years and Older, by External Cause, United States, 1995–2001



Although falls were the leading cause of TBI for both children and older adults, they represented only 39% of all causes among children compared with 51% among older adults. Motor vehicle-traffic was the second leading cause, with 11% among children and 9% among older adults. Although assaults accounted for a small percentage of TBIs among both children (4%) and older adults (1%), these figures may represent underestimates of the true extent of the problem. See “Limitations” in the Appendix for more detail (page 49).

Conclusion

An estimated 1.4 million TBI-related deaths, hospitalizations, and ED visits occur in the United States each year. This number is similar to previous reports, including *TBI in the United States: A Report to Congress*, published by CDC in 1999.¹ The findings show the importance of including ED visits because of the large number of TBIs seen only in that setting, especially among children. Although this report provides data on a wide range of TBIs occurring in the United States, it still does not capture all of them. Many people recover from their injuries, but each year an estimated 80,000 to 90,000 Americans sustain a TBI resulting in permanent disability.³ Thus TBI prevention to reduce incidence of TBIs, improved acute care and rehabilitation to reduce the likelihood of TBI-related disability, and increased access to services for those who do not fully recover must continue to be high national priorities.

Appendix A: Data

Table 1. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths, by Age Group, United States, 1995–2001

Age (yrs)	Emergency Department Visits*			Hospitalizations†			Deaths			Total‡	
	Number	Rate§	Row %	Number	Rate§	Row %	Number	Rate§	Row %	Number	Rate§
0–4	200,000	1,035.0	92.4	15,000	79.9	7.1	1,099	5.7	0.5	216,000	1,120.7
5–9	122,000	603.3	91.5	11,000	53.0	8.0	628	3.1	0.5	133,000	659.3
10–14	113,000	567.0	90.2	11,000	56.9	9.0	957	4.8	0.8	125,000	628.6
15–19	129,000	661.1	81.2	25,000	129.1	15.9	4,756	24.3	3.0	160,000	814.4
20–24	79,000	429.3	77.3	18,000	98.7	17.8	5,092	27.5	5.0	103,000	555.5
25–34	146,000	357.6	79.4	30,000	73.6	16.4	7,720	18.9	4.2	184,000	450.2
35–44	129,000	291.0	77.7	29,000	66.5	17.7	7,619	17.2	4.6	166,000	374.7
45–54	75,000	211.3	74.1	20,000	57.6	20.2	5,776	16.4	5.7	101,000	285.2
55–64	35,000	150.9	65.7	14,000	61.6	26.9	3,927	17.0	7.4	53,000	229.5
65–74	29,000	158.1	59.1	16,000	86.8	32.5	4,188	22.5	8.4	50,000	267.4
≥ 75	54,000	336.4	51.0	44,000	272.1	41.3	8,095	50.6	7.7	105,000	659.1
Total‡	1,111,000	403.1	79.6	235,000	85.2	16.8	49,900	18.1	3.6	1,396,000	506.4
Adj. ¶		401.2			85.5			18.1			504.8

* Persons who were hospitalized, died, transferred to another facility, or who had an unknown disposition were excluded.

† Persons who died while being hospitalized were excluded.

‡ Numbers, rates, and percentages may not sum to totals due to rounding.

§ Average annual rate per 100,000 population.

|| Sample size, or sample size of one of the components, is 30–59; the value of the estimate was reported but may not be stable.

¶ Age-adjusted to the 2000 U.S. standard population.

Emergency Department Visits

Table 2. Average Annual Numbers and Percentages of Traumatic Brain Injury-Related Emergency Department Visits, by Age Group and Disposition, United States, 1995–2001

Age (yrs)	Treated and Released		Other*		Total†
	Number	Row %	Number	Row %	Number
0–4	200,000	89.6	23,000‡	10.4‡	223,000
5–9	122,000	91.8	§	§	133,000
10–14	113,000	88.5	§	§	128,000
15–19	129,000	81.9	29,000‡	18.1‡	158,000
20–24	79,000	78.9	21,000‡	21.1‡	101,000
25–34	146,000	84.6	27,000‡	15.4‡	173,000
35–44	129,000	79.8	33,000‡	20.2‡	162,000
45–54	75,000	76.4	23,000‡	23.6‡	98,000
55–64	35,000	67.2	§	§	52,000
65–74	29,000‡	78.9‡	§	§	37,000
≥ 75	54,000	61.0	34,000	39.0	88,000
Total†	1,111,000	82.2	240,000	17.8	1,351,000

* Includes people who were hospitalized, died, transferred to another facility, or had an unknown disposition. They were excluded from the remaining emergency department tables.

† Numbers and percentages may not sum to totals due to rounding.

‡ Sample size is 30–59; the value of the estimate was reported but may not be stable.

§ Sample size is less than 30; the value of the estimates was not reported because it is not considered stable.

Table 3. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Emergency Department Visits, by Age Group and Sex, United States, 1995–2001

Age (yrs)	Male			Female			Total*	
	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]
0–4	124,000	1,253.6	62.0	76,000	806.1	38.0	200,000	1,035.0
5–9	74,000	711.1	60.4	48,000	490.1	39.6	122,000	603.3
10–14	79,000	773.5	69.9	34,000 [‡]	349.9 [‡]	30.1 [‡]	113,000	567.0
15–19	73,000	729.8	56.7	56,000	588.4	43.3	129,000	661.1
20–24	49,000	522.8	62.1	30,000 [‡]	331.9 [‡]	37.9 [‡]	79,000	429.3
25–34	91,000	441.1	62.1	55,000	273.0	37.9	146,000	357.6
35–44	80,000	361.4	61.7	49,000	221.5	38.3	129,000	291.0
45–54	36,000 [‡]	205.4 [‡]	47.7 [‡]	39,000	216.9	52.3	75,000	211.3
55–64	§	§	§	22,000 [‡]	182.4 [‡]	63.0 [‡]	35,000	150.9
65–74	§	§	§	§	§	§	29,000 [‡]	158.1 [‡]
≥ 75	19,000 [‡]	322.6 [‡]	35.0 [‡]	35,000	344.3	65.0	54,000	336.4
Total*	652,000	482.9	58.7	459,000	326.5	41.3	1,111,000	403.1
Adj.		470.3			329.3			401.2

* Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Sample size is 30–59; the value of the estimate was reported but may not be stable.

§ Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

|| Age-adjusted to the 2000 U.S. standard population.

Note: Persons who were hospitalized, died, transferred to another facility, or who had an unknown disposition were excluded.

Table 4. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Emergency Department Visits, by Age Group and Race, United States, 1995–2001

Age (yrs)	White			Black			American Indian/ Alaska Native Asian/Pacific Islander			Total*	
	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†
0–4	158,000	1,045.8	79.0	31,000	990.8	15.6	§	§	§	200,000	1,035.0
5–9	97,000	613.8	79.3	24,000‡	696.1‡	19.4‡	§	§	§	122,000	603.3
10–14	95,000	602.4	83.7	§	§	§	§	§	§	113,000	567.0
15–19	108,000	695.3	83.1	21,000‡	699.4‡	16.4‡	§	§	§	129,000	661.1
20–24	65,000	443.9	81.9	12,000‡	452.3‡	15.5‡	§	§	§	79,000	429.3
25–34	116,000	351.8	79.2	25,000‡	452.4‡	17.1‡	§	§	§	146,000	357.6
35–44	103,000	280.6	79.4	22,000‡	399.5‡	17.2‡	§	§	§	129,000	291.0
45–54	59,000	199.5	79.7	§	§	§	§	§	§	75,000	211.3
55–64	31,000‡	156.1‡	88.9‡	§	§	§	§	§	§	35,000	150.9
65–74	24,000‡	147.8‡	82.3‡	§	§	§	§	§	§	29,000‡	158.1‡
≥ 75	50,000	344.6	92.6	§	§	§	§	§	§	54,000	336.4
Total*	904,000	399.3	81.4	173,000	485.6	15.5	35,000	252.6	3.1	1,111,000	403.1
Adj. ††		404.9			441.5			261.3			401.2

* Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Sample size is 30–59; the value of the estimate was reported but may not be stable.

§ Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

†† Age-adjusted to the 2000 U.S. standard population.

Note: Persons who were hospitalized, died, transferred to another facility, or who had an unknown disposition were excluded.

Table 5. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Emergency Department Visits, by Age Group and External Cause, United States, 1995–2001

Age (yrs)	Motor Vehicle—Traffic*			Falls			Assault			Other/Unknown†		Total‡	
	Number	Rate§	Row %	Number	Rate§	Row %	Number	Rate§	Row %	Number	Row %	Number	Rate§
0–4				108,000	561.4	54.2				82,000	41.2	200,000	1,035.0
5–9				44,000	216.0	35.8				58,000	47.6	122,000	603.3
10–14				23,000¶	115.2¶	20.3¶				62,000	54.7	113,000	567.0
15–19	40,000	204.6	30.9				22,000¶	111.6¶	16.9¶	49,000	37.6	129,000	661.1
20–24	18,000¶	94.7¶	22.1¶				20,000¶	109.0¶	25.4¶	30,000¶	37.5¶	79,000	429.3
25–34	55,000	133.8	37.4	17,000¶	41.7¶	11.6¶	31,000¶	75.2¶	21.0¶	44,000	29.9	146,000	357.6
35–44	19,000¶	43.0¶	14.8¶	32,000¶	72.6¶	24.9¶	33,000¶	73.4¶	25.2¶	45,000	35.0	129,000	291.0
45–54	17,000¶	49.0¶	23.2¶							25,000¶	34.0¶	75,000	211.3
55–64												35,000	150.9
65–74												29,000¶	158.1¶
≥ 75				37,000	229.9	68.3						54,000	336.4
Total‡	204,000	73.9	18.3	343,000	124.4	30.9	135,000	49.1	12.2	429,000	38.6	1,111,000	403.1
Adj.**		72.8			124.6			48.6					401.2

* Motor vehicle–traffic includes the following external causes of injury: occupant, motorcyclist, pedal cyclist, pedestrian, other and unspecified person involved in a motor vehicle–traffic incident.

† Includes an annual rounded estimate of 263,000 struck by/against events (23.7% of total), 127,000 other events (11.4% of total), and 40,000 unknowns (3.6% of total).

‡ Numbers, rates, and percentages may not sum to totals due to rounding.

§ Average annual rate per 100,000 population.

|| Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

¶ Sample size is 30–59; the value of the estimate was reported but may not be stable.

** Age-adjusted to the 2000 U.S. standard population.

Note: Persons who were hospitalized, died, transferred to another facility, or who had an unknown disposition were excluded.

Hospitalizations

Table 6: Average Annual Numbers and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and Disposition, United States, 1995–2001

Age (yrs)	Discharged Alive						In-Hospital Deaths [‡]		Total [§]
	Home		Transferred*		Other/Unknown [†]		Number	Row %	Number
	Number	Row %	Number	Row %	Number	Row %			
0–4	15,000	90.5		1.9 [¶]	1,000 [¶]	3.1 [¶]	1,000 [¶]	4.5 [¶]	16,000
5–9	10,000	90.9	**	**	**	**	**	**	11,000
10–14	10,000	86.4	1,000 [¶]	5.8 [¶]	1,000 [¶]	5.0 [¶]	**	**	12,000
15–19	21,000	81.1	2,000	7.0	2,000	8.3	1,000	3.5	26,000
20–24	14,000	74.4	2,000	7.9	2,000	11.9	1,000 [¶]	5.8 [¶]	19,000
25–34	24,000	77.3	2,000	7.9	3,000	11.0	1,000	3.8	31,000
35–44	23,000	74.2	3,000	10.2	3,000	10.5	2,000	5.1	31,000
45–54	15,000	70.2	2,000	11.3	3,000	11.5	2,000	7.0	22,000
55–64	10,000	64.3	3,000	17.9	2,000	10.2	1,000	7.5	15,000
65–74	11,000	59.7	3,000	18.0	2,000	12.8	2,000	9.5	18,000
≥ 75	20,000	40.5	18,000	37.6	5,000	11.3	5,000	10.5	49,000
Total[§]	173,000	69.1	37,000	14.8	25,000	9.8	16,000	6.2	250,000

* Includes both long- and short-term care facilities.

† Includes patients who left against medical advice and who were discharged alive (but no disposition stated), and patients with unknown disposition.

‡ In-hospital deaths are excluded from the remaining hospitalization tables.

§ Numbers and percentages may not sum to totals due to rounding.

|| Cell had an estimate of less than 500; rounding to the nearest thousand resulted in an estimate of zero.

¶ Sample size is 30–59; the value of the estimate was reported but may not be stable.

** Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

Table 7: Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and Sex, United States, 1995–2001

Age (yrs)	Male			Female			Total*	
	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]
0–4	9,000	95.4	61.1	6,000	63.7	38.9	15,000	79.9
5–9	7,000	71.2	68.8	3,000	33.8	31.2	11,000	53.0
10–14	8,000	77.6	70.0	3,000	35.0	30.0	11,000	56.9
15–19	18,000	174.5	69.5	8,000	81.1	30.5	25,000	129.1
20–24	13,000	137.7	71.2	5,000	58.1	28.8	18,000	98.7
25–34	22,000	105.5	72.1	8,000	41.4	27.9	30,000	73.6
35–44	21,000	95.7	71.5	8,000	37.6	28.5	29,000	66.5
45–54	14,000	81.0	68.9	6,000	35.1	31.1	20,000	57.6
55–64	9,000	79.4	61.7	5,000	45.3	38.3	14,000	61.6
65–74	9,000	103.6	53.6	7,000	73.1	46.4	16,000	86.8
≥ 75	16,000	276.0	37.0	27,000	269.9	63.0	44,000	272.1
Total*	146,000	107.8	62.0	89,000	63.4	38.0	235,000	85.2
Adj. [‡]		110.4			60.7			85.5

* Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Age-adjusted to the 2000 U.S. standard population.

Note: In-hospital deaths were excluded.

Table 8. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and Race, United States, 1995–2001

Age (yrs)	White			Black			American Indian/ Alaska Native Asian/Pacific Islander			Other/Unknown		Total*	
	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Row %	Number	Rate [†]
0–4	9,000	56.7	55.5	3,000	95.7	9.5	‡	46.0 [§]	3.2 [§]	3,000	21.9	15,000	79.9
5–9	7,000	43.0	63.3	2,000	44.7	14.2				2,000	19.2	11,000	53.0
10–14	7,000	47.4	65.6	1,000	42.3	11.8				2,000	20.8	11,000	56.9
15–19	16,000	103.3	63.2	2,000	75.7	9.1				6,000	24.7	25,000	129.1
20–24	11,000	75.9	60.9	2,000	82.5	12.3				4,000	23.0	18,000	98.7
25–34	17,000	53.2	58.2	4,000	78.0	14.3	1,000 [§]	46.2 [§]	3.8 [§]	7,000	23.7	30,000	73.6
35–44	17,000	47.9	59.3	4,000	79.8	15.1	1,000 [§]	27.7 [§]	2.1 [§]	7,000	23.5	29,000	66.5
45–54	11,000	36.4	53.4	3,000	75.7	14.4				6,000	28.6	20,000	57.6
55–64	9,000	43.1	60.1	1,000	54.5	8.9				4,000	28.3	14,000	61.6
65–74	11,000	67.3	68.3	1,000 [§]	41.7 [§]	4.2 [§]				4,000	23.7	16,000	86.8
≥ 75	30,000	209.8	69.7	2,000	144.2	4.0	1,000 [§]	272.1 [§]	2.1 [§]	11,000	24.2	44,000	272.1
Total*	146,000	64.3	62.0	26,000	72.4	11.0	7,000	50.8	3.0	57,000	24.1	235,000	85.2
Adj. [¶]		63.8			73.9			59.9					85.5

* Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Cell had an estimate of less than 500.

§ Sample size is 30–59; the value of the estimate was reported but may not be stable.

|| Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

¶ Age-adjusted to the 2000 U.S. standard population.

Note: In-hospital deaths were excluded.

Table 9. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and External Cause, United States, 1995–2001

Age (yrs)	Motor Vehicle–Traffic*			Falls			Assault			Other/Unknown†		Total‡	
	Number	Rate§	Row %	Number	Rate§	Row %	Number	Rate§	Row %	Number	Row %	Number	Rate§
0–4	2,000	8.6	10.7	6,000	32.5	40.7	1,000	5.4	6.8	6,000	41.8	15,000	79.9
5–9	3,000	13.1	24.7	2,000	12.2	23.0				5,000	50.5	11,000	53.0
10–14	3,000	13.3	23.3	1,000	7.1	12.4				7,000	61.2	11,000	56.9
15–19	11,000	55.4	42.9	1,000	7.6	5.9	2,000	10.1	7.8	11,000	43.4	25,000	129.1
20–24	8,000	42.3	42.9	1,000	4.6	4.7	2,000	8.4	8.5	8,000	43.9	18,000	98.7
25–34	10,000	24.2	32.9	3,000	6.6	9.0	4,000	9.1	12.3	14,000	45.9	30,000	73.6
35–44	10,000	21.5	32.3	4,000	8.3	12.5	3,000	7.0	10.5	13,000	44.7	29,000	66.5
45–54	6,000	15.6	27.0	3,000	8.2	14.2	2,000	4.9	8.6	10,000	50.2	20,000	57.6
55–64	4,000	15.4	24.9	3,000	4.1	22.8				7,000	50.5	14,000	61.6
65–74	2,000	12.3	14.1	6,000	31.7	36.6				8,000	48.3	16,000	86.8
≥ 75	3,000	19.2	7.0	17,000	108.1	39.7				23,000	52.7	44,000	272.1
Total‡	59,000	21.6	25.3	48,000	17.5	20.5	14,000	5.2	6.1	113,000	48.1	235,000	85.2
Adj. ¶		21.5			17.7			5.1					85.5

* Motor vehicle–traffic includes the following external causes of injury: occupant, motorcyclist, pedal cyclist, pedestrian, other and unspecified person involved in a motor vehicle–traffic incident.

† Includes an annual rounded estimate of 6,000 struck by/against events (2.4% of total), 22,000 other events (9.3% of total), and 85,000 unknowns (36.4% of total).

‡ Numbers, rates, and percentages may not sum to totals due to rounding.

§ Average annual rate per 100,000 population.

|| Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

¶ Age-adjusted to the 2000 U.S. standard population.

Note: In-hospital deaths were excluded.

Table 10. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and Specific Motor Vehicle–Traffic (MVT) External Causes, United States, 1995–2001

Age (yrs)	MVT—Occupant			MVT—Motorcycle			MVT—Pedal Cycle			MVT—Pedestrian			Total*	
	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†
0–4	1,000	5.5	64.5	‡	‡	‡	‡	‡	‡	1,000 [§]	2.6 [§]	30.8 [§]	2,000	8.6
5–9	1,000	7.2	55.2	‡	‡	‡		1.7 [§]	12.7 [§]	1,000	3.6	27.4	3,000	13.1
10–14	1,000	6.4	48.2	‡	‡	‡	1,000 [§]	2.6 [§]	19.6 [§]	1,000	3.7	28.2	3,000	13.3
15–19	7,000	38.1	68.8	‡	‡	‡	‡	‡	‡	1,000 [§]	4.6 [§]	8.3 [§]	11,000	55.4
20–24	6,000	33.7	79.7	1,000 [§]	3.2 [§]	7.7 [§]	‡	‡	‡	‡	‡	‡	8,000	42.3
25–34	7,000	17.6	72.8	1,000 [§]	2.4 [§]	9.9 [§]	‡	‡	‡	1,000	2.2	9.2	10,000	24.2
35–44	7,000	15.5	71.9	1,000 [§]	1.7 [§]	7.7 [§]	‡	‡	‡	1,000 [§]	1.9 [§]	8.6 [§]	10,000	21.5
45–54	4,000	10.5	67.4	‡	‡	‡	‡	‡	‡	1,000 [§]	1.6 [§]	10.5 [§]	6,000	15.6
55–64	3,000	11.0	71.6	‡	‡	‡	‡	‡	‡	1,000 [§]	2.7 [§]	17.5 [§]	4,000	15.4
65–74	2,000	8.9	72.5	‡	‡	‡	‡	‡	‡	‡	‡	‡	2,000	12.3
≥ 75	2,000	14.3	74.6	‡	‡	‡	‡	‡	‡	‡	‡	‡	3,000	19.2
Total¶	42,000	15.1	70.2	4,000	1.5	6.7	2,000	0.8	3.9	7,000	2.5	11.6	59,000	21.6

* Total includes an additional average annual rounded estimate of 4,000 MVT unspecified cases and less than 500 with other MVT cause. Therefore, numbers, rates, and percentages will not sum to totals.

† Average annual rate per 100,000 population.

‡ Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

§ Sample size is 30–59; the value of the estimate was reported but may not be stable.

|| Cell had an estimate of less than 500; rounding to the nearest thousand resulted in an estimate of zero.

¶ Numbers may not sum to totals due to rounding.

Note: In-hospital deaths were excluded.

Table 11. Average Annual Numbers and Percentages of Traumatic Brain Injury-Related Hospitalizations, by Age Group and Expected Source of Payment, United States, 1995–2001

Age (yrs)	Private		Medicaid		Medicare		Workers Compensation		Other/Unknown*		Total†
	Number	Row %	Number	Row %	Number	Row %	Number	Row %	Number	Row %	Number
0–4	6,000	39.8	6,000	39.5	‡	‡	‡	‡	3,000	19.6	15,000
5–9	5,000	50.8	3,000	24.4	‡	‡	‡	‡	3,000	24.8	11,000
10–14	7,000	62.1	2,000	16.6	‡	‡	‡	‡	2,000	21.0	11,000
15–19	15,000	59.0	3,000	12.5	‡	‡	‡	‡	7,000	27.2	25,000
20–24	8,000	43.4	2,000	11.3	‡	‡	1,000 [§]	4.0 [§]	7,000	38.7	18,000
25–34	13,000	44.8	4,000	12.0	1,000 [§]	2.5 [§]	1,000	4.0	11,000	36.7	30,000
35–44	13,000	44.0	4,000	13.1	1,000 [§]	4.1 [§]	2,000	5.6	10,000	33.3	29,000
45–54	11,000	52.9	2,000	10.3	2,000	7.8	1,000 [§]	4.1 [§]	5,000	24.9	20,000
55–64	8,000	52.8	1,000	10.0	1,000	8.7	1,000 [§]	5.7 [§]	3,000	22.8	14,000
65–74	4,000	25.5	‡	‡	11,000	65.4	‡	‡	1,000 [§]	5.9 [§]	16,000
≥ 75	5,000	11.7	‡	‡	36,000	82.7	‡	‡	2,000	4.6	44,000
Total†	95,000	40.6	28,000	11.7	52,000	22.2	6,000	2.4	54,000	23.0	235,000

* Includes self pay, no charge, other government, other, and unknown.

† Numbers and percentages may not sum to totals due to rounding.

‡ Sample size is less than 30; the value of the estimate was not reported because it is not considered stable.

§ Sample size is 30–59; the value of the estimate was reported but may not be stable.

Note: In-hospital deaths were excluded.

Deaths

Table 12. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Deaths, by Age Group and Sex, United States, 1995–2001

Age (yrs)	Male			Female			Total*	
	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]
0–4	626	6.3	57.0	473	5.0	43.0	1,099	5.7
5–9	371	3.6	59.0	258	2.6	41.0	628	3.1
10–14	644	6.3	67.3	313	3.2	32.7	957	4.8
15–19	3,560	35.4	74.8	1,196	12.6	25.2	4,756	24.3
20–24	4,192	44.4	82.3	900	9.9	17.7	5,092	27.5
25–34	6,126	29.8	79.3	1,595	7.9	20.7	7,720	18.9
35–44	5,873	26.6	77.1	1,745	7.8	22.9	7,619	17.2
45–54	4,505	26.0	78.0	1,271	7.1	22.0	5,776	16.4
55–64	3,037	27.5	77.3	890	7.4	22.7	3,927	17.0
65–74	3,064	36.7	73.2	1,124	11.0	26.8	4,188	22.5
≥ 75	4,888	83.7	60.4	3,207	31.6	39.6	8,095	50.6
Total*	36,922	27.3	74.0	12,978	9.2	26.0	49,900	18.1
Adj. [‡]		28.4			8.9			18.1

* Total includes 43 cases with missing age. Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Age-adjusted to the 2000 U.S. standard population.

Table 13. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Deaths, by Age Group and Race, United States, 1995–2001

Age (yrs)	White			Black			Asian/Pacific Islander			American Indian/ Alaska Native		Total*	
	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]	Row %	Number	Rate [†]		
0–4	757	5.0	68.9	286	9.1	26.0	56	5.3	5.1	1,099	5.7		
5–9	465	3.0	73.9	134	4.0	21.4	30	2.8	4.7	628	3.1		
10–14	760	4.8	79.4	158	5.0	16.5	39	3.6	4.1	957	4.8		
15–19	3,714	24.0	78.1	864	28.5	18.2	178	16.6	3.7	4,756	24.3		
20–24	3,810	26.0	74.8	1,092	40.1	21.4	190	16.9	3.7	5,092	27.5		
25–34	5,971	18.2	77.3	1,461	26.5	18.9	287	11.6	3.7	7,720	18.9		
35–44	6,287	17.2	82.5	1,104	19.8	14.5	227	10.0	3.0	7,619	17.2		
45–54	4,931	16.5	85.4	683	17.7	11.8	162	9.9	2.8	5,776	16.4		
55–64	3,440	17.4	87.6	380	16.4	9.7	107	11.5	2.7	3,927	17.0		
65–74	3,779	23.1	90.3	313	19.1	7.5	96	16.3	2.3	4,188	22.5		
≥ 75	7,549	52.2	93.3	397	33.2	4.9	150	43.6	1.8	8,095	50.6		
Total*	41,498	18.3	83.2	6,878	19.3	13.8	1,524	11.2	3.1	49,900	18.1		
Adj. [‡]		18.1			19.9			12.4			18.1		

* Total includes 43 cases with missing age. Numbers, rates, and percentages may not sum to totals due to rounding.

† Average annual rate per 100,000 population.

‡ Age-adjusted to the 2000 U.S. standard population.

Table 14. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Deaths, by Age Group and External Cause, United States, 1995–2001

Age (yrs)	Motor Vehicle—Traffic*			Falls			Assault			Other/Unknown†		Total‡	
	Number	Rate§	Row %	Number	Rate§	Row %	Number	Rate§	Row %	Number	Row %	Number	Rate§
0–4	499	2.6	45.4	37	0.2	3.4	348	1.8	31.7	215	19.6	1,099	5.7
5–9	441	2.2	70.2	16	0.1	2.5	64	0.3	10.2	107	17.0	628	3.1
10–14	541	2.7	56.5	17	0.1	1.8	119	0.6	12.4	280	29.3	957	4.8
15–19	2,578	13.2	54.2	58	0.3	1.2	832	4.2	17.5	1,288	27.1	4,756	24.3
20–24	2,310	12.5	45.4	85	0.5	1.7	1,053	5.7	20.7	1,644	32.3	5,092	27.5
25–34	2,987	7.3	38.7	217	0.5	2.8	1,499	3.7	19.4	3,017	39.1	7,720	18.9
35–44	2,615	5.9	34.3	420	0.9	5.5	1,194	2.7	15.7	3,390	44.5	7,619	17.2
45–54	1,741	4.9	30.1	546	1.5	9.4	656	1.9	11.4	2,833	49.0	5,776	16.4
55–64	1,036	4.5	26.4	577	2.5	14.7	318	1.4	8.1	1,996	50.8	3,927	17.0
65–74	922	5.0	22.0	976	5.3	23.3	211	1.1	5.0	2,079	49.6	4,188	22.5
≥ 75	1,119	7.0	13.8	3,476	21.7	42.9	186	1.2	2.3	3,314	40.9	8,095	50.6
Total‡	16,800	6.1	33.7	6,426	2.3	12.9	6,499	2.4	13.0	20,176	40.4	49,900	18.1
Adj.¶		6.1			2.4			2.3					18.1

* Motor vehicle–traffic includes the following external causes of injury: occupant, motorcyclist, pedal cyclist, pedestrian, other and unspecified person involved in a motor vehicle–traffic incident.

† Includes an average annual estimate of 404 struck by/against events (0.8% of total), 19,413 other events (38.9% of total), and 359 unknowns (0.7% of total).

‡ Total includes 43 cases with missing age. Numbers, rates, and percentages may not sum to totals due to rounding.

§ Average annual rate per 100,000 population.

¶ Age-adjusted to the 2000 U.S. standard population.

Table 15. Average Annual Numbers, Rates, and Percentages of Traumatic Brain Injury-Related Deaths, by Age Group and Specific Motor Vehicle–Traffic (MVT) External Causes, United States, 1995–2001

Age (yrs)	MVT—Occupant			MVT—Motorcycle			MVT—Pedal Cycle			MVT—Pedestrian			Total*	
	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†	Row %	Number	Rate†
0–4	258	1.3	51.7	0	‡	0.1	3	‡	0.5	126	0.7	25.3	499	2.6
5–9	181	0.9	41.1	2	‡	0.6	43	0.2	9.7	123	0.6	27.8	441	2.2
10–14	245	1.2	45.3	9	0.0	1.7	64	0.3	11.8	113	0.6	20.9	541	2.7
15–19	1,559	8.0	60.5	68	0.3	2.6	38	0.2	1.5	132	0.7	5.1	2,578	13.2
20–24	1,309	7.1	56.7	141	0.8	6.1	22	0.1	1.0	134	0.7	5.8	2,310	12.5
25–34	1,602	3.9	53.6	243	0.6	8.1	42	0.1	1.4	248	0.6	8.3	2,987	7.3
35–44	1,290	2.9	49.3	229	0.5	8.8	62	0.1	2.4	315	0.7	12.0	2,615	5.9
45–54	830	2.3	47.7	139	0.4	8.0	42	0.1	2.4	252	0.7	14.5	1,741	4.9
55–64	515	2.2	49.7	52	0.2	5.0	19	0.1	1.9	166	0.7	16.0	1,036	4.5
65–74	472	2.5	51.2	13	0.1	1.4	15	0.1	1.7	158	0.9	17.2	922	5.0
≥ 75	558	3.5	49.8	6	0.0	0.5	13	0.1	1.2	225	1.4	20.1	1,119	7.0
Total§	8,819	3.2	52.5	903	0.3	5.4	365	0.1	2.2	1,998	0.7	11.9	16,800	6.1

* Total includes additional 4,698 cases with unspecified MVT cause and 16 with other MVT cause. Therefore, numbers, rates, and percentages will not sum to totals.

† Average annual rate per 100,000 population.

‡ Sample size was less than 20 for the 7 years combined, so the rate was suppressed.

§ Numbers may not sum to total due to rounding. Also includes 10 additional cases with age unknown.

Appendix B: Methods and Data Sources

The data presented in this report are based on three different national data sources: the National Vital Statistics System, the National Hospital Discharge Survey (NHDS), and the National Hospital Ambulatory Medical Care Survey (NHAMCS). These data sources were selected because all can produce national estimates for traumatic brain injury-related deaths, hospitalizations, and visits to hospital EDs. Data for the years 1995 to 2001 were used. The reasons for using data for this 7-year time period were (1) to obtain the most recent estimates of the burden of traumatic brain injuries possible and (2) to increase the stability of the estimated numbers and rates for hospitalizations and ED visits by using multiple years.

Data Sources

Emergency Department Visits

The National Hospital Ambulatory Medical Care Survey (NHAMCS), conducted by CDC's National Center for Health Statistics (NCHS), was used to characterize TBIs treated in EDs in the United States. The target population of the NHAMCS is in-person visits made in the United States to EDs and outpatient departments of nonfederal, short-stay hospitals (hospitals with an average stay of less than 30 days) or hospitals that specialize in general (medical or surgical) or children's general hospitals. Of the NHAMCS data, only ED visits were included in this report. The NHAMCS used a four-stage probability design with the stages being primary sampling units (PSUs),

hospitals within PSUs, clinics or EDs within hospitals, and patient visits within clinics or EDs. Hospital staff were asked to complete patient record forms for a systematic random sample of patient visits occurring during a randomly assigned 4-week reporting period. Each visit was assigned a sample weight based on the inverse probability of selection with adjustments for non-response. The individual sample weights were summed to produce national estimates of TBI-related ED visits. For age, sex, and race, missing values were imputed by randomly assigning a value from a record with similar ED volume, geographic region, immediacy with which the patient should be seen, and primary diagnosis. Additional information about the NHAMCS ED component is available.⁴

TBI-related cases were selected if one of the three diagnosis fields contained an ICD-9-CM diagnosis code for TBI⁵ (see Table 16). The external cause of injury (E code) was assigned based on the first E code field. Emergency department patients who died in the ED or who were later hospitalized or transferred to another facility were excluded from the analysis of ED visits.

During 1995 to 2001, the number of hospitals participating in the survey ranged from 364 to 398 (more than 90% of eligible, sampled hospitals each year), with the total number of unweighted ED visits ranging from 21,103 to 34,546. The annual number of TBI-related ED visits identified in the sample ranged from 254 to 469 for a total of 2,227 TBI-related ED visits sampled during 1995 to 2001.

Hospitalizations

The National Hospital Discharge Survey (NHDS) of the NCHS was used to estimate annual rates of TBI-related hospitalization. The NHDS provides data on discharges from nonfederal, short-stay hospitals (those with an average length of stay for all patients of less than 30 days) and from general (medical or surgical) hospitals or children's general hospitals in the United States. The NHDS uses a modified, three-stage probability design to select records, with the stages being PSUs, hospitals within the PSUs, and discharges within the hospitals. The modification of the design involved selection with certainty of the largest PSUs and hospitals. Demographic and medical data were collected for the selected discharges, and weights were assigned based on the inverse probability of selection with adjustments for nonresponse. The individual record weights were summed to produce estimates of TBI-related hospitalizations each year for the total U.S. population. Additional information about the NHDS data is available.⁶

TBI-related cases were selected if one of the seven diagnosis fields contained an ICD-9-CM diagnosis code for TBI⁵ (see Table 16). E codes were also contained within the seven diagnosis fields, and the external cause of injury was classified using the first E code that appeared in the list of codes. Hospitalized patients who died during hospitalization were excluded from the analysis.

During 1995 to 2001, the number of hospitals providing data for the survey ranged from 434 to 480 (90.2% to 96.6% of eligible, sampled hospitals), with the total number of discharges ranging from 263,000 to 330,000. The annual number of TBI-related hospitalizations identified in the sample ranged from 1,933 to 2,261 for a total of 14,661 TBI-related discharges sampled during 1995 to 2001.

Deaths

Multiple cause-of-death data from NCHS were used to describe TBI-related deaths. In the United States, state laws require completion of death certificates for all deaths; federal law mandates national collection and publication of deaths and other vital statistics data. The National Vital Statistics System, the federal compilation of these data, is the result of cooperation between NCHS and the states to provide access to statistical information from death certificates. Additional information about these data is available.⁷

TBI-related cases were selected if an ICD-9 diagnosis code⁸ (for 1995–1998; see Table 16) or ICD-10 diagnosis code⁹ (for 1999–2001; see Table 17) for TBI appeared in Part I of the death certificate. The E code was obtained from the underlying cause of death field.

Identification of Traumatic Brain Injury Cases

For all data sources, TBI cases were identified using CDC's case definition.^{10,11} All NHDS and NHAMCS records that contained in one or more of the diagnosis data fields the ICD-9-CM diagnosis codes in the appropriate range, as shown in Table 16, were identified as a TBI hospitalization or ED visit. All records that contained in Part I of the death certificate the ICD-9 diagnosis codes (for years 1995–1998) or ICD-10 diagnosis codes (for years 1999–2001) in the appropriate range, as shown in Tables 16 and 17, were identified as a TBI death. A record was counted only once regardless of the number of diagnosis codes (any listed) that met the criteria for TBI.

The ICD-9-CM codes for TBI included in the analysis differed slightly from those in the Barell Matrix,¹² a recommended categorization of ICD-9-CM codes for nonfatal injuries. The inclusion of 959.01 (head injury, unspecified) is supported by data from South Carolina in 1998 in which 63% of ED visits and 9% of hospitalizations were identified using only this code.¹³ The increased use of 959.01 was accompanied by a corresponding drop in the use of 854. Thus, to avoid underestimating TBIs, we included cases coded as 959.01. This is consistent with a previous CDC publication on TBI¹⁴ and the current CDC TBI case definition,¹⁰ and it is in a footnote to the Barell Matrix.

ICD-10 nature-of-injury codes used to identify cases of TBI death were agreed upon by experts, including researchers from NCHS, and were proposed as the provisional case definition by the National Center for Injury Prevention and Control in 2000. Concurrently, NCHS was conducting a study in which all causes of deaths for 1996 were coded using both ICD-9 and ICD-10. An analysis of the dual-coded data indicates that the agreement between the ICD-9 and ICD-10 set of codes used in this report to identify TBI is nearly 96.5% with a comparability ratio of 0.9985.

Table 16. ICD-9 and ICD-9-CM Codes for Traumatic Brain Injury-Related Emergency Department Visits (1995–2001), Hospitalizations (1995–2001), and Deaths (1995–1998)

<u>Description</u>	<u>ICD-9-CM (Hospitalizations and ED Visits)</u>	<u>ICD-9 (Deaths)</u>
Fracture of the vault or base of the skull	800.0–801.9	800.0–801.3
Other and unqualified multiple fractures of the skull	803.0–804.9	803.0–804.3
Intracranial injury, including concussion, contusion, laceration, and hemorrhage	850.0–854.1	850–854.1
Other open wound to the head	—	873.0–873.9
Late effect of fracture of skull and face bones	—	905.0
Late effect of intracranial injury without mention of skull fracture	—	907.0
Head injury, unspecified	959.01	—

Table 17. ICD-10 Codes for Traumatic Brain Injury-Related Deaths (1999–2001)

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

External Cause of Injury

External cause of injury categorization was based on E codes and classified using categories adapted from CDC's recommended frameworks for presenting injury data.^{15,16} The categories used are presented in Table 18.

Several changes occurred in the classification of external cause of injury between ICD-9 and ICD-10, including the prefixes used to distinguish external cause (from E codes for ICD-9 to codes beginning with V, W, X, Y, and *U [terrorism] for ICD-10) and the organization of transport incident codes (based on type of vehicle in ICD-9 and characteristics of the injured person in ICD-10). Based on the analysis of ICD-9 and ICD-10 dual-coded mortality data for 1996, overall, the comparability of external causes was high (1.0159 for all injury causes combined). However, for some specific external causes

of death, such as motor vehicle–traffic occupant deaths, the comparability was low.¹⁷ The comparability ratios for the external cause categories presented in this report are shown in Table 18. Because the mortality data for this report were averaged over 4 years of ICD-9 and 3 years of ICD-10, the impact of the specific comparability ratios would not be as great as if trends over the 7 years were examined. Because the morbidity data for all years presented were from ICD-9-CM (ICD-10-CM has not yet been implemented), comparability ratios were not necessary.

For this report, the external cause of injury categories were motor vehicle-traffic, unintentional falls, assaults, and struck by/against. Struck by/against events are those in which a person was struck unintentionally by another person or an object, such as falling debris or a ball in sports, or that someone struck against an object, such as a wall or another person. For this report, only unintentional and undetermined struck by/against events were included. Struck by/against events related to assaults (for example, being struck by a fist) are in the assault category. Struck by/against were only reported cumulatively for all ages because small sample sizes precluded reporting them for all three data sources.

Table 18. External Cause of Injury Categorization for ICD-9-CM Codes (Emergency Department Visits and Hospitalizations, 1995–2001), ICD-9 Codes (Deaths, 1995–1998), and ICD-10 Codes (Deaths, 1999–2001)

<u>Description</u>	<u>ICD-9 and ICD-9-CM</u>	<u>ICD-10</u>	<u>Comparability Ratio</u>
Motor vehicle traffic–related (unintentional)	E810–E819	V02–V04 (.1, .9); V09.2; V12–V14 (.3–.9); V19 (.4–.6); V20–V28 (.3–.9); V29 (.4–.9); V30–79 (.4–.9); V80 (.3–.5); V81.1; V82.1; V83–V86 (.0–.3); V87 (.0–.8); V89.2	0.9545
Occupant	E810–E819 (.0, .1)	V30–79 (.4–.9); V81.1; V82.1 V83–V86 (.0–.3)	0.6191
Motorcycle	E810–E819 (.2, .3)	V20–V28 (.3–.9); V29 (.4–.9)	1.1520
Pedal cycle	E810–E819 (.6)	V12–V14 (.3–.9); V19 (.4–.6)	0.8038
Pedestrian	E810–E819 (.7)	V02–V04 (.1, .9); V09.2	0.9535
Other and unspecified	E810–E819 (.4, .5, .8, .9)	V80 (.3–.5); V87 (.0–.8); V89.2	—
Falls (unintentional and undetermined)	E880–E886; E888; E987	W00–W19; Y30	0.9991 (unintentional) 0.9857 (undetermined)
Assault (includes firearm and other)	E960–E969	X85–Y09; Y87.1	1.0020
Struck by/against (unintentional and undetermined)*	E916–E917	W20–W22; W50–W52; Y29	1.0549 (unintentional)
Other and unspecified	All other E codes	All other cause codes	—

* Undetermined applies to ICD-10 only

Population Data

This report uses the U.S. Census bridged-race population estimates from 1995 to 2001 obtained from NCHS.¹⁸ The average annual population (derived by dividing the total population by seven) is presented in Table 19. The 2000 standard population from the U.S. Bureau of the Census was used to calculate the age-adjusted TBI-related rates using the direct method.¹⁹ The weight applied to the average annual population to derive the 2000 standard population is also presented in Table 19.

Table 19. Average Annual 1995–2001 Population, by Age Group, Sex, and Race; Weights for 2000 Standard Population, by Age Group

Age (Yrs)	Sex		Race			Total	Weights (Based on the 2000 standard population)
	Males	Females	White	Black	American Indian/ Alaska Native Asian/Pacific Islander		
0–4	9,874,215	9,423,966	15,095,515	3,138,680	1,063,986	19,298,181	0.0691356496
5–9	10,345,466	9,858,413	15,740,503	3,395,611	1,067,764	20,203,879	0.0725328983
10–14	10,227,161	9,732,826	15,714,077	3,169,042	1,076,869	19,959,987	0.0730317441
15–19	10,068,679	9,518,090	15,479,078	3,034,174	1,073,517	19,586,769	0.0721687774
20–24	9,439,593	9,063,391	14,650,290	2,725,401	1,127,293	18,502,984	0.0664775665
25–34	20,551,748	20,283,668	32,857,490	5,510,677	2,467,249	40,835,415	0.1355731628
35–44	22,045,302	22,326,739	36,535,544	5,564,296	2,272,202	44,372,041	0.1626127865
45–54	17,314,451	17,996,078	29,797,134	3,865,008	1,648,387	35,310,529	0.1348339972
55–64	11,035,654	12,019,904	19,806,343	2,319,673	929,542	23,055,558	0.0872470269
65–74	8,340,453	10,241,986	16,362,312	1,634,137	585,989	18,582,439	0.0660369801
≥ 75	5,837,042	10,162,797	14,460,335	1,195,914	343,590	15,999,838	0.0603494104
Total	135,079,762	140,627,859	226,498,622	35,552,613	13,656,387	275,707,622	—

Statistical Analysis

For death data, SAS software²⁰ was used to calculate average annual numbers, rates, row percentages, and age-adjusted rates. For hospitalization and ED data, SAS software was used to calculate total numbers. Microsoft Excel software was then used to calculate average annual numbers, rates, row percentages, and age-adjusted rates.

Average annual numbers were calculated by adding the numbers for all 7 years and dividing the totals by 7. For hospitalization and ED visits, these numbers were rounded to the nearest thousand. Average annual rates were calculated by dividing the total number for all 7 years by the total population for all 7 years. Row percentages were also calculated by dividing each number by the total number for all 7 years. Because numbers, rates, and row percentages were all calculated before rounding and were calculated based on the totals for all 7 years and not the annual average, some results may not sum to the total presented in the data tables.

An age adjustment was made using the direct method to eliminate differences in observed rates that result from age differences in the population distribution. This adjustment is usually done to allow accurate comparison of two or more populations at one point in time or a single population at two or more points in time.

Age-adjusted rates were calculated by the direct method, as follows:

$$\sum_{i=1}^n r_i (W_i)$$

where r_i = age-specific rates for the population of interest,

W_i = age-specific weight based on the 2000 U.S. standard population, and

n = total number of age groups over the age range of the age-adjusted rate.

Age adjustment by the direct method requires use of a standard age distribution; in this case, the year 2000 standard population was selected.

Based on the complex sample design of the NHDS and the NHAMCS, estimates of the number and rate of TBIs requiring hospitalization or treatment at EDs were reported based on the NCHS guidelines below:²¹

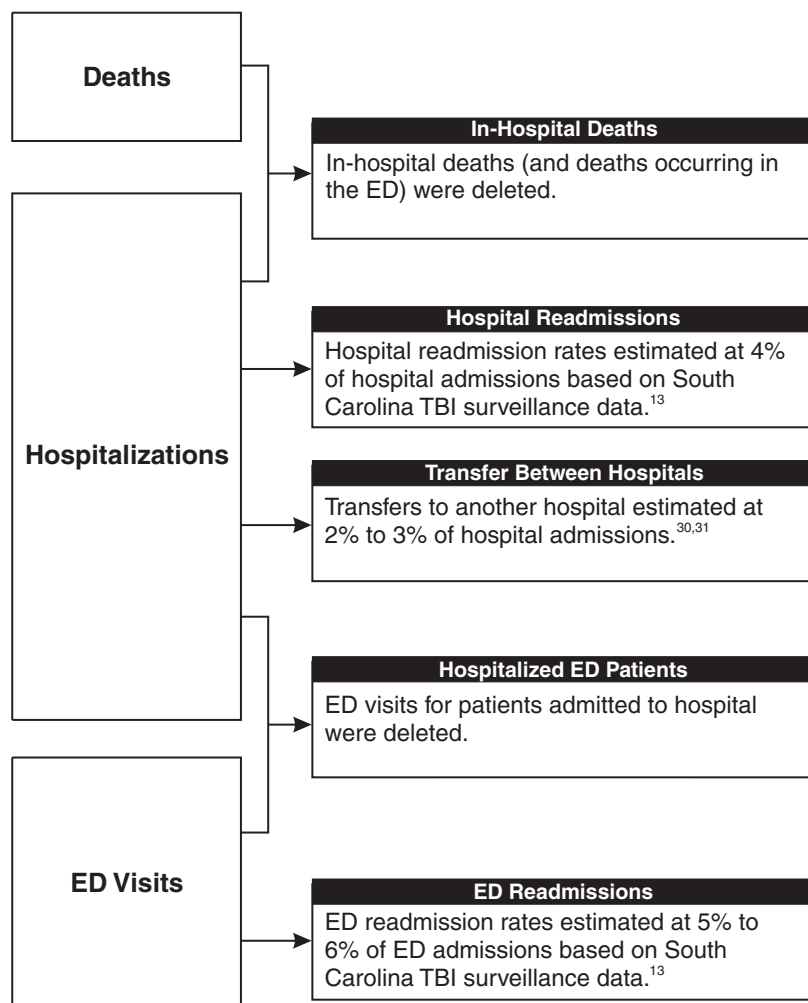
- If the sample size was less than 30, the value of the estimates was not reported because it is not considered stable.
- If the sample size was 30 to 59, the value of the estimate was reported, but it may not be stable.

For the death data, if the sample size was less than 20 for the 7 years combined, the rates were suppressed because the data are not considered stable.¹⁷

Limitations

- Three different data sources were used. Results should be interpreted with caution because differences in study methods may have influenced the findings. The NHDS and NHAMCS were based on a sample of inpatients discharged from nonfederal short-stay hospitals (NHDS) and ED visits (NHAMCS), while multiple cause-of-death data included all deaths.
- The potential for sampling bias exists with any survey. NHDS and NHAMCS measures to decrease this possibility included stratified sampling of hospitals, random selection of discharges within hospitals and visits within EDs, and even distribution of sampling throughout the year.
- The overall burden of TBI in the United States has been underestimated because data for an estimated 439,000 TBIs treated by physicians during office visits and 89,000 treated in outpatient settings were not included in this report.²² In addition, TBI for which no medical advice was sought, an estimated 25% of all mild and moderate TBIs, were not included.²³ Also, both NHDS and NHAMCS do not include data from federal, military, or Veterans Administration hospitals.
- The lack of external cause of injury coding (E coding) was a problem, particularly for the NHDS data, in which more than one third of cases were missing an E code. Increased E code reporting would increase the rates by external cause. We also only reported data by cause for the leading causes of TBI for the three data sets combined. The actual leading causes varied among ED visits, hospitalizations, and deaths. Causes beyond those we reported were combined as Other/Unknown due to limitations in sample size for more detailed reporting and to be consistent among all three data sources. As a result, some causes were not included, such as firearm injuries, which are the leading cause of TBI death.^{24,25} E codes also may not capture all of the injuries attributable to a particular cause or intent, particularly controversial ones such as assault. Among children, 25% of all injuries resulting from assaults may not be accounted for by E codes.²⁶ Assaults might also not be properly recognized, especially in vulnerable populations, such as children²⁷ and older adults.²⁸
- Injury severity was not addressed because we could not uniformly apply a measure of severity to all three data sets. ICDMAP-90,²⁹ a computer algorithm that converts ICD-9-CM diagnosis codes to a 6-level score approximating the Abbreviated Injury Scale (AIS), was only applicable to NHDS and NHAMCS data.

Figure 8. Sources of Potential Duplication When Combining Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths



- The NHDS and NHAMCS data are based on hospitalizations and visits to EDs—not on individual persons. It is not possible to unduplicate cases in which individuals were hospitalized or treated in EDs more than once for the same injury. Although this limitation precludes calculating the true incidence of TBI, the effects on the data are assumed to be quite small. Specifically, data from a population-based follow-up study in South Carolina indicate a readmission rate to the hospital of approximately 4% and a readmission rate to the ED of 5% to 6%.¹³ Patients may also have been transferred between hospitals and, therefore, double counted. The percentage of those reportedly double counted as a result of transfer following head injury has been reported to be 2% to 3%.^{30,31} Patients who have been hospitalized and later died from their injuries could be another source of overcounting. However, deaths that occurred among patients hospitalized or treated at EDs were excluded based on information available in the hospital discharge and ED data sets. Patients who were seen in the ED and later hospitalized could also be double counted; however, documented hospitalizations were excluded from those counted as seen in the ED. Emergency department patients reported to have been transferred were also excluded to help limit double counting. Because none of these data sets are mutually exclusive, the combined number or rate of TBI might be overestimated since some cases would still be double counted (see Figure 8).

- Trend analysis was not examined. Instead, we combined data from the 7-year period to provide more stable estimates. Previous reports document that the number of TBI-related deaths^{24,25} and hospitalizations³² appear to have been declining over time.
- Analyses were not conducted separately by state because the sampling schemes used by both NHDS and NHAMCS were designed to produce national estimates, not state-based estimates. For more information on nonfatal TBI rates by state, other resources are available, such as a CDC publication estimating nonfatal TBI-related hospitalizations by state,³³ nonfatal TBI-related hospitalizations derived from CDC-funded TBI surveillance data in 14 states,¹⁴ and a CDC website with state-by-state information about available TBI data.³⁴

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