SURVEILLANCE REPORT

Traumatic Brain Injury-related Hospitalizations and Deaths by Age Group, Sex, and Mechanism of Injury

UNITED STATES 2016 / 2017

ACKNOWLEDGEMENTS

This traumatic brain injury surveillance report was prepared by staff from the Division of Injury Prevention (DIP), National Center for Injury Prevention and Control (NCIPC), Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services, Atlanta, Georgia.

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This report describes the incidence of traumatic brain injury (TBI) collected from multiple data sources. Data on TBI-related hospitalizations were obtained from the 2016 and 2017 Healthcare Cost and Utilization Project's National Inpatient Sample, sponsored by the Agency for Healthcare Research and Quality. Data on TBI deaths were obtained from the National Vital Statistics System's 2016 and 2017 multiple-cause-of-death files.

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DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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EXECUTIVE SUMMARY

Traumatic brain injury (TBI) is a head injury caused by an external force to the head or body resulting in disruption of normal brain function.[1] TBI is preventable. However, it results in death and disability for thousands of people each year and remains a serious public health concern. In the United States TBIs were diagnosed in nearly 2.9 million emergency department visits, hospitalizations, and deaths that occurred during 2014.[2]

This surveillance report describes 2016 and 2017 national incidence estimates of TBI-related hospitalizations and deaths by age group, principal mechanism of injury, injury intent, and sex.* Estimates of TBI-related hospitalizations were calculated from the Healthcare Cost and Utilization Project's (HCUP) National Inpatient Sample (NIS).^ HCUP serves as a resource of encounter-level health care data derived from a suite of state-based administrative health care record databases.[3] TBI deaths were assessed from the National Vital Statistics System (NVSS),^ which captures data for all deaths registered in all 50 U.S. states and the District of Columbia.[4] This TBI surveillance report is an update to the Centers for Disease Control and Prevention's (CDC's) last TBI surveillance report published in 2019 that described estimates of TBI-related hospitalizations and deaths for the 2014 data year.[2]

Key Findings

TBI-RELATED HOSPITALIZATIONS

- **Approximately 227,000 TBI-related hospitalizations occurred in 2016 but counts decreased to almost 224,000 in 2017.**
- **Children ages 0-17 years accounted for approximately 8.6% of all TBI-related hospitalizations in 2016 and 7.8% in 2017.**
- **Unintentional falls and motor vehicle crashes were the most common mechanisms of injury contributing to a TBI-related hospitalization.**
  - Unintentional falls accounted for 47.7% (2016) and 49.1% (2017; weighted estimate) of all TBI-related hospitalizations.
  - Motor vehicle crashes accounted for 25.0% (2016) and 24.5%, (2017) of all TBI-related hospitalizations.
- **Rates of TBI-related hospitalizations per 100,000 population were highest among the following groups:**
  - adults aged ≥75 years (313.4 in 2016 and 320.8 in 2017);
  - those aged 65-74 years (104.8 in 2016 and 102.7 in 2017); and
  - individuals aged 55-64 years (67.7 in 2016 and 67.5).
- **In 2016 males had significantly higher age-adjusted rates compared with females among the major unintentional and intentional principal mechanisms of injury that contributed to a TBI-related hospitalization. Specifically, males had higher age-adjusted rates of:**
  - unintentional falls (36.2 versus 24.0);
  - motor vehicle crashes (23.3 versus 11.4; twofold higher);
  - unintentionally being struck by or against an object (2.5 versus 1.2; twofold higher),
  - intentional self-harm (0.7 versus 0.3; twofold higher), and
  - assault (8.1 versus 1.7; more than fourfold higher).

*Note: Identification and classification of TBI morbidity and mortality are described in the "Methodological Appendix."

^Note: Data sources analyzed for TBI morbidity and mortality and data exclusions are described in the "Methods" section.

- **In 2017 males had significantly higher age-adjusted rates compared with females among the major unintentional and intentional principal mechanisms of injury that contributed to a TBI-related hospitalization. Specifically, males had higher age-adjusted rates of:**
  - unintentional falls (35.6 versus 23.9);
  - motor vehicle crashes (22.5 versus 10.8; twofold higher);
  - unintentionally being struck by or against an object (2.3 versus 0.9; more than twofold higher);
  - intentional self-harm (0.8 versus 0.3; more than twofold higher); and
  - assault (7.5 versus 1.7; more than fourfold).
- **The most common principal mechanisms of injury for TBI-related hospitalizations among children aged 0-17 years were falls (rate of 8.3 in 2016 and 7.7 in 2017) and motor vehicle crashes (7.4 in 2016 and 6.8 in 2017).**

TBI-RELATED DEATHS

- **Approximately 60,000 TBI-related deaths occurred in 2016, and deaths increased to over 61,000 in 2017.**
- **Children ages 0-17 years accounted for approximately 4.5% of all TBI-related deaths in both years.**
- **Suicide and unintentional falls were the most common mechanisms of injury contributing to a TBI-related death. Suicide accounted for 33.8% of all TBI-related deaths in 2016 and 34.7% in 2017. Unintentional falls accounted for approximately 28% of all TBI-related deaths in both years.**
- **Rates of TBI-related deaths per 100,000 population were highest among adults aged ≥75 years (75.5 in 2016 and 77.0 in 2017), those aged 65-74 years (24.2 in 2016 and 24.3 in 2017), and individuals aged 55-64 years (19.1 in 2016 and 19.5 in 2017).**
- **In 2016, males had significantly higher age-adjusted rates compared with females among the major unintentional and intentional principal mechanisms of injury that contributed to a TBI-related death. Specifically, males had higher age-adjusted rates of:**
  - unintentional falls (6.1 versus 3.2);
  - motor vehicle crashes (5.2 versus 1.9; more than twofold higher);
  - suicide (12.3 versus 1.9; more than sixfold higher); and
  - homicide (2.7 versus 1.0; more than twofold higher).
- **In 2017, males had significantly higher age-adjusted rates compared with females among the major unintentional and intentional principal mechanisms of injury that contributed to a TBI-related death. Specifically, males had higher age-adjusted rates of:**
  - unintentional falls (6.3 versus 3.2);
  - motor vehicle crashes (4.9 versus 1.8; more than twofold higher);
  - suicide (13.0 versus 1.9; more than sixfold higher); and
  - homicide (2.7 versus 1.0; more than twofold higher).

Limitations

- The analysis presented in this surveillance report did not differentiate by injury severity, although some codes included in the CDC's TBI surveillance definition are indicative of a more severe injury.
- Findings presented do not include patients who sought care in the emergency department or outside of the hospital setting (e.g., primary care, urgent care, specialty care) or individuals who did not seek care for their TBI.
- This report does not include TBIs from Veterans Administration (VA), military, or federal hospitals.
- The mechanism and intent of injury are unknown for a portion of hospitalizations (7.8% in 2016, 8.3% in 2017). As a result, estimates of TBI-related hospitalizations by mechanism of injury and injury intent are undercounts.
- This analysis disaggregated TBI estimates into broad categories of mechanism of injury, which limits the specificity of conclusions that can be drawn regarding primary causes of TBI-related hospitalizations and deaths.

Conclusions

- The oldest age group (≥75 years) had the highest numbers and rates of TBI-related hospitalizations and deaths during both 2016 and 2017.
- Unintentional falls were the leading cause of injury for TBI-related hospitalizations during 2016 and 2017. Annually, half of TBI-related hospitalizations attributed to falls were among the oldest age group (≥75 years), which suggests a need to intensify prevention efforts related to falls, particularly among older adults.
- Suicide was the leading cause of TBI-related deaths during 2016 and 2017, accounting for 33.8% and 34.7%, respectively, of all TBI-related deaths. This mirrors the increase in suicide rates overall in the United States,[5] suggesting the need for promotion of programs and practices[#] with the best available evidence for preventing suicide.

[#]https://www.cdc.gov/violenceprevention/pdf/suicideTechnicalPackage.pdf

NOTABLE REPORT CHANGES FROM 2014 DATA YEAR TO 2016 AND 2017 DATA YEARS

TRANSITION FROM INTERNATIONAL CLASSIFICATION OF DISEASES, NINTH EDITION, CLINICAL MODIFICATION TO TENTH EDITION, CLINICAL MODIFICATION (ICD–9–CM TO ICD–10–CM)

Beginning October 1, 2015, the Department of Health and Human Services required all hospitals and health care providers covered by the Health Insurance Portability and Accountability Act (HIPAA) to use ICD–10–CM when reporting medical diagnoses.[6] Although the coding structure of ICD–10–CM is based on ICD–10 (published by the World Health Organization), the classification scheme was expanded to capture greater detail on diagnoses and conditions needed in morbidity data. Notably, injury codes in ICD–10–CM constitute about 60% of all codes, compared with about 15% in ICD–9–CM.[7] Overall, ICD–10–CM contains almost five times the number of codes found in ICD–9–CM[8] and will potentially provide more detailed information on clinical care for billing and public health surveillance. Due to the 2015 data year containing both ICD–9–CM and ICD–10–CM, the 2015 data year is not presented in this updated report.

Early research focused on the effects of the transition from ICD–9–CM to ICD–10–CM reported a notable increase in time for medical coding and decreased medical coder productivity, especially for inpatient coding.[9] These changes are of great concern, especially for external cause of injury (ECOI) coding. These codes are generally not required for health care provider billing and reimbursement, and increased ICD–10–CM time demands could discourage coders from entering ECOI codes for injury-related clinical care. As medical coders become accustomed to ICD–10–CM coding, ECOI completeness for inpatient coding is expected to increase. In Kentucky hospital discharge data, the drop in ECOI completeness lasted only during the first month after ICD–10–CM implementation.[10]

CDC'S NEW TBI MORBIDITY SURVEILLANCE DEFINITION

A new surveillance definition for TBI morbidity was necessary due to the transition from ICD–9–CM to ICD–10–CM. In 2016, CDC proposed an ICD–10–CM TBI morbidity surveillance definition that included specific S and T diagnosis codes based on the General Equivalence Mappings (GEMs) of the diagnosis codes used in the ICD–9–CM TBI morbidity surveillance definition.[8] The proposed code set for the TBI morbidity surveillance definition was incorporated into CDC's proposed ICD–10–CM injury diagnosis matrix†.[8] State health department representatives in four states assessed the positive predictive value (PPV) for ICD–10–CM codes 1) intracranial injury (S06) or 2) skull fracture only (S02.0, S02.1-, S02.8-, S02.91) without other proposed TBI codes in randomly sampled emergency department (ED) and shock trauma records.[11] Findings of this multisite study revealed the PPV for the intracranial injury codes ranged from 70% to 88% for "high" certainty of TBI. This finding meant the records included documentation of 1) head imaging positive for TBI; 2) loss of consciousness, or confusion or memory problems after an injury event; or 3) three or more signs or symptoms indicative of TBI. Furthermore, the PPV for skull fracture codes ranged from 54% to nearly 78% for "high" certainty of TBI among study sites in four states. This early study showed that among different settings in these four states, ICD–10–CM codes for intracranial injury and skull fracture displayed a high PPV for capturing "high" certainty TBIs in ED billing datasets.

†Proposed ICD–10–CM codes included in the TBI morbidity surveillance definition described in "Methods" section.

Notably, the CDC's proposed ICD–10–CM TBI morbidity surveillance definition excluded the diagnosis code S09.90 (unspecified injury of head),[8] although the previous ICD–9–CM TBI morbidity surveillance definition included its complementary ICD–9–CM diagnosis code (959.01).[12] During the ICD–9–CM coding era, multiple studies reported that the S09.90 codes represented a significant proportion of TBI morbidity records identified in their samples.[13-15] However, only 25% of cases assigned the diagnosis code ICD–9–CM 959.01 (unspecified injury to the head) met the clinical definition of TBI in a prospective cohort study.[14] Given the concerns over the validity of the ICD–9–CM 959.01 (unspecified injury to the head) code, four states and CDC reviewed sampled ED medical records containing it's complementary ICD–10–CM code (S09.90), without other proposed TBI codes, for evidence of TBI based on medical documentation.[16] Findings of this multisite study displayed varying PPV ranging from 36% to 52%, varying by state, for medium or high evidence of TBI, while 48% to 64% of records, varying by state, contained low or no evidence of a TBI.[16] Overall, this initial study indicated that exclusion of the S09.90 code in surveillance estimates may result in many missed TBI cases, while inclusion may result in many false positives. Although the multisite study focused on ED medical records solely assigned S09.90 (unspecified injury of head), findings of this study informed the decision to exclude the S09.90 diagnosis code from the surveillance case definition for TBI-related hospitalizations estimated in this report. Overall, this decision was based on the same concerns over the validity of the S09.90 code for identifying TBI cases in hospitalization data.

Preliminary data analysis of the 2016 HCUP Nationwide Emergency Department Sample (NEDS) data revealed that, when ICD–10–CM code S09.90 was included in the analysis, age-adjusted rates of TBI-related ED visits were 792 per 100,000 population.[§] Subsequently, when ICD–10–CM code S09.90 was removed from the analysis (leaving only the ICD–10–CM codes included in the proposed surveillance definition), age-adjusted rates of TBI-related ED visits decreased to 264 per 100,000 population. Due to the large proportion of ED medical encounters coded as S09.90 and concerns over the possibility of including many false positives, ED visits for the 2016 and 2017 data years are not presented. Additionally, due to differences in surveillance definitions for TBI morbidity, numbers and rates of TBI-related hospitalizations in this report should not be compared to previous reports.

CHANGES IN THE IDENTIFICATION AND CLASSIFICATION OF TBI-RELATED HOSPITALIZATIONS AND DEATHS^^

For the 2016 and 2017 data, TBIs diagnosed in the hospital were included if the health record listed an ICD–10–CM injury diagnosis code in the primary diagnosis field and an ICD–10–CM TBI code in any diagnosis field. This represents a change in the inclusion criteria used to estimate 2014 TBI-related hospitalizations, as the inclusion criteria for those estimates did not require a primary diagnosis of injury. However, requiring these codes is in line with CDC's and the Council of State and Territorial Epidemiologists' recommendations of restricting analysis of hospitalizations to those with injuries severe enough to be the primary reason for hospitalization.[17]

In previous versions of this report, falls of undetermined intent requiring hospitalization were included in the unintentional falls category.[2,12] However, in this report, falls of undetermined intent were not included with unintentional falls. ICD–10–CM coding guidance instructs that undetermined intent is to be used only in cases where the documentation specifies that the intent cannot be determined.

Deaths were included as TBI-related if any multiple-cause-of-death codes listed in the death record indicated a TBI-related diagnosis and the single underlying cause of death was listed as an injury. This methodology represents a change in the calculation of TBI-related deaths from previous CDC reports, which did not require that an injury be listed as the underlying cause of death.

[§]Preliminary data analysis utilized HCUPnet (https://hcupnet.ahrq.gov/#setup), a free online query system based on data from HCUP.

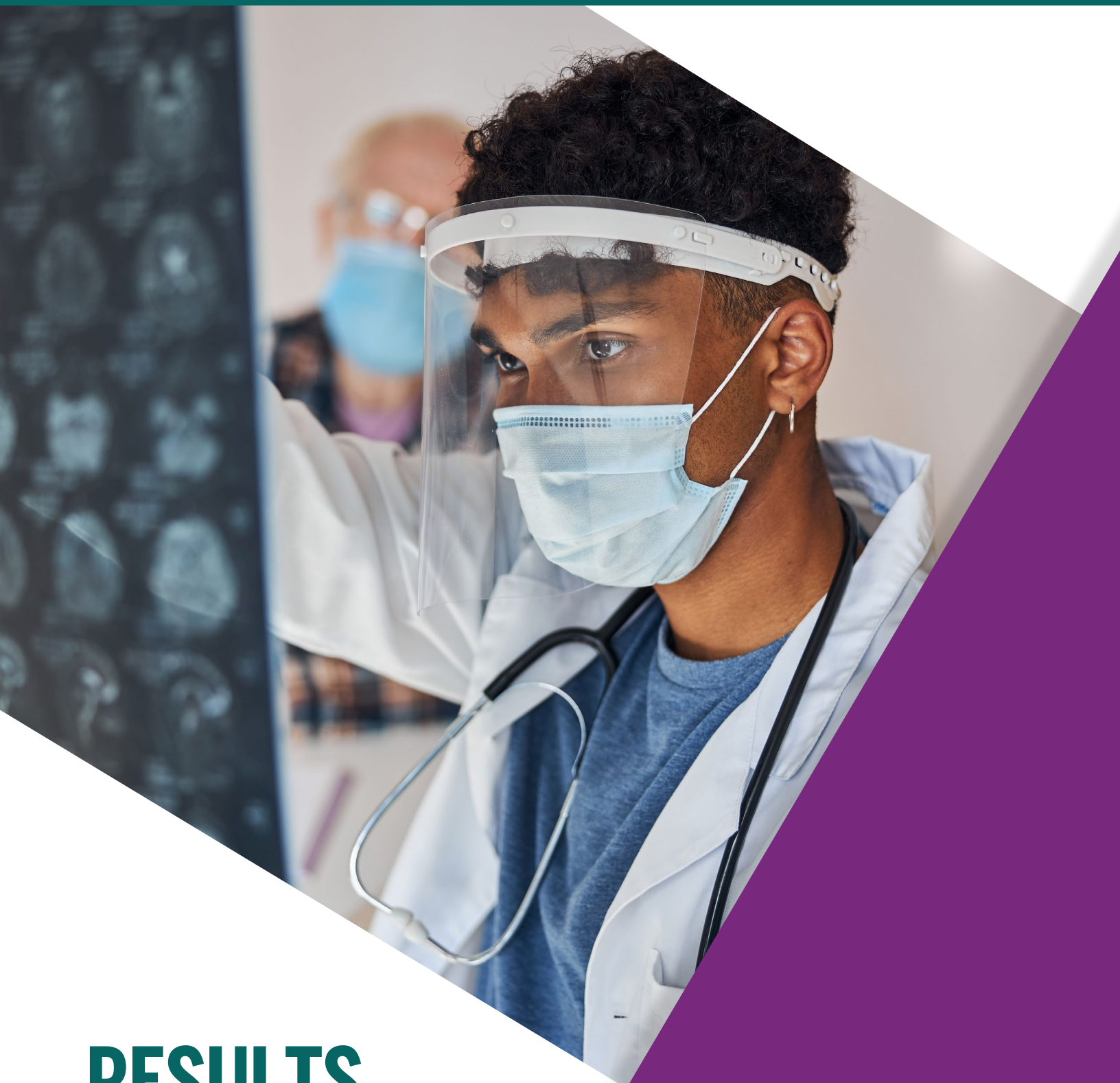
^^Note: Identification and classification of TBI morbidity and mortality are described in the "Methods" section.

METHODS

TBI-related nonfatal hospitalization (i.e., inpatient stays) estimates were obtained from the 2016 and 2017 HCUP's NIS files. The NIS produces a stratified sample of approximately 20% of U.S. hospital discharges and is sponsored by the Agency for Healthcare Research and Quality. The NIS contains data on approximately 7 million unweighted records.[3] Records were included if the primary diagnosis was an injury (codes included in the appendix) and if a proposed TBI-related ICD–10–CM code[6] was present in any diagnosis field. The following TBI-related ICD–10–CM codes correspond to the preliminary TBI case definition developed by NCIPC and National Center for Health Statistics (NCHS)[8]: S02.0. S02.1, S02.8, S02.91, S04.02, S04.03, S04.04, S06, S07.1, T74.4. For this analysis, the injury mechanism/intent categories of interest were motor vehicle traffic crashes, unintentional falls, unintentional struck by or against an object, other or unspecified unintentional injury, suicide/intentional self-harm injury, homicide/assault, and other/unknown (codes included in the appendix). The Center for Medicare and Medicaid Services (CMS) coding guideline specifies that all transport accident categories assume accidental intent.[18] The injury mechanism/intent categories were based on the first valid external cause of injury because a record could potentially have multiple external cause of injury codes (methods and codes included in the methodological appendix).

TBI-related deaths were obtained from the 2016 and 2017 NVSS multiple-cause-of-death files. NVSS is a partnership between the NCHS and state/local jurisdictions that results in the compilation of records of all deaths in the United States.[4] Deaths were included if they had an injury underlying cause of death (see codes in the methodological appendix) and a TBI-related ICD–10 code[8] in one of the multiple-cause-of-death fields. The following TBI-related ICD–10 codes correspond to the established TBI death surveillance definition:[2] S01, S02.0, S02.1, S02.3, S02.7-S02.9, S04.0, S06, S07.0, S07.1, S07.8, S07.9, S09.7-S09.9, T90.1, T90.2, T90.4, T90.5, T90.8, T90.9. The injury mechanism/intent categories for deaths were the same as for hospitalizations and were based on the underlying cause of death field (codes included in the methodological appendix).

Rates were calculated using bridged race population estimates obtained from NCHS as the denominator.[19] While deaths are a complete census of all occurrences, confidence intervals were presented to account for random variation.[20] Hospitalizations were weighted to provide national estimates, and confidence intervals were calculated using complex survey procedures in SAS 9.4.[21] For estimates, NIS suppression rules included no cells with counts <11 and at least two hospitals must contribute to each cell. Numbers, estimates, rates, and confidence intervals were presented by age group, by age group and mechanism/intent, and by sex and mechanism/intent. Rates based on <20 counts were suppressed. Age-adjusted rates were standardized to the 2000 U.S. population.[22] All rates were compared between 2016 and 2017 by examining nonoverlapping confidence intervals. T-tests were used to analyze between-group differences for rates of TBI-related hospitalizations and deaths. Only selected comparisons were tested for statistical significance. A similar approach was used to compare male and female rates.



RESULTS

Traumatic Brain Injury-related Hospitalizations and Deaths by Age Group, Sex, and Mechanism of Injury

— United States, 2016 and 2017

LIST OF FIGURES[§] AND TABLES

TRAUMATIC BRAIN INJURY (TBI)-RELATED HOSPITALIZATIONS AND DEATHS

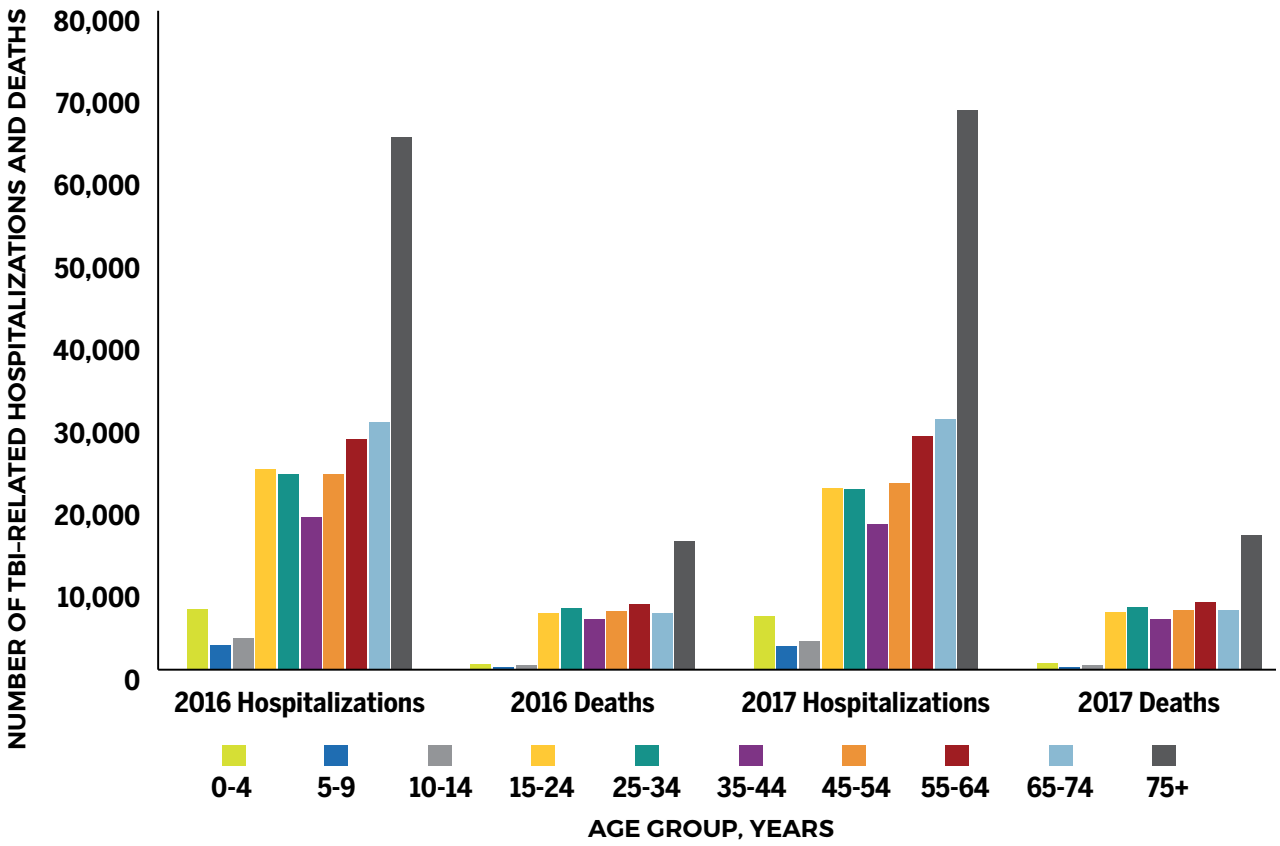
TBI-RELATED HOSPITALIZATIONS

TBI-RELATED DEATHS

[§]Note: All data presented in the figures are presented in tabular form in the Appendix.

FIGURE 1A[1]

Estimated number of traumatic brain injury-related (TBI) hospitalizations† and deaths by age group — United States, 2016 and 2017



Key Findings

- Approximately 227,000 TBI-related hospitalizations occurred in 2016, and the count decreased to almost 224,000 in 2017.
- Adults aged ≥75 years accounted for the highest proportion of all TBI-related hospitalizations in both 2016 and 2017 (28.5%, N= 64,610 and 30.3%, N= 67,875, respectively) among all the age groups analyzed.
- Individuals aged 65-74 years had the second highest number of TBI-related hospitalizations in 2016 (N= 29,990) and 2017 (N= 30,430).
- Approximately 59,000 TBI-related deaths occurred in 2016, while counts of this health event increased to over 61,000 in 2017.
- Adults aged ≥75 years accounted for the highest proportion of all TBI-related deaths in both 2016 and 2017 (26.1%, N= 15,561 and 26.6%, N= 16,284, respectively) among all the age groups analyzed.

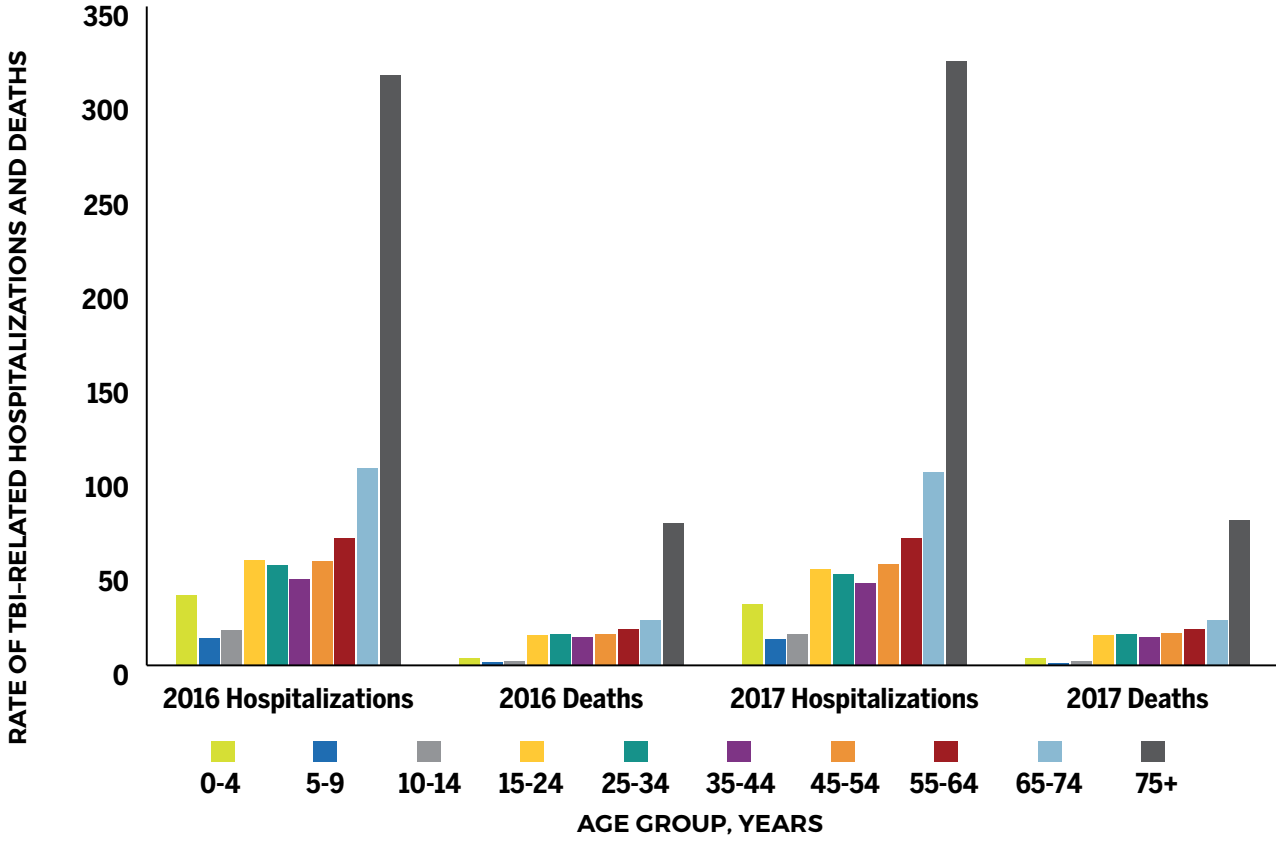
SOURCES: For hospitalizations, Healthcare Cost and Utilization Project's National Inpatient Sample; for deaths, CDC's National Vital Statistics System.

[1]Estimated counts of TBI-related hospitalizations presented in tabular form in Supplemental Table 1.

†In-hospital deaths and patients who transferred from another hospital were excluded.

FIGURE 1B[1]

Estimated rate* of traumatic brain injury-related (TBI) hospitalizations† and deaths by age group — United States, 2016 and 2017



Key Findings

- Rates of TBI-related hospitalizations per 100,000 population were highest among adults aged ≥75 years (313.4 in 2016 and 320.8 in 2017), those aged 65-74 years (104.8 in 2016 and 102.7 in 2017), and individuals aged 55-64 years (67.7 in 2016 and 67.5 2017).
- Similarly, rates of TBI-related deaths per 100,000 population were highest among adults aged ≥75 years (75.5 in 2016 and 77.0 in 2017), those aged 65-74 years (24.2 in 2016 and 24.3 in 2017), and individuals aged 55-64 years (19.1 in 2016 and 19.5 in 2017).

SOURCES: For hospitalizations, Healthcare Cost and Utilization Project's National Inpatient Sample; for deaths, CDC's National Vital Statistics System.

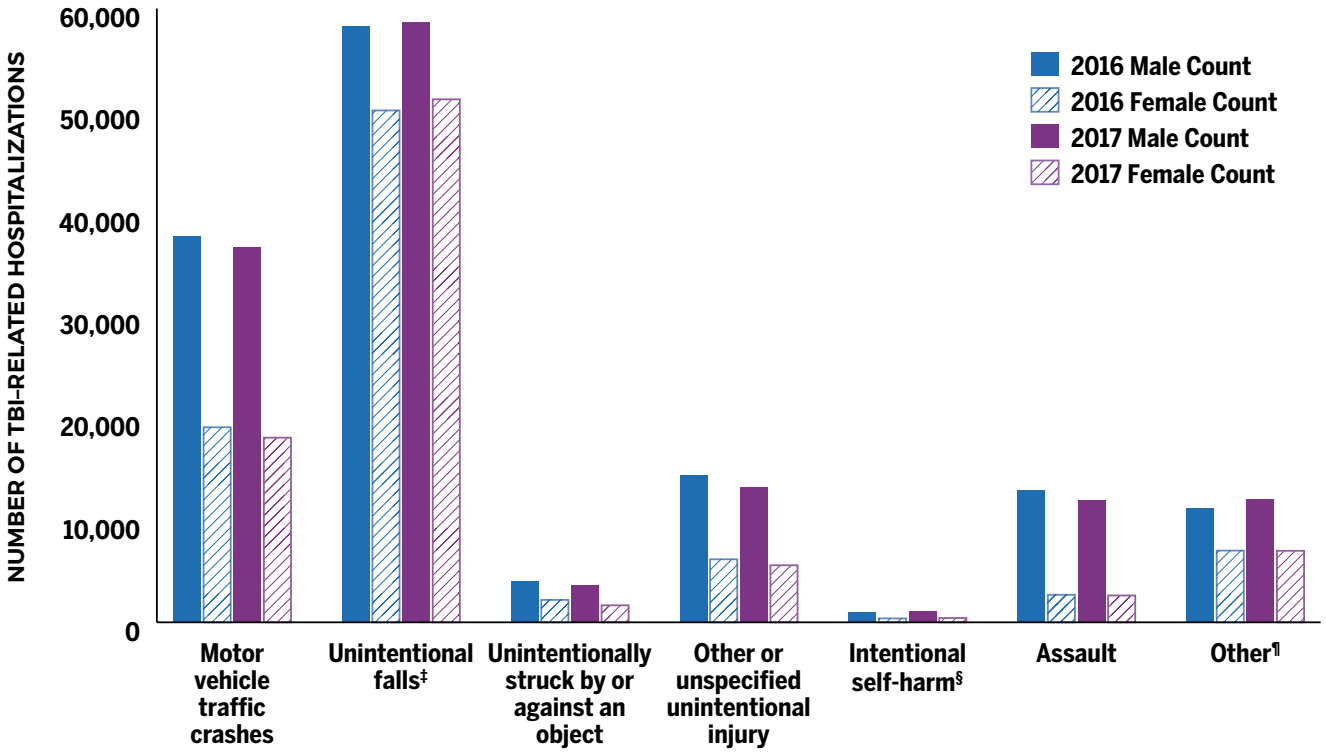
[1]Estimated rates of TBI-related hospitalizations are presented in tabular form in Supplemental Table 1.

*Per 100,000 population.

†In-hospital deaths and patients who transferred from another hospital were excluded.

FIGURE 2A[1]

Estimated number of traumatic brain injury-related (TBI) hospitalizations[†] by sex and mechanism of injury — United States, 2016 and 2017



Key Findings

In 2016, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related hospitalization, males had higher counts when compared with females. Males had higher counts of:

- unintentional falls (58,290 versus 50,035);
- motor vehicle crashes (37,705 versus 19,065);
- unintentionally being struck by or against an object (3,990 versus 2,190);
- intentional self-harm (955 versus 380); and
- assault (12,900 versus 2,700).

SOURCE: Healthcare Cost and Utilization Project's National Inpatient Sample

[1]Estimated counts of TBI-related hospitalizations are presented in tabular form in Supplemental Table 2.

[†]In-hospital deaths and patients who transferred from another hospital were excluded.

[‡]Falls of undetermined intent were not included.

[§]Age <10 years were excluded because determining intent in younger children can be difficult.

[¶]Includes undetermined intent, legal intervention, war, intentional self-harm for age <10 years, and cases without information about cause of injury.

FIGURE 2A[1] (cont'd)

Estimated number of traumatic brain injury-related (TBI) hospitalizations[†] by sex and mechanism of injury — United States, 2016 and 2017

Key Findings (cont'd)

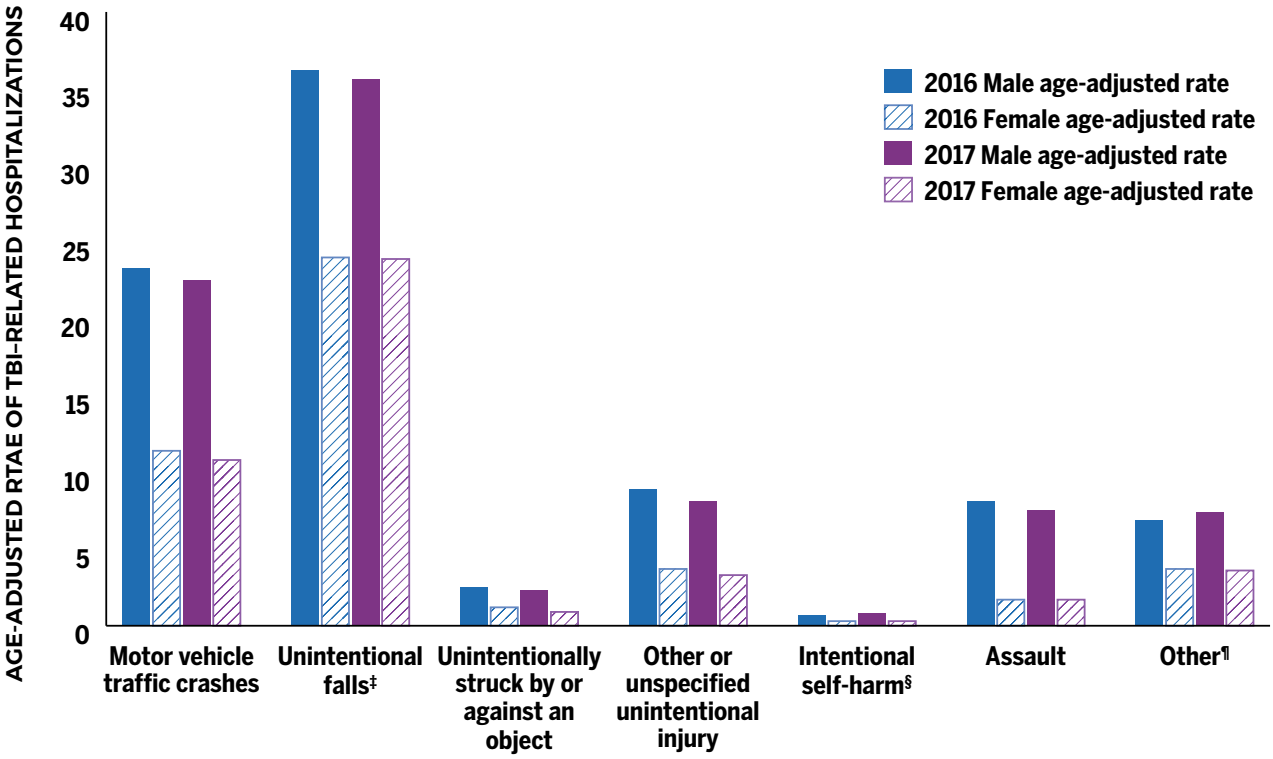
In 2017, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related hospitalization, males had higher counts when compared with females. Males had higher counts of:

- unintentional falls (58,640 versus 51,125);
- motor vehicle crashes (36,665 versus 18,050);
- unintentionally being struck by or against an object (3,675 versus 1,660);
- intentional self-harm (1,040 versus 420); and
- assault (11,965 versus 2,625).

In 2016 and 2017, unintentional falls were the leading mechanism of injury contributing to a TBI-related hospitalization among both men and women.

FIGURE 2B[1]

Estimated age-adjusted rate[††] of traumatic brain injury-related (TBI) hospitalizations[†] by sex and mechanism of injury — United States, 2016 and 2017



Key Findings

In 2016, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related hospitalization, males had significantly higher age-adjusted rates compared with females (t-tests p-value <0.05). Males had higher age-adjusted rates of:

- unintentional falls (36.2 versus 24.0, per 100,000 population);
- motor vehicle crashes (23.3 versus 11.4; twofold higher);
- unintentionally being struck by or against an object (2.5 versus 1.2; twofold higher),
- intentional self-harm (0.7 versus 0.3; twofold higher), and
- assault (8.1 versus 1.7; more than fourfold higher).

SOURCE: Healthcare Cost and Utilization Project's National Inpatient Sample

[1]Estimated rates of TBI-related hospitalizations are presented in tabular form in Supplemental Table 2.

[††]Hospitalizations with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

[‡]Falls of undetermined intent were not included.

[§]Age <10 years were excluded because determining intent in younger children can be difficult. Rates for TBI-related hospitalizations due to intentional self-harm were age-adjusted to the population 10 years and older.

[¶]Includes undetermined intent, legal intervention, war, intentional self-harm for age <10 years, and cases without information about cause of injury.

FIGURE 2B[1] (cont'd)

Estimated age-adjusted rate[††] of traumatic brain injury-related (TBI) hospitalizations[†] by sex and mechanism of injury — United States, 2016 and 2017

Key Findings (cont'd)

In 2017 among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related hospitalization, males had significantly (t-tests p-value <0.05) higher age-adjusted rates compared with females. Males had higher age-adjusted rates of:

- unintentional falls (35.6 versus 23.9, per 100,000 population);
- motor vehicle crashes (22.5 versus 10.8; more than twofold higher);
- unintentionally being struck by or against an object (2.3 versus 0.9; more than twofold higher);
- intentional self-harm (0.8 versus 0.3; twofold higher); and
- assault (7.5 versus 1.7; more than fourfold higher).

TABLE 1 – Estimated number and rate* of traumatic brain injury-related (TBI) hospitalizations† by age group and mechanism of injury — United States, 2016 and 2017

AGE GROUP (YRS)	YEAR	Motor vehicle traffic crashes		Unintentional falls‡		Unintentionally struck by or against an object		Other or unspecified unintentional injury		Intentional self-harm§		Assault		Other¶	
		NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)
0-17	2016	5,485	7.4 (6.5 - 8.4)	6,085	8.3 (7.0 - 9.5)	1,350	1.8 (1.5 - 2.2)	3,120	4.2 (3.6 - 4.8)	§	§	1,515	2.1 (1.7 - 2.4)	1,895	2.6 (1.8 - 3.4)
	2017	5,015	6.8 (5.9 - 7.7)	5,680	7.7 (6.5 - 8.9)	1,005	1.4 (1.1 - 1.6)	2,880	3.9 (3.3 - 4.5)	§	§	1,545	2.1 (1.7 - 2.5)	1,405	1.9 (1.3 - 2.5)
0-4	2016	840	4.2 (3.3 - 5.2)	3,525	17.7 (14.7 - 20.7)	390	2.0 (1.5 - 2.5)	835	4.2 (3.3 - 5.1)	§	§	1,070	5.4 (4.1 - 6.6)	735	3.7 (2.3 - 5.0)
	2017	740	3.7 (2.9 - 4.5)	3,330	16.7 (13.7 - 19.8)	345	1.7 (1.2 - 2.3)	585	2.9 (2.3 - 3.6)	§	§	1,025	5.2 (3.8 - 6.5)	475	2.4 (1.5 - 3.3)
5-9	2016	910	4.5 (3.5 - 5.4)	985	4.8 (3.8 - 5.9)	275	1.3 (0.9 - 1.8)	405	2.0 (1.5 - 2.5)	§	§	30	0.1 (0.0 - 0.3)	340	1.7 (0.9 - 2.4)
	2017	945	4.7 (3.7 - 5.6)	985	4.9 (3.9 - 5.8)	215	1.1 (0.7 - 1.4)	440	2.2 (1.6 - 2.7)	§	§	50	0.2 (0.1 - 0.4)	230	1.1 (0.6 - 1.7)
10-14	2016	1,245	6.0 (5.0 - 7.1)	880	4.3 (3.4 - 5.2)	375	1.8 (1.3 - 2.3)	770	3.7 (2.9 - 4.6)	20	0.1 (0.0 - 0.2)	85	0.4 (0.2 - 0.6)	450	2.2 (1.4 - 3.0)
	2017	1,210	5.8 (4.8 - 6.9)	715	3.4 (2.7 - 4.2)	200	1.0 (0.7 - 1.3)&	895	4.3 (3.4 - 5.2)	35	0.2 (0.0 - 0.3)	110	0.5 (0.3 - 0.8)	295	1.4 (0.9 - 1.9)
15-24	2016	12,695	29.2 (26.4 - 32.0)	2,860	6.6 (5.9 - 7.3)	750	1.7 (1.4 - 2.0)	3,805	8.7 (7.8 - 9.7)	305	0.7 (0.5 - 0.9)	2,290	5.3 (4.6 - 5.9)	1,610	3.7 (2.8 - 4.6)
	2017	11,290	26.2 (23.7 - 28.6)	2,715	6.3 (5.6 - 7.0)	610	1.4 (1.2 - 1.7)	3,255	7.5 (6.7 - 8.3)	320	0.7 (0.5 - 0.9)	2,200	5.1 (4.4 - 5.8)	1,625	3.8 (2.9 - 4.6)
25-34	2016	10,965	24.5 (22.0 - 27.0)	3,315	7.4 (6.7 - 8.1)	470	1.1 (0.8 - 1.3)	3,175	7.1 (6.4 - 7.8)	315	0.7 (0.5 - 0.9)	3,800	8.5 (7.5 - 9.5)	1,670	3.7 (2.8 - 4.7)
	2017	10,220	22.6 (20.4 - 24.7)	3,170	7.0 (6.3 - 7.7)	490	1.1 (0.9 - 1.3)	2,790	6.2 (5.5 - 6.8)	330	0.7 (0.5 - 0.9)	3,295	7.3 (6.4 - 8.1)	1,660	3.7 (2.8 - 4.6)
35-44	2016	7,140	17.6 (15.9 - 19.4)	4,090	10.1 (9.2 - 11.0)	445	1.1 (0.9 - 1.3)	2,345	5.8 (5.1 - 6.5)	190	0.5 (0.3 - 0.6)	2,815	7.0 (6.1 - 7.8)	1,420	3.5 (2.8 - 4.2)
	2017	7,185	17.6 (15.8 - 19.4)	3,475	8.5 (7.7 - 9.4)	385	0.9 (0.7 - 1.2)	2,265	5.6 (4.9 - 6.2)	225	0.6 (0.4 - 0.7)	2,540	6.2 (5.5 - 7.0)	1,610	3.9 (3.2 - 4.7)
45-54	2016	7,775	18.2 (16.3 - 20.1)	7,650	17.9 (16.6 - 19.2)	560	1.3 (1.1 - 1.6)	2,865	6.7 (6.0 - 7.4)	245	0.6 (0.4 - 0.7)	2,695	6.3 (5.6 - 7.1)	1,965	4.6 (3.6 - 5.6)
	2017	7,525	17.8 (16.1 - 19.5)	6,910	16.3 (15.1 - 17.6)	545	1.3 (1.0 - 1.6)	2,750	6.5 (5.8 - 7.2)	260	0.6 (0.4 - 0.8)	2,665	6.3 (5.6 - 7.0)	1,985	4.7 (3.8 - 5.6)
55-64	2016	7,255	17.5 (15.8 - 19.2)	13,080	31.6 (29.5 - 33.6)	630	1.5 (1.2 - 1.8)	2,865	6.9 (6.2 - 7.7)	160	0.4 (0.2 - 0.5)	1,865	4.5 (3.9 - 5.1)	2,190	5.3 (4.3 - 6.3)
	2017	6,915	16.5 (15.0 - 18.1)	13,600	32.5 (30.5 - 34.4)	610	1.5 (1.2 - 1.7)	2,575	6.1 (5.5 - 6.8)	185	0.4 (0.3 - 0.6)	1,820	4.3 (3.8 - 4.9)	2,585	6.2 (5.1 - 7.2)
65-74	2016	4,615	16.1 (14.5 - 17.7)	19,225	67.2 (63.4 - 70.9)	855	3.0 (2.5 - 3.5)	1,945	6.8 (6.0 - 7.6)	55	0.2 (0.1 - 0.3)	675	2.4 (1.9 - 2.8)	2,620	9.2 (7.7 - 10.7)
	2017	4,965	16.8 (15.2 - 18.3)	19,670	66.4 (62.7 - 70.1)	745	2.5 (2.1 - 3.0)	1,720	5.8 (5.1 - 6.5)	60	0.2 (0.1 - 0.3)	630	2.1 (1.7 - 2.5)	2,640	8.9 (7.5 - 10.3)
75+	2016	3,340	16.2 (14.4 - 18.0)	52,750	255.9 (243.3 - 268.4)	1,430	6.9 (6.0 - 7.8)	1,565	7.6 (6.6 - 8.6)	45	0.2 (0.1 - 0.4)	265	1.3 (0.9 - 1.6)	5,215	25.3 (21.8 - 28.8)
	2017	3,730	17.6 (15.7 - 19.5)	55,200	260.9 (248.3 - 273.4)	1,190	5.6 (4.9 - 6.4)	1,475	7.0 (6.1 - 7.9)	45	0.2 (0.1 - 0.4)	255	1.2 (0.9 - 1.5)	5,980	28.3 (24.1 - 32.5)
Total††	2016	56,780	17.6 (16.1 - 19.1)	108,365	33.5 (32.0 - 35.1)	6,180	1.9 (1.8 - 2.1)	20,575	6.4 (5.9 - 6.8)	1,335	0.5 (0.4 - 0.5)	15,600	4.8 (4.4 - 5.3)	18,220	5.6 (4.8 - 6.5)
	2017	54,725	16.8 (15.5 - 18.2)	109,775	33.8 (32.2 - 35.3)	5,335	1.6 (1.5 - 1.8)&	18,750	5.8 (5.4 - 6.2)	1,460	0.5 (0.4 - 0.6)	14,590	4.5 (4.1 - 4.9)	19,085	5.9 (5.0 - 6.7)
Adjusted††	2016	56,780	17.3 (16.7 - 17.9)	108,360	29.8 (29.1 - 30.5)	6,180	1.8 (1.7 - 2.0)	20,575	6.2 (6.0 - 6.5)	1,335	0.5 (0.4 - 0.5)	15,590	4.9 (4.6 - 5.1)	18,215	5.3 (4.9 - 5.6)
	2017	54,725	16.6 (16.0 - 17.1)	109,770	29.4 (28.7 - 30.1)	5,335	1.6 (1.5 - 1.7)&	18,750	5.7 (5.4 - 5.9)&	1,460	0.5 (0.5 - 0.6)	14,590	4.5 (4.3 - 4.8)	19,085	5.4 (5.1 - 5.8)

TABLE 1 (cont'd) – Estimated number and rate* of traumatic brain injury-related (TBI) deaths by age group and mechanism of injury — United States, 2016 and 2017

Key Findings

- Children ages 0-17 years accounted for approximately 8.6% of all TBI-related hospitalizations in 2016 and 7.8% in 2017.
- In 2016 and 2017, unintentional falls accounted for the highest age-adjusted rate (29.8 and 29.4 per 100,000 population, respectively) and proportion (47.7%; N=108,360 and 49.1% (weighted estimate); n=109,770, respectively) of all TBI-related hospitalizations in the United States. During both 2016 and 2017, rates for TBI-related hospitalizations attributable to unintentional falls were highest among adults aged ≥75 years (255.9 and 260.9, respectively), 65-74 years (67.2 and 66.4, respectively), and 55-64 years (31.6 and 32.5, respectively).
- Motor vehicle crashes were the second leading cause of TBI-related hospitalizations, with an age-adjusted rate of 17.3 in 2016 and 16.6 in 2017 and accounted for approximately 25% of all TBI-related hospitalizations in both data years. Age groups with the highest rate of motor vehicle crashes leading to a TBI-related hospitalization were 15-24 years (29.2 in 2016 and 26.2 in 2017) and 25-34 years (24.5 in 2016 and 22.6 in 2017).
- The most common principal mechanisms of injury for TBI-related hospitalizations among children aged 0-17 (analyzed separately) were unintentional falls (rates of 8.3 in 2016 and 7.7 in 2017) and motor vehicle crashes (7.4 in 2016 and 6.8 in 2017).
- The age-adjusted rate of TBI-related hospitalization for each mechanism of injury remained steady between 2016 and 2017, except unintentionally struck by or against an object and other or unspecified unintentional injury which decreased significantly by 11% and 8%, respectively, from one year to the next.

SOURCE: Healthcare Cost and Utilization Project's National Inpatient Sample

Abbreviations: CI = confidence interval.

*Per 100,000 population

†In-hospital deaths and patients who transferred from another hospital were excluded.

‡Falls of undetermined intent were not included.

§Age <10 years were excluded because determining intent in younger children can be difficult. Rates for TBI-related hospitalizations due to intentional self-harm were age-adjusted to the population 10 years and older.

¶Includes undetermined intent, legal intervention, war, intentional self-harm for age <10 years, and cases without information about cause of injury.

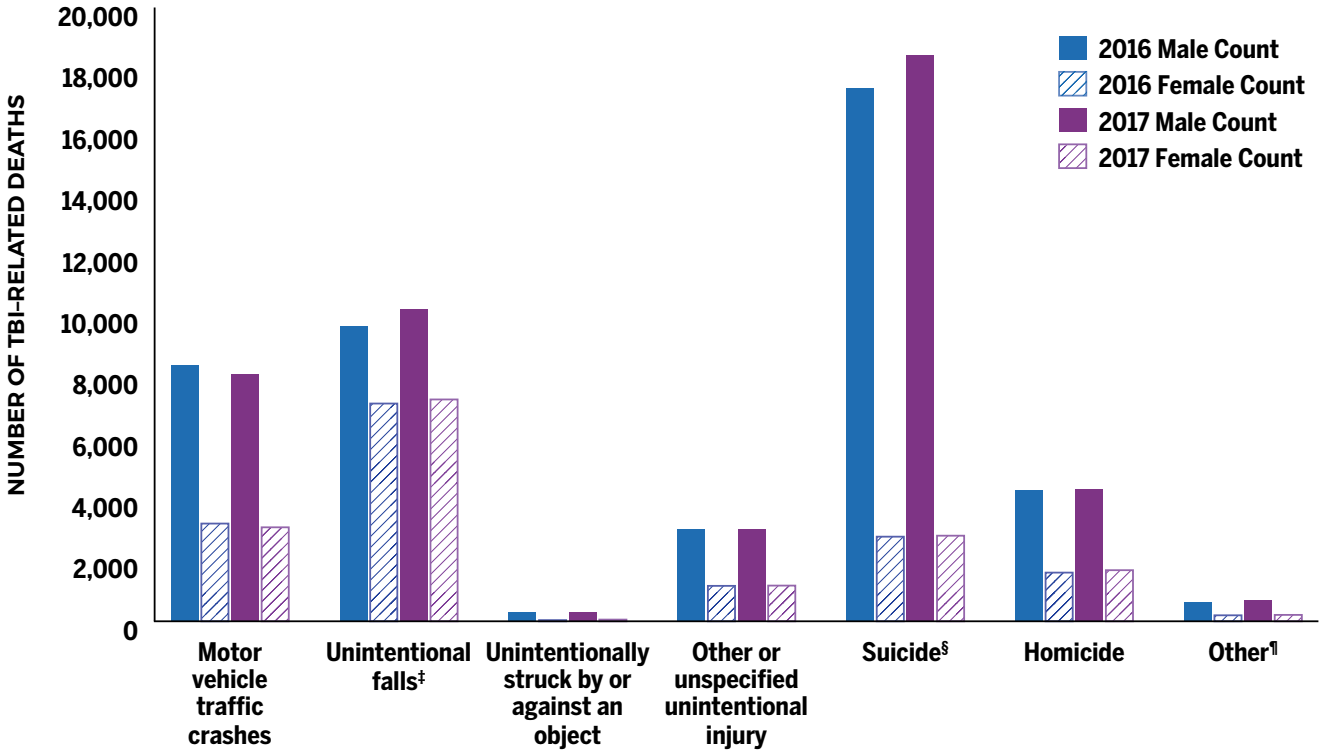
&Rate significantly different compared to 2016, t-tests p-value <0.05.

††Hospitalizations with missing age were included.

‡‡Hospitalizations with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

FIGURE 3A[5]

Number of traumatic brain injury-related (TBI) deaths by sex and mechanism of injury — United States, 2016 and 2017



Key Findings

In 2016, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related death, males had higher counts when compared with females. Males had higher counts of:

- unintentional falls (9,601 versus 7,095);
- motor vehicle crashes (8,357 versus 3,184);
- unintentionally being struck by or against an object (298 versus 38);
- suicide (17,382 versus 2,757); and
- homicide (4,280 versus 1,586).

SOURCE: CDC's National Vital Statistics System

[5]Counts of TBI-related deaths are presented in tabular form in Supplemental Table 3.

‡Falls of undetermined intent were not included.

§Age <10 years were excluded because determining intent in younger children can be difficult.

¶Includes undetermined intent, legal intervention, war, and intentional self-harm for age <10 years.

FIGURE 3A[5] (cont'd)

Number of traumatic brain injury-related (TBI) deaths by sex and mechanism of injury — United States, 2016 and 2017

Key Findings (cont'd)

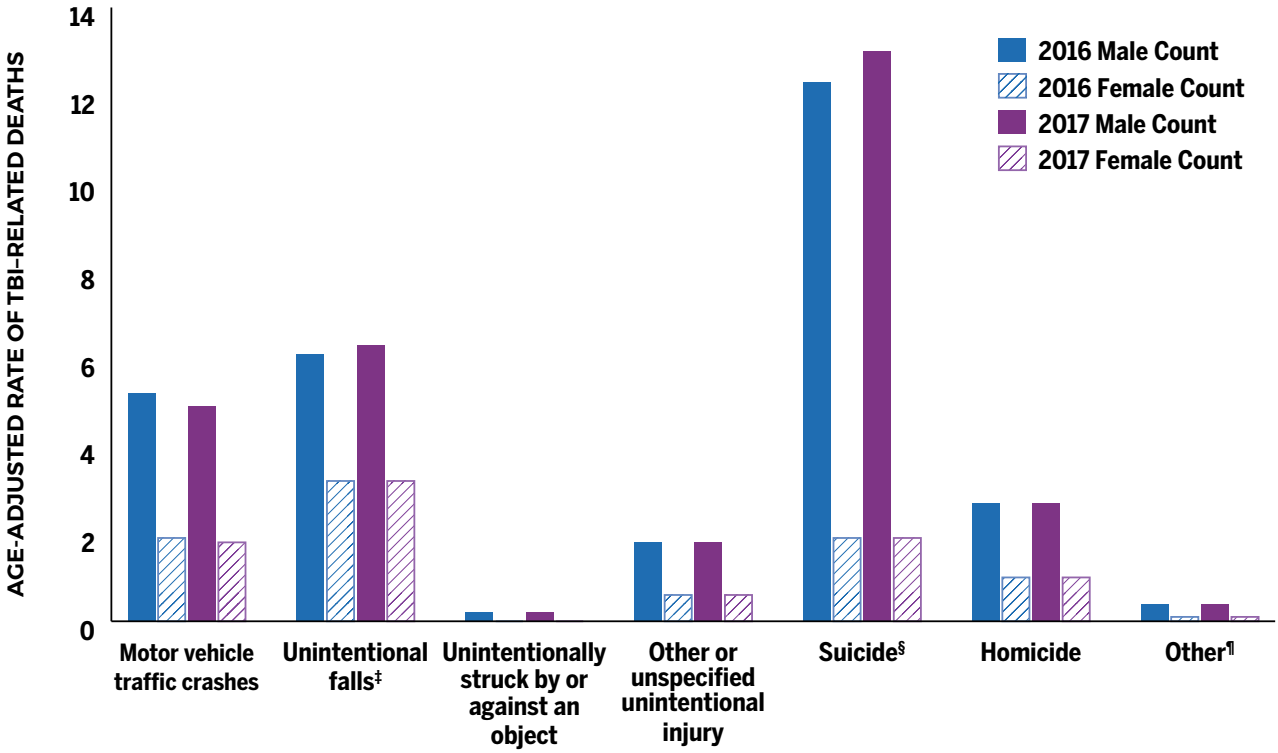
In 2017, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related death, males had higher counts when compared with females. Males had higher counts of:

- unintentional falls (10,180 versus 7,228);
- motor vehicle crashes (8,036 versus 3,062);
- unintentionally being struck by or against an object (291 versus 55);
- suicide (18,436 versus 2,789); and
- homicide (4,316 versus 1,665).

In 2016 and 2017, suicide was the leading mechanism of injury contributing to a TBI-related death among males; during the same time period unintentional falls were the leading cause of TBI-related death among females.

FIGURE 3B[6]

Age-adjusted rate[††] of traumatic brain injury-related (TBI) deaths by sex and mechanism of injury — United States, 2016 and 2017



Key Findings

In 2016, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related death, males had significantly (t-tests p-value <0.05) higher age-adjusted rates compared with females. Males had higher age-adjusted rates of:

- unintentional falls (6.1 versus 3.2, per 100,000 population);
- motor vehicle crashes (5.2 versus 1.9; more than twofold higher);
- suicide (12.3 versus 1.9; more than sixfold higher); and
- homicide (2.7 versus 1.0; more than twofold higher).

SOURCE: CDC's National Vital Statistics System

[6]Rates of TBI-related deaths are presented in tabular form in Supplemental Table 3.

[††]Deaths with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

[‡]Falls of undetermined intent were not included.

[§]Age <10 years were excluded because determining intent in younger children can be difficult. Rates for deaths due to suicide were age-adjusted to the population 10 years and older.

[¶]Includes undetermined intent, legal intervention, war, and intentional self-harm for age <10 years.

FIGURE 3B[6] (cont'd)

Age-adjusted rate†† of traumatic brain injury-related (TBI) deaths by sex and mechanism of injury — United States, 2016 and 2017

Key Findings (cont'd)

In 2017, among the major unintentional and intentional principal mechanism categories examined that contributed to a TBI-related death, males had significantly (t-tests p-value <0.05) higher age-adjusted rates compared with females. Males had higher age-adjusted rates of:

- unintentional falls (6.3 versus 3.2 per 100,000 population);
- motor vehicle crashes (4.9 versus 1.8; more than twofold higher);
- suicide (13.0 versus 1.9; more than sixfold higher); and
- homicide (2.7 versus 1.0; more than twofold higher).

Suicide accounted for the highest age-adjusted rate (12.3 in 2016 and 13.0 in 2017) of TBI-related deaths among men.

Among women, unintentional falls accounted for the highest age-adjusted rate (3.2 in both years) of TBI-related deaths.

TABLE 2 – Number and rate* of traumatic brain injury-related (TBI) deaths by age group and mechanism of injury — United States, 2016 and 2017

AGE GROUP (YRS)	YEAR	Motor vehicle traffic crashes		Unintentional falls‡		Unintentionally struck by or against an object		Other or unspecified unintentional injury		Suicide§		Homicide		Other¶	
		NO.	RATE (95% CI)€	NO.	RATE (95% CI)€	NO.	RATE (95% CI)€	NO.	RATE (95% CI)€	NO.	RATE (95% CI)€	NO.	RATE (95% CI)€	NO.	RATE (95% CI)€
0-17	2016	981	1.3 (1.2 - 1.4)	46	0.1 (0.0 - 0.1)	36	0.0 (0.0 - 0.1)	324	0.4 (0.4 - 0.5)	§	§	638	0.9 (0.8 - 0.9)	57	0.1 (0.1 - 0.1)
	2017	940	1.3 (1.2 - 1.4)	54	0.1 (0.1 - 0.1)	36	0.0 (0.0 - 0.1)	308	0.4 (0.4 - 0.5)	§	§	665	0.9 (0.8 - 1.0)	92	0.1 (0.1 - 0.2)
0-4	2016	213	1.1 (0.9 - 1.2)	17	††	18	††	129	0.6 (0.5 - 0.8)	§	§	303	1.5 (1.3 - 1.7)	28	0.1 (0.1 - 0.2)
	2017	231	1.2 (1.0 - 1.3)	19	††	17	††	126	0.6 (0.5 - 0.7)	§	§	312	1.6 (1.4 - 1.7)	45	0.2 (0.2 - 0.3)
5-9	2016	179	0.9 (0.7 - 1.0)	††	††	13	††	51	0.2 (0.2 - 0.3)	§	§	56	0.3 (0.2 - 0.4)	††	††
	2017	134	0.7 (0.5 - 0.8)	††	††	††	††	46	0.2 (0.2 - 0.3)	§	§	69	0.3 (0.3 - 0.4)	††	††
10-14	2016	183	0.9 (0.8 - 1.0)	11	††	††	††	80	0.4 (0.3 - 0.5)	157	0.8 (0.6 - 0.9)	67	0.3 (0.3 - 0.4)	††	††
	2017	181	0.9 (0.7 - 1.0)	11	††	††	††	70	0.3 (0.3 - 0.4)	178	0.9 (0.7 - 1.0)	64	0.3 (0.2 - 0.4)	††	††
15-24	2016	2,449	5.6 (5.4 - 5.9)	96	0.2 (0.2 - 0.3)	20	0.0 (0.0 - 0.1)	312	0.7 (0.6 - 0.8)	2,542	5.8 (5.6 - 6.1)	1,405	3.2 (3.1 - 3.4)	95	0.2 (0.2 - 0.3)
	2017	2,266	5.2 (5.0 - 5.5)	109	0.3 (0.2 - 0.3)	18	††	292	0.7 (0.6 - 0.8)	2,846	6.6 (6.4 - 6.8)&	1,379	3.2 (3.0 - 3.4)	120	0.3 (0.2 - 0.3)
25-34	2016	2,260	5.1 (4.8 - 5.3)	191	0.4 (0.4 - 0.5)	40	0.1 (0.1 - 0.1)	335	0.7 (0.7 - 0.8)	3,125	7.0 (6.7 - 7.2)	1,401	3.1 (3.0 - 3.3)	143	0.3 (0.3 - 0.4)
	2017	2,091	4.6 (4.4 - 4.8)&	201	0.4 (0.4 - 0.5)	34	0.1 (0.1 - 0.1)	362	0.8 (0.7 - 0.9)	3,264	7.2 (7.0 - 7.5)	1,474	3.3 (3.1 - 3.4)	131	0.3 (0.2 - 0.3)&
35-44	2016	1,519	3.8 (3.6 - 3.9)	327	0.8 (0.7 - 0.9)	40	0.1 (0.1 - 0.1)	366	0.9 (0.8 - 1.0)	2,795	6.9 (6.6 - 7.2)	974	2.4 (2.3 - 2.6)	125	0.3 (0.3 - 0.4)
	2017	1,501	3.7 (3.5 - 3.9)	318	0.8 (0.7 - 0.9)	37	0.1 (0.1 - 0.1)	395	1.0 (0.9 - 1.1)	2,854	7.0 (6.7 - 7.3)	913	2.2 (2.1 - 2.4)	130	0.3 (0.3 - 0.4)
45-54	2016	1,562	3.7 (3.5 - 3.8)	798	1.9 (1.7 - 2.0)	49	0.1 (0.1 - 0.2)	539	1.3 (1.2 - 1.4)	3,281	7.7 (7.4 - 7.9)	697	1.6 (1.5 - 1.8)	146	0.3 (0.3 - 0.4)
	2017	1,483	3.5 (3.3 - 3.7)	819	1.9 (1.8 - 2.1)	47	0.1 (0.1 - 0.1)	539	1.3 (1.2 - 1.4)	3,424	8.1 (7.8 - 8.4)	735	1.7 (1.6 - 1.9)	148	0.4 (0.3 - 0.4)
55-64	2016	1,419	3.4 (3.2 - 3.6)	1,690	4.1 (3.9 - 4.3)	56	0.1 (0.1 - 0.2)	666	1.6 (1.5 - 1.7)	3,402	8.2 (7.9 - 8.5)	541	1.3 (1.2 - 1.4)	130	0.3 (0.3 - 0.4)
	2017	1,434	3.4 (3.2 - 3.6)	1,712	4.1 (3.9 - 4.3)	71	0.2 (0.1 - 0.2)	685	1.6 (1.5 - 1.8)	3,536	8.4 (8.2 - 8.7)	588	1.4 (1.3 - 1.5)	149	0.4 (0.3 - 0.4)
65-74	2016	928	3.2 (3.0 - 3.5)	2,602	9.1 (8.7 - 9.4)	48	0.2 (0.1 - 0.2)	563	2.0 (1.8 - 2.1)	2,468	8.6 (8.3 - 9.0)	234	0.8 (0.7 - 0.9)	68	0.2 (0.2 - 0.3)
	2017	892	3.0 (2.8 - 3.2)	2,758	9.3 (9.0 - 9.7)	54	0.2 (0.1 - 0.2)	581	2.0 (1.8 - 2.1)	2,582	8.7 (8.4 - 9.0)	267	0.9 (0.8 - 1.0)	67	0.2 (0.2 - 0.3)
75+	2016	829	4.0 (3.7 - 4.3)	10,959	53.2 (52.2 - 54.2)	49	0.2 (0.2 - 0.3)	1,105	5.4 (5.0 - 5.7)	2,367	11.5 (11.0 - 11.9)	187	0.9 (0.8 - 1.0)	65	0.3 (0.2 - 0.4)
	2017	885	4.2 (3.9 - 4.5)	11,452	54.1 (53.1 - 55.1)	53	0.3 (0.2 - 0.3)	1,078	5.1 (4.8 - 5.4)	2,541	12.0 (11.5 - 12.5)	179	0.8 (0.7 - 1.0)	96	0.5 (0.4 - 0.6)&
Total††	2016	11,541	3.6 (3.5 - 3.6)	16,696	5.2 (5.1 - 5.2)	336	0.1 (0.1 - 0.1)	4,146	1.3 (1.2 - 1.3)	20,139	7.1 (7.0 - 7.2)	5,866	1.8 (1.8 - 1.9)	816	0.3 (0.2 - 0.3)
	2017	11,098	3.4 (3.3 - 3.5)&	17,408	5.4 (5.3 - 5.4)&	346	0.1 (0.1 - 0.1)	4,175	1.3 (1.2 - 1.3)	21,225	7.4 (7.3 - 7.5)&	5,981	1.8 (1.8 - 1.9)	901	0.3 (0.3 - 0.3)
Adjusted§§	2016	11,541	3.5 (3.5 - 3.6)	16,694	4.4 (4.4 - 4.5)	336	0.1 (0.1 - 0.1)	4,146	1.2 (1.2 - 1.2)	20,137	6.9 (6.8 - 7.0)	5,865	1.8 (1.8 - 1.9)	815	0.2 (0.2 - 0.3)
	2017	11,098	3.4 (3.3 - 3.4)&	17,408	4.5 (4.5 - 4.6)&	346	0.1 (0.1 - 0.1)	4,174	1.2 (1.1 - 1.2)	21,225	7.2 (7.1 - 7.3)&	5,980	1.9 (1.8 - 1.9)	900	0.3 (0.3 - 0.3)&

TABLE 2 (cont'd) – Number and rate* of traumatic brain injury-related (TBI) deaths by age group and mechanism of injury — United States, 2016 and 2017

Key Findings:

- Children ages 0-17 years accounted for approximately 4.5% of all TBI-related deaths in both years.
- Suicide accounted for the highest age-adjusted rate (6.9 [2016] and 7.2 [2017] per 100,000 population) and proportion (33.8% [2016] and 34.7% [2017]) of all TBI-related deaths in the United States.
- Rates of TBI-related deaths attributable to suicide were highest among those aged ≥75 years (11.5 in 2016 and 12.0 in 2017).
- Unintentional falls were the second leading cause of TBI-related deaths, with an age-adjusted rate of 4.4 in 2016 and 4.5 in 2017 and accounted for approximately 28% of all TBI-related deaths in both years.
- Adults aged ≥75 years had the highest rate of TBI-related deaths caused by unintentional falls, with rates of 53.2 in 2016 and 54.1 in 2017.
- Motor vehicle crashes were the third most common cause of TBI-related deaths in both years, with age-adjusted rates of 3.5 and 3.4 and contributing to 11,541 and 11,098 deaths in 2016 and 2017, respectively.
- Rates of TBI-related deaths attributable to motor vehicle crashes were highest among those aged 15-24 years (5.6 in 2016) and (5.2 in 2017). In 2016, the second highest rate was found among those 25-34 years (5.1), and in 2017, among those aged 25-34 (4.6) and adults aged ≥75 years (4.2).
- From 2016 to 2017, the rate of TBI-related deaths increased significantly by 13.8% and 4.3%, respectively, for suicide among those aged 15-24 years and overall. The adjusted rate also increased significantly for unintentional falls and other mechanism of injury category. The rate decreased significantly by 9.8% and 2.9%, respectively, for motor vehicle crashes among those aged 25-34 years and overall from 2016 to 2017.
- The top principal mechanism of injury leading to TBI-related death among young children and adolescents aged 0-17 years was motor vehicle crashes (1.3) in both 2016 and 2017.

SOURCE: CDC's National Vital Statistics System

Abbreviations: CI = confidence interval.

*Per 100,000 population.

‡Falls of undetermined intent were not included.

§Age <10 years were excluded because determining intent in younger children can be difficult. Rates for deaths due to suicide were age-adjusted to the population 10 years and older.

¶Includes undetermined intent, legal intervention, war, and intentional self-harm for age <10 years.

&Rate significantly different compared to 2016, t-tests p-value <0.05.

‡‡Deaths with missing age were included.

§§Deaths with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

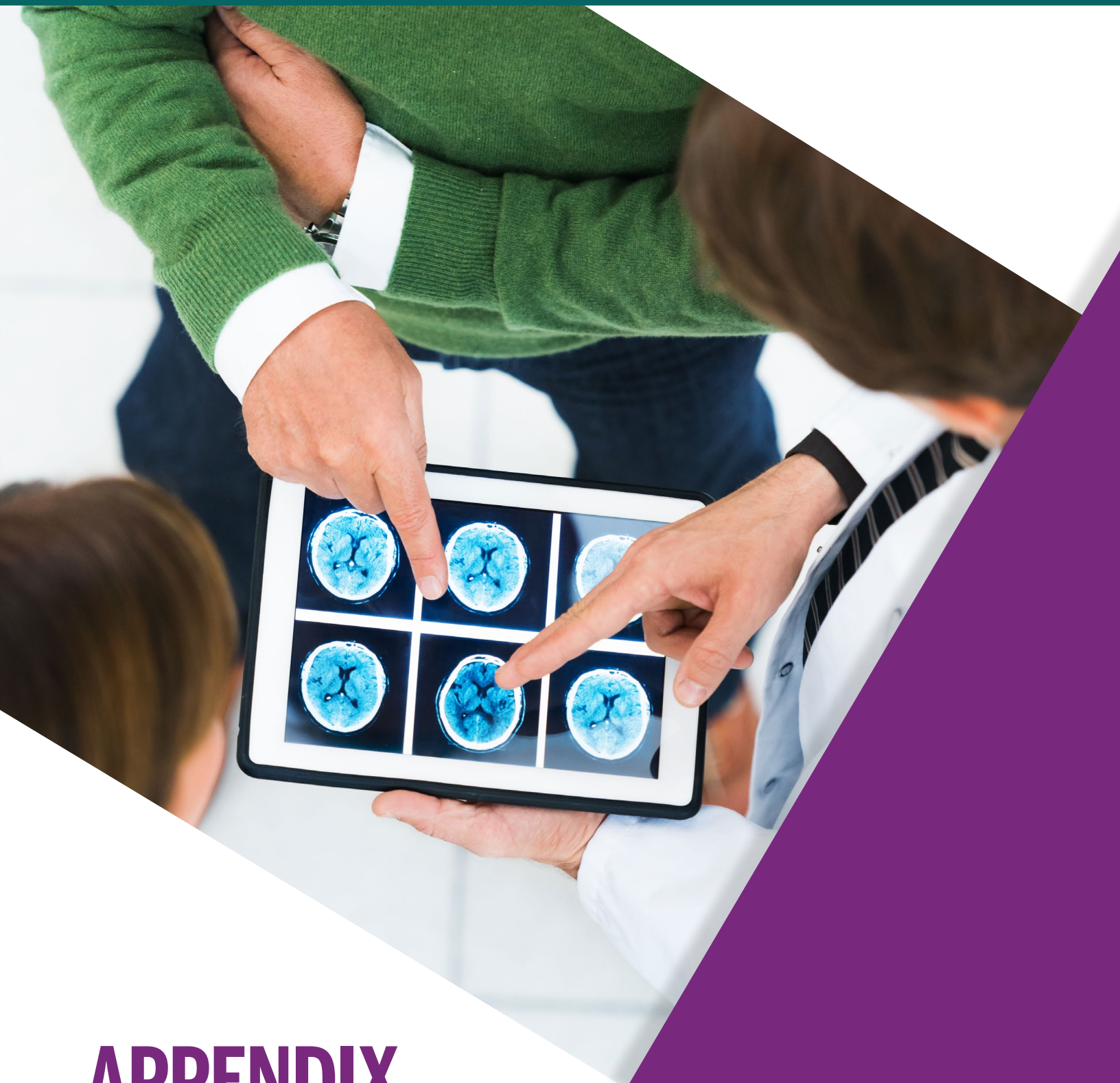
The findings in this report are subject to the following limitations:

- The analysis presented in this surveillance report did not differentiate by injury severity, although some codes included in the CDC's TBI surveillance definition are indicative of a more severe injury.
- Findings presented do not include patients who sought care in the emergency department or outside of the hospital setting (e.g., primary care, urgent care, specialty care) or individuals who did not seek care for their TBI.
- This report does not include TBIs from Veterans Administration (VA), military, or federal hospitals.
- The mechanism and intent of injury are unknown for a portion of hospitalizations (7.8% in 2016, 8.3% in 2017). As a result, estimates of TBI-related hospitalizations by mechanism of injury and injury intent are undercounts.
- This analysis disaggregated TBI estimates into broad categories of mechanism of injury, which limits the specificity of conclusions that can be drawn regarding primary causes of TBI-related hospitalizations and deaths.

Conclusions

- The oldest age group (≥75 years) had the highest numbers and rates of TBI-related hospitalizations and deaths during both 2016 and 2017.
- Unintentional falls were the leading cause of injury for TBI-related hospitalizations during 2016 and 2017. Annually, half of TBI-related hospitalizations attributed to falls were among the oldest age group (≥75 years), which suggests a need to intensify prevention efforts related to falls, particularly among older adults.
- Suicide was the leading cause of TBI-related deaths during 2016 and 2017, accounting for 33.8% and 34.7%, respectively, of all TBI-related deaths. This mirrors the increase in suicide rates overall in the United States,[5] suggesting the need for promotion of programs and practices[#] with the best available evidence for preventing suicide.

[#]https://www.cdc.gov/violenceprevention/pdf/suicideTechnicalPackage.pdf



APPENDIX

METHODOLOGICAL APPENDIX

Hospitalizations

To minimize double-counting, in-hospital deaths and transfers from another hospital were excluded. An injury subset was then created by searching the primary diagnosis field for one of the following codes: S00-S99; T07-T34; T36-T50 with a 6th character of 1, 2, 3, or 4; T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, or T49.9 with a 5th character of 1, 2, 3, or 4; T51-T76; T79; O9A.2-O9A.5; T84.04; or M97. The codes must have a 7th character of A, B, C, or missing, which reflects initial encounter, active treatment. Once the injury subset was created, TBI-related hospitalizations were identified if a record had one of the following codes in any diagnosis field.

CODE(S)*	DESCRIPTION
S02.0, S02.1	Fracture of skull
S02.8, S02.91	Fracture of other specified skull and facial bones; unspecified fracture
S04.02, S04.03, S04.04	Injury of optic chiasm; injury of optic tract and pathways; injuries of visual cortex
S06	Intracranial injury
S07.1	Crushing injury of skull
T74.4	Shaken infant syndrome

*Only include case if the 7th character is "A" or "B" for S02.0, S02.1, S02.8, S02.91 or "A" for S04.02, S04.03, S04.04, S06, S07.1, and T74.4, which indicates initial encounter. Cases with a 7th character of "missing" will also be included.

For classifying hospitalizations by cause, each case was assigned a single cause based on the first valid external cause of injury. Because there are multiple fields in which codes with external cause information can be found and potentially multiple external cause codes for each case, fields were searched in a specific order for external cause information (see table below for specific order). Additionally, separate external cause of injury fields were eliminated in the 2017 data, so the search strategy was different for each year. With the ICD–10–CM coding scheme, external cause of injury information can be found in both diagnosis codes (T codes) and external cause of injury codes (V-Y codes). The potential codes can be found in the table below.

CODE(S)*	DESCRIPTION
V00-V99	Transport accidents
W00-X58	Other external causes of accidental injury
X71-X83	Intentional self-harm
X92-Y09	Assault
Y21-Y33	Event of undetermined intent
Y35-Y38	Legal intervention, operations of war, military operations and terrorism
T14.91	Suicide attempt
T15-T19	Effects of foreign body entering through natural orifice

CODE(S)*	DESCRIPTION
T36-T50 with a 6th character of 1, 2, 3, or 4 Note: Include T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, and T49.9 with a 5th character of 1, 2, 3, or 4 (Intent information for these codes is included in the 5th character and not the 6th)	Poisoning by drugs, medicaments, and biological substances
T51-T65	Toxic effects of substances chiefly non-medicinal as to source
T71	Asphyxiation
T73	Effects of deprivation
T74, T76	Adult and child abuse, neglect, and other maltreatment, confirmed or suspected
T75.0-T75.4	Effects of lightning, drowning, and vibration, motion sickness, electrocution

*Only Include cases if the 7th character of the code is A or missing (reflects initial encounter, active treatment)

For the 2016 data, these codes were searched for in the following order: diagnosis field 1, external cause fields 1-4, then diagnosis fields 2-30. For the 2017 data, diagnosis field 1 was initially searched for T codes, then diagnosis fields 2-40 searched for V-Y codes, and finally diagnosis fields 2-40 searched for T codes. The first code found was considered the first valid external cause of injury.

Once the first valid external cause of injury was identified, it was classified into the categories of interest by the following codes. These codes correspond to the ICD–10–CM external cause of injury matrix[23]:

MECHANISM AND/OR INTENT	ICD–10–CM CODES*
Motor vehicle traffic crashes	V02-V04 (.1, .9), V09.2, V09.3, V12-V14 (.3-.9), V19.4-V19.6, V19.9, V20-V28 (.3-.9), V29.4-V29.9, V30-V79 (.4-.9), V80.3-V80.5, V81.1, V82.1, V83-V86(.0-.3), V87.0-V87.8, V89.2
Unintentional falls	V00 with 6th character=1, W00-W15, W16 with 6th character=2, W16.42, W16.92, W17, W18.1-W18.3, W19
Unintentionally struck by/ against an object	V00.0, [V00.1-V00.8] (with 6th character = 2), W18.0, W20, W21, W22.01-W22.03, W22.042, W22.09, W22.1, W22.8, W50-W52
Other or unspecified unintentional injury	All the other codes in the T15-T19, [T36-T65, T71] (with 6th character = 1), [T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, T49.9, T51.9, T52.9, T53.9, T54.9, T56.9, T57.9, T58.0, T58.1, T58.9, T59.9, T60.9, T61.0, T61.1, T61.9, T62.9, T63.9, T64, T65.9] (with 5th character = 1), T71.20, T71.21, T71.29, T71.9, T73, T75.0, T75.2-T75.4, V00-V99, W00-W99, X00-X58 ranges

Intentional self-harm	T14.91, [T36-T65, T71] (with 6th character = 2), [T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, T49.9, T51.9, T52.9, T53.9, T54.9, T56.9, T57.9, T58.0, T58.1, T58.9, T59.9, T60.9, T61.0, T61.1, T61.9, T62.9, T63.9, T64, T65.9] (with 5th character = 2), X71-X83
Assault	[T36-T65, T71] (with 6th character = 3), [T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, T49.9, T51.9, T52.9, T53.9, T54.9, T56.9, T57.9, T58.0, T58.1, T58.9, T59.9, T60.9, T61.0, T61.1, T61.9, T62.9, T63.9, T64, T65.9] (with 5th character = 3), T74, T76, X92-X99, Y00-Y09, Y38
Other	[T36-T65, T71] (with 6th character = 4), [T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9, T49.9, T51.9, T52.9, T53.9, T54.9, T56.9, T57.9, T58.0, T58.1, T58.9, T59.9, T60.9, T61.0, T61.1, T61.9, T62.9, T63.9, T64, T65.9] (with 5th character = 4), T75.1, Y21-Y33, Y35-Y37

*Only include cases if the 7th character of the code is A or missing (reflects initial encounter, active treatment)

Suicide/Intentional self-harm in children

For suicide and intentional self-harm data, deaths and hospitalizations among children <10 years were not presented because it is unclear if children <10 are able to form suicidal intent.[24] Rates for deaths due to suicide and intentional self-harm hospitalizations were age-adjusted to the population 10 years and older. Any suicides or intentional self-harm hospitalizations in the 0-9 year age group were moved to the "other/unknown" cause category so that the sum of causes equals the total number of TBI-related hospitalizations and deaths.

Deaths

Injury-related deaths in U.S. residents were identified if the underlying cause of death was one of the following ICD–10 codes: V01-Y36, Y85-Y87, Y89, U01-U03. From this injury subset, TBI-related deaths were selected if one of the following ICD–10 codes were in any of the record-axis multiple-cause-of-death fields.

CODE(S)	DESCRIPTION
S01	Open wound of head
S02.0, S02.1, S02.3, S02.7-S02.9	Fracture of skull and facial bones
S04.0	Injury of optic nerve and pathways
S06	Intracranial injury
S07.0, S07.1, S07.8, S07.9	Crushing injury of head
S09.7-S09.9	Other and unspecified injuries of head
T90.1, T90.2, T90.4, T90.5, T90.8, T90.9	Sequelae of injuries of head

To identify the cause of injury, the following codes were searched for in the underlying cause of death field. These codes are consistent with the ICD–10 external cause of injury matrix.[25]

MECHANISM AND/OR INTENT	ICD–10–CM CODES
Motor vehicle traffic crashes	[V02-V04] (.1,.9), V09.2, [V12-V14] (.3-.9), V19 (.4-.6), [V20-V28] (.3-.9), [V29-V79] (.4-.9), V80 (.3-.5), V81.1, V82.1, [V83-V86] (.0-.3), V87 (.0-.8), V89.2
Unintentional falls	W00-W19
Unintentionally struck by/ against an object	W20-W22, W50-W52
Other or unspecified unintentional injury	All the other codes in the V01-X59, Y85-Y86 ranges
Suicide	U03, X60-X84, Y87.0
Homicide	U01-U02, X85-Y09, Y87.1
Other	Y10-Y34, Y87.2, Y89.9, Y35-Y36, Y89 (.0,.1)

SUPPLEMENTAL TABLE 1

Estimated number and rate* of traumatic brain injury-related (TBI) hospitalizations† and deaths by age group — United States, 2016 and 2017

AGE GROUP (YRS)	YEAR	Hospitalizations†		Deaths	
		NO.	RATE* (95% CI)	NO.	RATE* (95% CI)
0-17	2016	19,530	26.5 (23.3 - 29.7)	2,698	3.7 (3.5 - 3.8)
	2017	17,610	23.9 (21.0 - 26.9)	2,810	3.8 (3.7 - 4.0)
0-4	2016	7,395	37.1 (31.4 - 42.8)	708	3.6 (3.3 - 3.8)
	2017	6,500	32.7 (27.2 - 38.1)	750	3.8 (3.5 - 4.0)
5-9	2016	2,945	14.4 (12.1 - 16.8)	310	1.5 (1.3 - 1.7)
	2017	2,865	14.1 (11.9 - 16.3)	274	1.3 (1.2 - 1.5)
10-14	2016	3,825	18.5 (15.8 - 21.3)	508	2.5 (2.2 - 2.7)
	2017	3,460	16.7 (14.2 - 19.2)	517	2.5 (2.3 - 2.7)
15-24	2016	24,315	55.9 (51.3 - 60.5)	6,919	15.9 (15.5 - 16.3)
	2017	22,015	51.0 (47.0 - 55.0)	7,030	16.3 (15.9 - 16.7)
25-34	2016	23,710	53.0 (48.7 - 57.3)	7,495	16.8 (16.4 - 17.1)
	2017	21,955	48.5 (44.6 - 52.4)	7,557	16.7 (16.3 - 17.1)
35-44	2016	18,445	45.6 (42.0 - 49.1)	6,146	15.2 (14.8 - 15.6)
	2017	17,685	43.4 (40.0 - 46.8)	6,148	15.1 (14.7 - 15.5)
45-54	2016	23,755	55.6 (51.6 - 59.6)	7,072	16.5 (16.2 - 16.9)
	2017	22,640	53.6 (49.8 - 57.4)	7,195	17.0 (16.6 - 17.4)
55-64	2016	28,045	67.7 (63.3 - 72.1)	7,904	19.1 (18.7 - 19.5)
	2017	28,290	67.5 (63.5 - 71.6)	8,175	19.5 (19.1 - 19.9)
65-74	2016	29,990	104.8 (99.2 - 110.4)	6,911	24.2 (23.6 - 24.7)
	2017	30,430	102.7 (97.3 - 108.1)	7,201	24.3 (23.7 - 24.9)
75+	2016	64,610	313.4 (298.5 - 328.4)	15,561	75.5 (74.3 - 76.7)
	2017	67,875	320.8 (305.8 - 335.7)	16,284	77.0 (75.8 - 78.1)
Total§	2016	227,055	70.3 (66.5 - 74.1)	59,540	18.4 (18.3 - 18.6)
	2017	223,720	68.8 (65.2 - 72.4)	61,134	18.8 (18.7 - 19.0)&
Adjusted¶	2016	227,035	65.7 (64.3 - 67.2)	59,534	17.3 (17.1 - 17.4)
	2017	223,715	63.6 (62.3 - 65.0)	61,131	17.5 (17.4 - 17.7)

SOURCES: Healthcare Cost and Utilization Project's National Inpatient Sample and CDC's National Vital Statistics System.

Abbreviations: CI = confidence interval.

*Per 100,000 population.

†In-hospital deaths and patients who transferred from another hospital were excluded.

§Cases with missing age were included. Numbers subject to rounding error.

¶Cases with missing age were excluded. Rates age-adjusted to NCHS 2000 U.S. standard population.

&Rate significantly different compared to 2016, t-tests p-value <0.05.

SUPPLEMENTAL TABLE 2

Estimated number and rate* of traumatic brain injury-related (TBI) hospitalizations† by sex and mechanism of injury — United States, 2016 and 2017

SEX	YEAR		Motor vehicle traffic crashes		Unintentional falls‡		Unintentionally struck by or against an object		Other or unspecified unintentional injury		Intentional self-harm§		Assault		Other¶	
			NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)
MALE	2016	Crude**	37,705	23.7 (21.7 - 25.7)	58,290	36.6 (34.8 - 38.5)	3,990	2.5 (2.3 - 2.7)	14,395	9.0 (8.4 - 9.7)	955	0.7 (0.6 - 0.8)	12,900	8.1 (7.4 - 8.9)	11,205	7.0 (5.9 - 8.2)
		Adjusted††	37,705	23.3 (22.4 - 24.2)	58,285	36.2 (35.2 - 37.2)	3,990	2.5 (2.3 - 2.7)	14,395	8.9 (8.5 - 9.3)	955	0.7 (0.6 - 0.8)	12,900	8.1 (7.6 - 8.5)	11,200	6.9 (6.5 - 7.4)
	2017	Crude**	36,665	22.9 (21.0 - 24.8)	58,640	36.6 (34.8 - 38.4)	3,675	2.3 (2.1 - 2.5)	13,175	8.2 (7.6 - 8.8)	1,040	0.7 (0.6 - 0.9)	11,965	7.5 (6.8 - 8.1)	12,085	7.5 (6.4 - 8.7)
		Adjusted††	36,665	22.5 (21.6 - 23.3)	58,635	35.6 (34.6 - 36.5)	3,675	2.3 (2.1 - 2.4)	13,175	8.1 (7.8 - 8.5)	1,040	0.8 (0.6 - 0.9)	11,965	7.5 (7.0 - 7.9)	12,085	7.4 (6.9 - 7.9)
FEMALE	2016	Crude**	19,065	11.6 (10.6 - 12.7)‡‡	50,035	30.5 (29.1 - 32.0)‡‡	2,190	1.3 (1.2 - 1.5)‡‡	6,160	3.8 (3.4 - 4.1)‡‡	380	0.3 (0.2 - 0.3)‡‡	2,700	1.6 (1.5 - 1.8)‡‡	7,010	4.3 (3.6 - 4.9)‡‡
		Adjusted††	19,065	11.4 (10.9 - 11.9)‡‡	50,035	24.0 (23.2 - 24.7)‡‡	2,190	1.2 (1.0 - 1.3)‡‡	6,160	3.7 (3.4 - 3.9)‡‡	380	0.3 (0.2 - 0.3)‡‡	2,690	1.7 (1.6 - 1.9)‡‡	7,010	3.7 (3.4 - 3.9)‡‡
	2017	Crude**	18,050	10.9 (10.0 - 11.8)‡‡	51,125	31.0 (29.6 - 32.4)‡‡	1,660	1.0 (0.9 - 1.1)‡‡	5,575	3.4 (3.1 - 3.7)‡‡	420	0.3 (0.2 - 0.4)‡‡	2,625	1.6 (1.4 - 1.8)‡‡	6,990	4.2 (3.6 - 4.9)‡‡
		Adjusted††	18,050	10.8 (10.3 - 11.2)‡‡	51,125	23.9 (23.2 - 24.6)‡‡	1,660	0.9 (0.8 - 1.0)‡‡	5,575	3.3 (3.1 - 3.5)‡‡	420	0.3 (0.2 - 0.4)‡‡	2,625	1.7 (1.5 - 1.8)‡‡	6,990	3.6 (3.3 - 3.9)‡‡

SOURCE: Healthcare Cost and Utilization Project's National Inpatient Sample

Abbreviations: CI = confidence interval.

*Per 100,000 population.

†In-hospital deaths and patients who transferred from another hospital were excluded.

‡Falls of undetermined intent were not included.

§Age <10 years were excluded because determining intent in younger children can be difficult. Rates for TBI-related hospitalizations due to intentional self-harm were age-adjusted to the population 10 years and older.

¶Includes undetermined intent, legal intervention, war, intentional self-harm for age <10 years, and cases without information about cause of injury.

**Hospitalizations with missing age were included.

††Hospitalizations with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

&Rate significantly different compared to 2016, t-tests p-value <0.05.

‡‡Rate significantly different compared to male, t-tests p-value <0.05.

SUPPLEMENTAL TABLE 3

Number and rate* of traumatic brain injury-related (TBI) deaths by sex and mechanism of injury — United States, 2016 and 2017

SEX	YEAR		Motor vehicle traffic crashes		Unintentional falls‡		Unintentionally struck by or against an object		Other or unspecified unintentional injury		Suicide§		Homicide		Other¶	
			NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)	NO.	RATE* (95% CI)
MALE	2016	Crude**	8,357	5.3 (5.1 - 5.4)	9,601	6.0 (5.9 - 6.2)	298	0.2 (0.2 - 0.2)	2,992	1.9 (1.8 - 1.9)	17,382	12.6 (12.4 - 12.7)	4,280	2.7 (2.6 - 2.8)	621	0.4 (0.4 - 0.4)
		Adjusted††	8,357	5.2 (5.0 - 5.3)	9,599	6.1 (6.0 - 6.2)	298	0.2 (0.2 - 0.2)	2,992	1.8 (1.8 - 1.9)	17,380	12.3 (12.2 - 12.5)	4,279	2.7 (2.6 - 2.8)	620	0.4 (0.4 - 0.4)
	2017	Crude**	8,036	5.0 (4.9 - 5.1)	10,180	6.4 (6.2 - 6.5)	291	0.2 (0.2 - 0.2)	3,012	1.9 (1.8 - 1.9)	18,436	13.2 (13.0 - 13.4)	4,316	2.7 (2.6 - 2.8)	693	0.4 (0.4 - 0.5)
		Adjusted††	8,036	4.9 (4.8 - 5.0)	10,180	6.3 (6.2 - 6.4)	291	0.2 (0.2 - 0.2)	3,011	1.8 (1.8 - 1.9)	18,436	13.0 (12.8 - 13.2)	4,315	2.7 (2.6 - 2.8)	692	0.4 (0.4 - 0.5)
FEMALE	2016	Crude**	3,184	1.9 (1.9 - 2.0)‡‡	7,095	4.3 (4.2 - 4.4)‡‡	38	0.0 (0.0 - 0.0)‡‡	1,154	0.7 (0.7 - 0.7)‡‡	2,757	1.9 (1.8 - 2.0)‡‡	1,586	1.0 (0.9 - 1.0)‡‡	195	0.1 (0.1 - 0.1)‡‡
		Adjusted††	3,184	1.9 (1.9 - 2.0)‡‡	7,095	3.2 (3.1 - 3.3)‡‡	38	0.0 (0.0 - 0.0)‡‡	1,154	0.6 (0.6 - 0.6)‡‡	2,757	1.9 (1.8 - 2.0)‡‡	1,586	1.0 (0.9 - 1.0)‡‡	195	0.1 (0.1 - 0.1)‡‡
	2017	Crude**	3,062	1.9 (1.8 - 1.9)‡‡	7,228	4.4 (4.3 - 4.5)‡‡	55	0.0 (0.0 - 0.0)‡‡	1,163	0.7 (0.7 - 0.7)‡‡	2,789	1.9 (1.8 - 2.0)‡‡	1,665	1.0 (1.0 - 1.1)‡‡	208	0.1 (0.1 - 0.1)‡‡
		Adjusted††	3,062	1.8 (1.8 - 1.9)‡‡	7,228	3.2 (3.1 - 3.3)‡‡	55	0.0 (0.0 - 0.0)‡‡	1,163	0.6 (0.6 - 0.6)‡‡	2,789	1.9 (1.8 - 2.0)‡‡	1,665	1.0 (1.0 - 1.1)‡‡	208	0.1 (0.1 - 0.1)‡‡

SOURCE: CDC's National Vital Statistics System

Abbreviations: CI = confidence interval.

*Per 100,000 population.

‡ Falls of undetermined intent were not included. They were included in this category in previous versions of this report.

§Age <10 years were excluded because determining intent in younger children can be difficult. Rates for TBI-related deaths due to suicide were age-adjusted to the population 10 years and older.

¶Includes undetermined intent, legal intervention, war, and intentional self-harm for age <10 years.

**Deaths with missing age were included.

††Deaths with missing age were excluded. Rates age-adjusted to the NCHS 2000 U.S. standard population.

&Rate significantly different compared to 2016, t-tests p-value <0.05.

‡‡Rate significantly different compared to male, t-tests p-value <0.05.

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