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# Traumatic Brain Injury-Related Emergency Department Visits Among American Indian and Alaska Native Persons—National Patient Information Reporting System, 2005–2014

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## Abstract

**Objective:** The American Indian/Alaska Native (AI/AN) population has a disproportionately high rate of traumatic brain injuries (TBIs). However, there is little known about incidence and common mechanisms of injury among AI/AN persons who seek care in an Indian Health Service (IHS) or tribally managed facility.

**Methods:** Using the IHS National Patient Information Reporting System, we assessed the incidence of TBI-related emergency department visits among AI/AN children and adults seen in IHS or tribally managed facilities over a 10-year period (2005–2014).

**Results:** There were 44 918 TBI-related emergency department visits during the study period. Males and persons aged 18 to 34 years and 75 years and older had the highest rates of TBI-related emergency department visits. Unintentional falls and assaults contributed to the highest number and proportion of TBI-related emergency department visits. The number and age-adjusted rate of emergency department visits for TBI were highest among persons living in the Southwest and Northern Plains when compared with other IHS regions.

**Conclusion:** Thousands of AI/AN children and adults are seen each year in emergency departments for TBI and the numbers increased over the 10-year period examined. Evidence-based interventions to prevent TBI-related emergency department visits, such as programs to reduce the risk for older adult falls and assault, are warranted.

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**Keywords**

Alaska native; American Indian; assault; brain injury; fall; TBI; tribal

ACCORDING TO THE INDIAN HEALTH SERVICE (IHS), American Indian and Alaska Native (AI/AN) persons face significant health disparities and a life expectancy that is approximately 5 years less than that of the overall US population (73.0 years to 78.5 years, respectively).[1] Previous reports identify unintentional injury as the third leading cause of death among AI/AN persons of all ages.[2,3] To help improve the health and safety of AI/AN communities, the IHS provides or funds medical and public health services, including injury prevention activities, for approximately 2.3 million AI/AN persons who belong to 573 federally recognized tribes in 37 states.[3]

One type of injury placing significant burden on the AI/AN population is traumatic brain injury (TBI). According to the American Congress of Rehabilitation Medicine, "A TBI is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force."[4] Depending on the severity of the injury, individuals who sustain a TBI may experience a wide range of functional short- or long-term changes affecting thinking (eg, memory and reasoning), sensation (eg, sight and balance), language (eg, communication and understanding), and/or emotion (eg, depression, personality changes, and social inappropriateness).[5] Studies over the last few decades consistently find that AI/AN persons have higher rates of TBI than do other racial/ethnic groups.[6–13] Recently, Daugherty et al[12] found that, in 2017, AI/AN persons had the highest age-adjusted rates for TBI-related deaths compared with all other racial/ethnic groups in the United States (28.3 per 100 000 as compared with 19.4 per 100 000 for non-Hispanic whites, 16.6 per 100 000 for non-Hispanic blacks, 8.0 per 100 000 for non-Hispanic Asian and Pacific Islanders, and 11.3 per 100 000 for Hispanics).

According to a Centers for Disease Control and Prevention (CDC) report, there were approximately 2.53 million TBI-related emergency department visits in the United States in 2014.[14] However, the datasets used to produce this and other national estimates do not contain information on patients' race and ethnicity, nor do they capture care provided by IHS or tribal medical or public health facilities; therefore, there is little known about the incidence and common mechanisms of this injury among a substantial portion of AI/AN persons who seek care in an emergency department for a TBI in the United States.

To address this information gap, we assessed the incidence of TBI-related emergency department visits among AI/AN children and adults seen in IHS or tribally managed facilities over a 10-year period (2005–2014). Using data from the IHS National Patient Information Reporting System (NPIRS), TBI-related emergency department visit data are presented by age, sex, mechanism of injury, and IHS region. Findings from this analysis can help to inform prevention strategies for this at-risk population.

## METHODS

The IHS uses NPIRS, a central repository for inpatient and outpatient encounters in IHS or tribally managed facilities as well as contracted care, to track patient statistics through the use of billing codes. In this analysis, emergency department visit age-adjusted rates captured in NPIRS were calculated as the number of visits per 100 000 user population. User population was defined by the IHS as an unduplicated count of eligible AI/AN persons by residence who had a direct or contract healthcare encounter (inpatient, outpatient, or dental) with the IHS-funded health system during the 3 preceding years. Geographic data were categorized into regions for analysis: Alaska, East (Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Maine, Maryland, Massachusetts, Mississippi, Missouri, New Hampshire, New Jersey, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, West Virginia), Northern Plains (Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, South Dakota, Wisconsin, and Wyoming), Southern Plains (Kansas and Oklahoma), and Southwest (Arizona, Colorado, Nevada, New Mexico, and Utah). We excluded the Western region from inpatient and emergency department discharge datasets due of the lack of IHS or tribally managed hospitals and emergency departments and the incompleteness of information on contract health services. Initial medical encounters were included in this analysis. Subsequent medical encounters were only included if they occurred at least 1 year after the initial TBI-related visit. TBI-related visits were defined by one of up to 15 diagnoses listed on the record including one of the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes for TBI (800: fracture of vault of skull; 801: fracture of the base of skull; 803: other and unqualified skull fractures; 804: multiple fractures involving skull or face with other bones; 850: concussion; 851: cerebral laceration and contusion; 852: subarachnoid, subdural, and extradural hemorrhage, following injury; 853: other and unspecified intracranial hemorrhage following injury; 854.0, 854.1: intracranial injury of other and unspecified nature; 950.1–950.3: injury to the optic nerve and pathways; 959.01: unspecified head injury; and 995.55: shaken infant syndrome).[15]

TBI-related visits were analyzed by year, sex, age group, region, mechanism of injury (defined using *ICD-9-CM* external cause of injury codes),[16] and discharge disposition. Per IHS requirements, cells with fewer than 5 observations were suppressed to avoid identifying individuals. All age-adjusted rates used the direct method and the 2000 projected US population as the standard.[17] Poisson regression was used to obtain 95% confidence intervals for comparison within groups and was compared by examining nonoverlapping confidence intervals. Gamma intervals were used when the cell size was small.[18,19] JoinPoint regression software from the National Cancer Institute was used to calculate the annual percent changes (APCs) of TBI-related emergency department visit rates from 2005 to 2014 for overall and by sex, age group, and IHS region and the change in percentages for mechanism of injury and disposition to illustrate trends over time. APCs were considered significantly different from zero for $P$ values < .05. Data analysis was performed using SAS software version 9.4 (SAS Institute Inc, Cary, North Carolina).

## RESULTS

During 2005–2014, 44 918 TBI-related emergency department visits occurred within IHS hospitals, tribally managed facilities, or contracted care (see Table 1). The overall age-adjusted rate of TBI-related emergency department visits significantly increased between 2008 and 2014 (APC = 4.37, $P < .05$; see Figure 1). Males had higher age-adjusted rates of TBI-related emergency department visits than females throughout the study period (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A336, see Figure 2). Individuals aged 18 to 34 years and 75 years and older had the highest rates of TBI-related emergency department visits during most of our study period. The trends in rates of TBI-related emergency department visits varied by age group (see Figure 3). For example, while the rate of emergency department visits for those aged 0 to 17 years significantly increased between 2008 and 2014 (APC = 3.19, $P < .05$), the rate for those aged 18 to 34 remained relatively constant over the study period.

Regional differences were observed in the age-adjusted rate of TBI-related emergency department visits during the study period (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JHTR/A336). The age-adjusted rate of emergency department visits for TBI was highest among persons living in the Southwest and the Northern Plains when compared with other IHS regions. Over the study period some regions experienced increases in rates (Southern Plains, Southwest), some were stable (Northern Plains, East), and some decreased (Alaska last 3 years) (see Supplemental Digital Content Figure 1, available at: http://links.lww.com/JHTR/A336). Unintentional falls contributed to the highest number and proportion of TBI-related emergency department visits during the entire 10-year study period (see Supplemental Digital Content Table 2, available at: http://links.lww.com/JHTR/A336). Assault was the second leading cause of TBI-related emergency department visits from 2005 to 2014. For the most part, percentage of TBI-related ED visits due to each mechanism of injury were stable over time, with the exception of both assaults and motor vehicle crashes. Proportions for these decreased late in the study period (see Figure 4).

From 2005 to 2014, a majority of patients (67.5% in 2005 and 76.3% in 2014) were discharged from IHS or tribally managed healthcare facilities following a TBI-related emergency department visit (see Supplemental Digital Content Table 2, available at: http://links.lww.com/JHTR/A336). However, there were statistically significant changes over time (see Figure 5). The percentage of patients who were discharged significantly increased between 2010 and 2014 (APC = 2.60, $P < .05$) while the percentage of patients who were transferred significantly decreased during this same period (APC = −=9.23, $P < .05$). Finally, the percentage of patients who were admitted significantly decreased between 2005 and 2014 (APC = −4.85, $P < .05$).

## DISCUSSION

Thousands of AI/AN children and adults are seen each year in emergency departments for TBI in IHS or tribally managed facilities and the rates increased significantly during the study period. Increases in the rate of emergency department visits have also been noted

among the overall US population. A recent CDC report found that age-adjusted rates of TBI-related emergency department visits among the overall US population increased 54% (521.6–801.9 per 100 000 population) during a similar time frame.[14]

In this study, adults ages 18 to 34 years and older adults 75 years and older had the highest rates of TBI-related emergency department visits. This differs from the rates for the overall US population in which the rates are highest among very young children ages 0 to 4 years and older adults, ages 75 years and older.[14] Higher rates among AI/AN adults ages 18 to 34 years as compared with the overall US population may be attributed to higher rates of substance use disorders (which in turn leads to an increased risk for injury) and the increased risk for motor vehicle-related injuries and deaths among this age group in AI/AN communities.[6,12,20] In a CDC report, AI/AN persons ages 15 to 34 years had the highest rate of TBI-related hospitalizations and deaths attributable to motor vehicle crashes.[14] According to an IHS report, AI/AN persons were reported to have a motor vehicle-related death rate that is 200% greater than all other racial/ethnic groups.[21] Primary enforcement of seat belt laws, enforcement of blood alcohol concentration laws of 0.08% (0.08 g/dL) for drivers 21 years and older, and high-visibility enforcement (ie, publicized sobriety checkpoint programs and increased police enforcement efforts coupled with mass media campaigns), are some of the strategies that have been shown to be effective in reducing motor vehicle crash-related injury and deaths in AI/AN communities.[22] Continued focus on implementing these evidence-based strategies, as well as those focused on addressing substance use disorders, may support further reductions in TBIs among this at-risk age group.

Rates of TBI-related emergency department visits among AI/AN older adults 75 years and older overtook those of adults aged 18 to 34 years in 2013. The rising rate of TBI-related emergency department visits among older adults has been connected to the significant increase in fall-related TBIs.[23] Concern over the growing rate of fall-related injuries, such as TBI, on the health and safety of older Americans nationwide has expanded over the last decade and AI/AN persons are at increased risk for fall-related deaths.[3,23] Murphy et al[20] found that the unintentional fall death rate among AI/AN persons was 1.4 times higher than that among white persons. Incidence of fall-related deaths varies by region—with the highest rates in the Southwest and Northern Plains.[20] Among older adult fall-related deaths, more than half have been attributed to TBI.[24] There are several evidence-based and cost-effective older adult fall prevention strategies in the United States (eg, strength and balance exercises, medication review, and physical therapy).[25–27] To support widespread clinical interventions that can protect older adults from falls and their potentially devastating effects, the CDC developed the STEADI (Stopping Elderly Accidents, Deaths & Injuries) initiative (www.cdc.gov/STEADI). Launched in 2012, STEADI seeks to help healthcare providers identify patients at risk for a fall; identify modifiable risk factors; and implement effective strategies to treat or reduce risk.[28] Recently, the CDC created the *Coordinated Care Plan to Prevent Older Adult Falls* to give healthcare providers, practices, and healthcare systems a framework for implementing a STEADI-based fall prevention program.[29] The CDC is currently working to assess the feasibility of implementing STEADI-based fall prevention programs in health systems that serve AI/AN communities. Still, unlike research on motor vehicle crashes, there is a dearth of research on the effectiveness of older adult fall

prevention interventions within AI/AN communities. Further research on evidence-based fall prevention strategies is warranted.

Assault was the second leading cause of TBI-related emergency department visits in this study. In contrast, assault is the fourth leading cause of TBI-related emergency department visits among the overall US population.[14] High rates of intentional injuries (including suicide, intimate partner violence, and child mal-treatment) within the AI/AN community have been documented previously.[3,30–32] Although we were unable to explore the types of assaults leading to TBIs in this study, a review by Sapra et al[31] found that lifetime prevalence of childhood physical abuse among AI/AN youth is 15%[33] and the lifetime prevalence of physical assault by an intimate partner ranges from approximately 30% to 40%.[34–36] Hoopes et al[30] examined trauma registry data in Washington state and found that AI/AN patients had a higher percentage of intentional injuries—homicide/assault and suicide/self-harm—than non-Hispanic, white persons (20.1% vs 6.7%). Higher rates of poverty and unemployment in AI/AN communities[37,38] have been cited as potential contributors to an increased risk for suicide and interpersonal violence. In addition, historical traumas from events such as relocation, forced boarding school attendance, and assimilation are considered important factors in the perpetuation of intentional injuries among AI/AN persons.[39,40] Despite these collective historical trauma experiences, AI/AN communities have shown resiliency through social support and cultural engagement.[41] Interest in culture and strengthening cultural connectedness have been identified as important protective factors for promoting health and avoiding violence in AI/AN communities.[41] Additional research, using a community-based participatory research approach that examines protective factors to address TBIs resulting from intentional injuries among AI/AN children and adults, may be beneficial.[31]

In our analysis, AI/AN males had nearly twice the rate of TBI-related emergency department visits than females. This finding is consistent with previous studies on TBI-related emergency department visits and hospitalizations among AI/AN persons. A review of IHS hospital discharge data between 1992 and 1996 also found distinct differences between TBI rates between males and females, with male TBI rates 2.5 times greater than that of females.[9] Reports on the overall US population also find males at increased risk for this injury; however, the differences in rates between males and females are not as pronounced. Taylor et al[23] reported that the TBI-related emergency department visits, hospitalizations, and death rates between males and females varied by about 18% (959.0 per 100 000 for males compared with 810.8 per 100 000 for females).[21] Future research might explore the factors contributing to these differences to potentially develop sex-specific prevention strategies.

The number and age-adjusted rate of emergency department visits for TBI were highest among persons living in the Southwest and Northern Plains, when compared with other IHS regions. Factors that may impact regional differences in TBI rates, and other injury rates, may include the availability of healthcare services (including distance to a healthcare facility), inconsistent implementation of TBI care practices, poverty level, rural environments, need for expanded tribal traffic safety legislation, and limited availability of law enforcement.[3,20,30,42] Additionally, healthcare utilization and insurance coverage may vary by region. This may particularly affect healthcare-seeking behaviors of individuals with

mild TBI (the type of TBI most commonly seen in an emergency department),[43] as some may not seek medical care for this injury. Murphy et al[20] described the need to tailor AI/AN injury prevention efforts to specific local settings and problems and be inclusive of community engagement to ensure success. Further examination of the leading causes of TBI by region and risk and protective factors can help begin this process and address emerging needs for TBI prevention activities in high-risk areas.

These data allowed us to produce numbers and rates of TBI-related emergency department visits at IHS and tribally managed facilities using the NPIRS dataset for the first time. This fills an information gap that exists in current datasets used to produce national estimates. Still, there are a few limitations to their use. First, IHS and tribally managed facilities are available to AI/AN persons registered as part of a federally recognized tribe. Approximately 2.6 million AI/AN persons access IHS services. In comparison, 5.2 million people self-reported as AI/AN, alone or in combination of other races, in the US census.[44] Thus, these data provide an incomplete picture of AI/AN persons who sustain a TBI because they do not include information regarding those treated in a non-IHS healthcare or nontribally managed facility whose care is paid for through other insurance, such as private insurance or Medicare. It is possible that those individuals who choose to seek care at IHS healthcare tribally managed facilities or utilize IHS coverage at non-IHS healthcare facilities are in some ways different from those who choose not to seek care at these facilities and are covered by other insurance. Additional research regarding potential differences between those who do and do not seek care through IHS or tribally managed facilities may be beneficial. In addition, the Western region was excluded from the analysis based on the rationale described previously. Second, it is possible that the mechanisms of injury reported in Supplemental Digital Content Table 2 (available at: http://links.lww.com/JHTR/A336) are not a completely accurate reflection of the mechanisms of injury among all AI/AN people in general. Third, NPIRS might not capture data from IHS or tribally managed sites that do not use an electronic health record (EHR) compatible with the IHS EHR. Usage of EHRs may vary by IHS region.[45] Finally, the available data do not allow for the assessment of whether any observed trends in the number and rates of emergency department visits over time resulted from a true change in TBI incidence, from care-seeking behaviors, or for other unexamined reasons.

## CONCLUSION

Thousands of AI/AN children and adults are seen each year in IHS or tribally managed facilities for TBI and the numbers increased significantly during the study period. Males, older adults, and AI/AN persons who live in the Southwest and Northern Plains were at increased risk. During the study period, the rates of falls and assault-related TBI emergency department visits were approximately double the rates of other causes. Evidence-based interventions, tailored to the context of the AI/AN community, are needed to prevent TBIs, particularly those that address the leading causes, such as programs to reduce the risk for older adult falls and assault.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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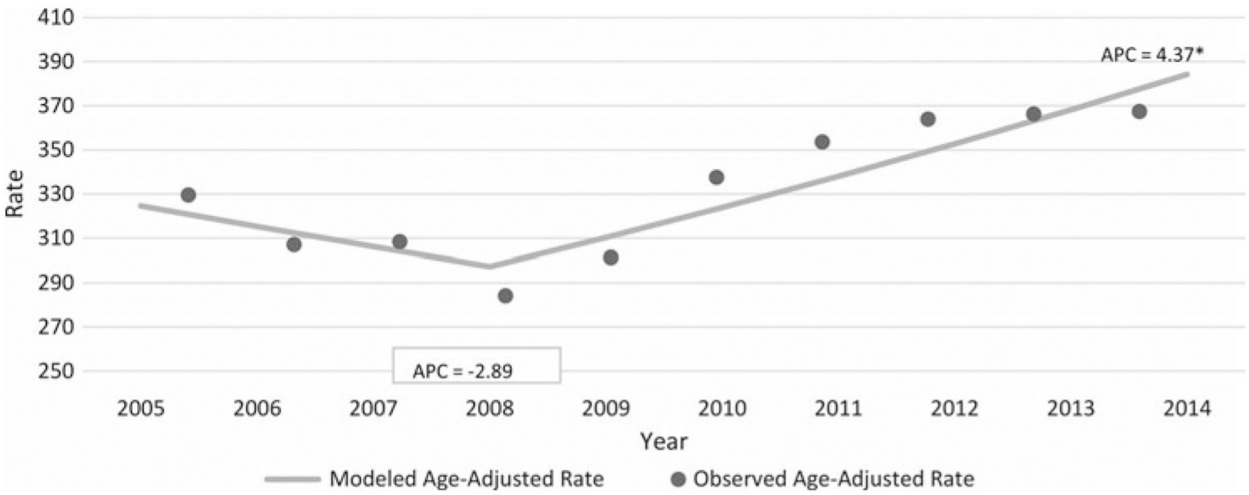


**Figure 1.**

Trend in TBI-related emergency department visit (based on *ICD-9-CM* diagnosis codes used in the TBI morbidity surveillance case definition[14]) age-adjusted rates (age-adjusted to the 2000 US standard population—adjustments made by 5 age groups: 0–17, 18–34, 35–54, 55–74, and ≥75 years) per 100 000 among American Indian and Alaska Natives in the National Patient Information Reporting System, 2005–2014. Asterisk (*) denotes statistically significant APC. APCs were calculated using JoinPoint regression. APC indicates annual percent change; *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; TBI , traumatic brain injury.

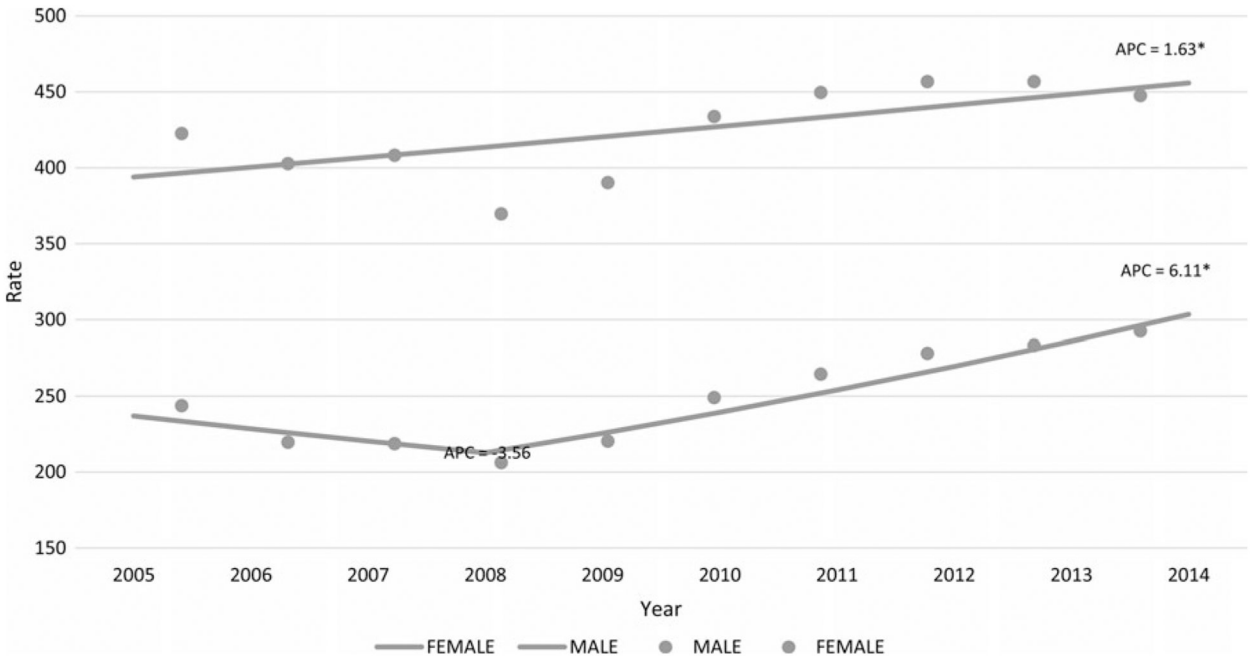


**Figure 2.**

Trend in TBI-related emergency department visit (based on *ICD-9-CM* diagnosis codes used in the TBI morbidity surveillance case definition[14]) age-adjusted rates (age-adjusted to the 2000 US standard population—adjustments made by 5 age groups: 0–17, 18–34, 35–54, 55–74, and ≥75 years) per 100 000 among American Indian and Alaska Natives in the National Patient Information Reporting System, by sex, 2005–2014. Asterisk (*) denotes statistically significant APC. APCs were calculated using JoinPoint regression. APC indicates annual percent change; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*; TBI , traumatic brain injury.

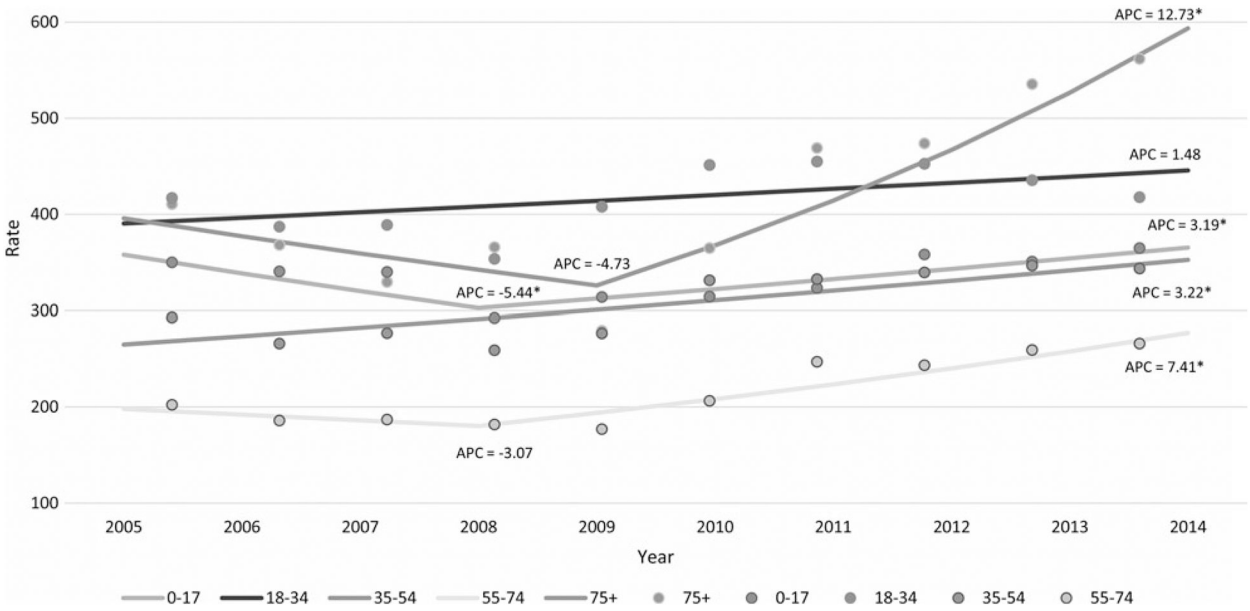


**Figure 3.**

Trend in TBI-related emergency department visit (based on *ICD-9-CM* diagnosis codes used in the TBI morbidity surveillance case definition[14]) age-adjusted rates (age-adjusted to the 2000 US standard population—adjustments made by 5 age groups: 0–17, 18–34, 35–54, 55–74, and ≥75 years) per 100 000 among American Indian and Alaska Natives in the National Patient Information Reporting System, by age, 2005–2014. Asterisk (*) denotes statistically significant APC. APCs were calculated using JoinPoint regression. APC indicates annual percent change; *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; TBI , traumatic brain injury.

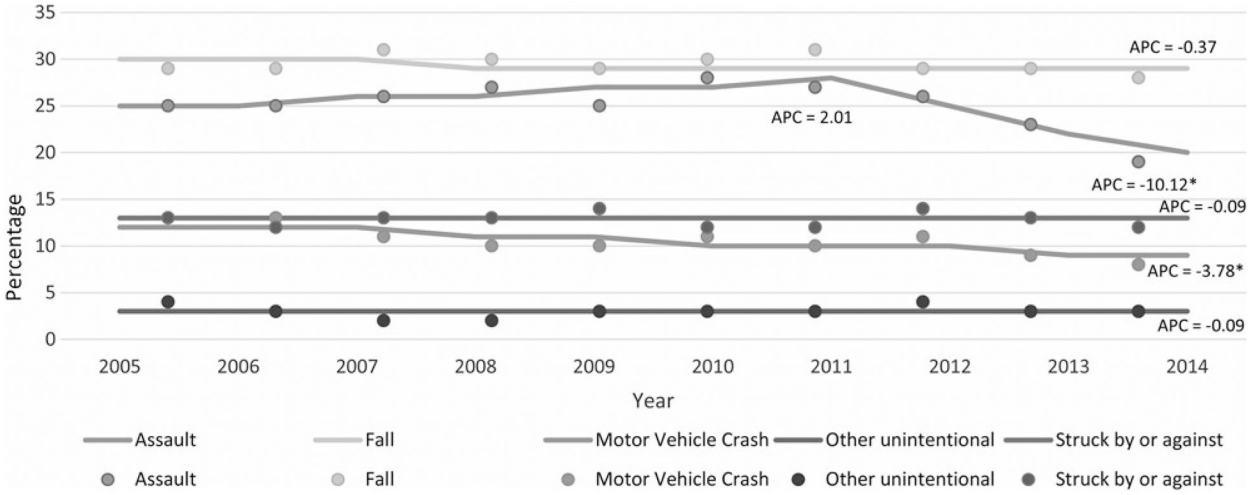


**Figure 4.**

Trend in percentage of TBI-related emergency department visits (based on *ICD-9-CM* diagnosis codes used in the TBI morbidity surveillance case definition[14]) due to each mechanism of injury among American Indian and Alaska Natives in the National Patient Information Reporting System, 2005–2014. Asterisk (*) denotes statistically significant APC. APCs were calculated using JoinPoint regression. Due to small numbers and missing data, self-harm and other or no mechanism specified are not presented in the figure. APC indicates annual percent change; *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; TBI, traumatic brain injury.

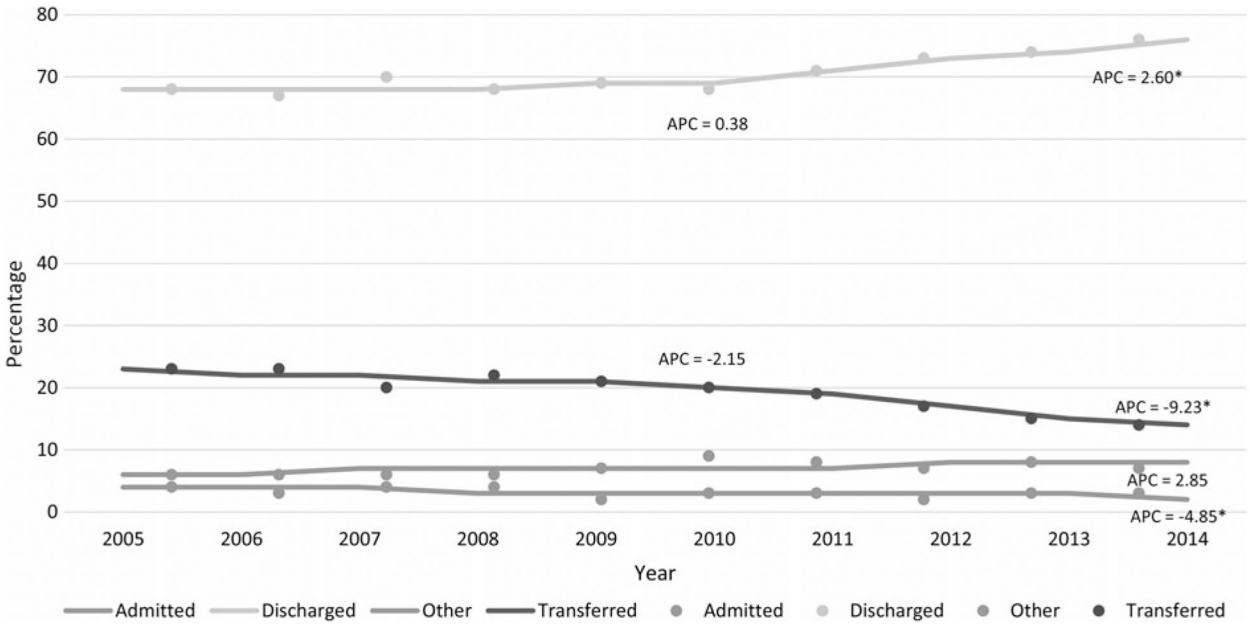


**Figure 5.**

Trend in percentage of TBI-related emergency department visits (based on *ICD-9-CM* diagnosis codes used in the TBI morbidity surveillance case definition[14]) by disposition among American Indian and Alaska Natives in the National Patient Information Reporting System, 2005–2014. Asterisk (*) denotes statistically significant APC. APCs were calculated using JoinPoint regression. APC indicates annual percent change; *ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification*; TBI, traumatic brain injury.

## TABLE 1

Number and age-adjusted[a] rates for traumatic brain injury-related emergency department visits[b] in the National Patient Information Reporting System, 2005–2014

| Year | Number | Rate[c] |
|---|---|---|
| 2005 | 4237 | 329.5 |
| 2006 | 4018 | 307.0 |
| 2007 | 4069 | 308.3 |
| 2008 | 3752 | 284.1 |
| 2009 | 4133 | 301.3 |
| 2010 | 4616 | 337.5 |
| 2011 | 4851 | 353.5 |
| 2012 | 5046 | 363.8 |
| 2013 | 5066 | 366.2 |
| 2014 | 5130 | 367.4 |
| Total | 44918 | 333.4 |

[a] Age-adjusted to the 2000 US standard population (adjustments made by 5 age groups: 0–17, 18–34, 35–54, 55–74, and ≥75 years).

[b] Based on ICD-9-CM TBI-related diagnosis codes used in the TBI morbidity surveillance case definition.[14]

[c] Rate per 100 000 population.