State of Alaska Epidemiology **Bulletin** Recommendations and Reports

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Traumatic Brain Injury in Alaska

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Executive Summary

The purpose of this report is to characterize the epidemiology of traumatic brain injury (TBI)-related morbidity and mortality in Alaska, identify independent risk factors for mortality following a severe TBI, provide estimates of statewide Medicaid expenditures resulting from TBI-related injuries, and understand the reported service needs for populations living with a TBI in Alaska. In doing so, this report highlights the considerable burden of TBI-related injuries in Alaska and the disproportionate impact of TBIs in certain populations. A TBI can be characterized as a bump, blow, or jolt to the head, or a penetrating head injury that disrupts normal brain function. The severity of TBIs range from mild to severe injury that can result in prolonged periods of unconsciousness, coma, or death. Substantial neurologic complications may occur following a TBI, including seizures, dementia, Alzheimer's disease, cranial nerve injuries, psychiatric complications, and disruption of childhood development.

During 2016–2021, Alaska's TBI-related mortality rate was the highest in the nation, and more than double the national average. TBI-related mortality rates were highest among people aged ≥85 years, males, American Indian/Alaska Native (AI/AN) people, and those living in the Northern Region. TBI-related mortality resulting from suicide was attributable to 43% of all TBI-related deaths in Alaska. Young adults were disproportionately affected by suicide. Rates of TBI-related mortality attributable to suicide in people aged 25–34 years were over three times as high as the 2019 national average. One in four deaths in people aged <30 years occurred following a TBI. Among patients hospitalized following a TBI in Alaska, those with intentionality to their injury indicative of self-harm were over eight times as likely to die than those with an unintentional injury. AI/AN people experienced a disproportionate burden of TBI-related mortality in Alaska, with an age-adjusted rate that was over three times higher than the national average.

A large proportion of TBI morbidity in Alaska is due to unintentional falls, resulting in 39% of TBI emergency department (ED) visits during 2016–2021 and 44% of TBI hospitalizations during 2017–2021. However, considerable differences were observed for mechanisms of injury attributing to TBI morbidity by age, sex, location, and race. Among adults aged 15–34 years, the most common mechanism for both TBI ED visits and inpatient hospitalizations was motor vehicle crashes. Whereas unintentional falls were the most common mechanism of injury for ED visits among persons aged ≥35 years and inpatient hospitalizations among persons aged ≥45 years. Rates of TBI attributable to assault were 1.6 and 3.7 times higher among males compared to females for ED visits and inpatient hospitalizations, respectively. Unintentional falls were the most common mechanism of injury for TBI-related ED visits in all regions of Alaska apart from the Southwest region, where assault was the most common mechanism for TBI-related ED visits. For TBI inpatient hospitalizations, unintentional falls were the most common mechanism of injury in all regions, except for the Southwest and Northern regions where the most common mechanism of injury was motor vehicle crashes. In the Northern region, all-terrain vehicle (ATV) and snowmachine-related injuries represented 39% of all TBI hospitalizations. Rates of TBI hospitalization and ED visits by race were highest among AI/AN people.

TBIs result in substantial economic burden on populations and health care systems. Although not reflective of the total financial cost of TBIs in Alaska, the total Medicaid expenditures spent on TBI-related claims in Alaska during 2017–2021 exceeded $29 million. The average Medicaid expenditures per claim were highest for inpatient ($26,048) and long-term care services ($18,052).

People with an existing TBI in Alaska and their family members, caregivers, or guardians reported a range of perceived barriers to accessing TBI services. These principally included geographic and financial limitations, but overall awareness of TBI-related services was also low. Health care professionals also reported observing difficulties in patient access to and provision of TBI services, including a lack of coordinated case management and financial restraints resulting in breakdowns in continuity of care.

The findings from this report underscore the disproportionate impact of TBIs in Alaska compared to other states, the need for targeted TBI prevention efforts, and the need for increased access to appropriate treatment and supportive services statewide.

1.0 Introduction

A traumatic brain injury (TBI) can be characterized as a bump, blow, or jolt to the head, or a penetrating head injury that disrupts normal brain function. The severity of TBIs range from mild to severe injury that can result in prolonged periods of unconsciousness, coma, or death. Substantial neurologic complications may occur following a TBI, including seizures, dementia, Alzheimer's disease, and cranial nerve injuries. People may also suffer from various psychiatric complications, including depression, posttraumatic stress disorder, generalized anxiety disorder, obsessive-compulsive disorder, and other cognitive and behavioral sequelae. TBIs in children may disrupt childhood development, resulting in potential cognitive, academic, and socio-behavioral impacts.

TBIs are a considerable source of morbidity and mortality nationwide, contributing to approximately 1 million deaths over the last 2 decades.[1] In 2019, more than 223,000 TBI-related inpatient hospitalizations were recorded nationwide; in 2020, 60,611 deaths were attributable to TBIs.[2] While anyone is at risk for experiencing a TBI, residents of rural areas are at increased risk of TBI-related mortality relative to their urban counterparts.[3] The reasons for this are thought to include higher costs for care, limited access to specialized care, further distance to care, and inability to pay. Residents of rural areas in the US who survive a TBI are also more likely to experience challenges accessing specialized TBI care and TBI-related services to help in their recovery.[4,6]

Alaska has one of the highest reported rates of TBI-related mortality nationwide.[3] With a population of approximately 734,300 people distributed across large geographic distances, Alaska exemplifies many of the challenges associated with TBIs in rural areas, including challenges in health care access, lack of specialized TBI care, and high rates of outdoor activities known to increase risk of TBIs.

The purpose of this report is to characterize the epidemiology of TBI-related morbidity and mortality in Alaska, identify independent risk factors for mortality following a severe TBI, provide estimates of statewide Medicaid expenditures resulting from TBI-related injuries, and understand the service needs for TBI care in Alaska.

2.0 Methods

Data were obtained from multiple statewide surveillance systems and databases, each of which is described in detail below. Data sources were grouped into one of four categories: morbidity, mortality, Medicaid expenditure, and population needs. Morbidity and mortality rates were calculated per 100,000 population. Population estimates were obtained from the Alaska Department of Labor and Workforce Development, Research and Analysis Section.[7] Morbidity and mortality data were also stratified to examine TBI rates by age, sex, race, public health region of residence, year, and mechanism of injury. Age-adjusted rates of TBI-related mortality and inpatient hospitalizations were calculated to facilitate more accurate comparisons to the national averages for corresponding available years. For this, the direct method of standardization was applied utilizing the 2000 U.S. standard Census population weighting.

2.1 Morbidity

2.1.1 Health Facilities Data Reporting Program

The Health Facilities Data Reporting (HFDR) managed by the Health Analytics and Vital Record Section (HAVRS) collects inpatient and outpatient discharge data from Alaska health care facilities. Initiated in 2001 as a passive system, the Alaska Hospital Discharge Database collected voluntarily reported inpatient discharge data. It was expanded in 2008, to incorporate outpatient discharges which included hospital emergency department, ambulatory surgery, and radiology data. In December 2014, discharge reporting became mandatory for hospitals and expanded facility types, which resulted in more comprehensive and consistent statewide inpatient and outpatient discharge data. By 2021, the HFDR included all in-state health care facilities in Alaska (apart from the two Department of Defense hospitals). For this analysis, the HFDR was used to examine TBI outpatient discharges only as the Alaska Trauma registry was used to provide detailed inpatient TBI hospitalization data.

The HFDR data were queried for emergency department (ED) visits from 2016–2021 using the same established methodology as national TBI surveillance reports.[8] Identified TBI cases required both a recorded injury (Appendix A) as the principal diagnosis and any TBI-related International Classification of Diseases, tenth revision (ICD-10) code as developed by CDC's National Center for Injury Prevention and Control (NCIPC) and National Center for Health Statistics (NCHS) [9] (Appendix B) recorded in any of the 29 diagnosis fields. To classify TBI records by injury mechanism, each case was assigned a single cause based on the first valid external cause of injury. As there are multiple fields in which codes with external cause information can be found and potentially multiple causes for each case, fields were searched in a specific order for external cause information (Appendix D). Four hundred and fifty (4%) ED visit records were excluded that had no valid external cause of injury identified. Once the first valid external cause of injury was identified, it was classified into the categories of interest (Appendix E) corresponding to the ICD-10-CM external cause of injury matrix.[10] CDC categorizes all-terrain vehicle (ATV) and snowmachine injuries into the mechanism of "other, unspecified". However, due to the prevalence of ATV and snowmachine use in Alaska and their role as primary motor vehicles in many communities, we categorized ATVs and snowmachine injuries as "motor vehicle crashes" for all analyses.

National estimates of TBI-related ED visits are not available. Therefore, to enable accurate comparisons for rates of non-fatal hospitalizations between Alaska and the national average, we also queried the HFDR for non-fatal inpatient hospitalizations from 2016–2021 using the same methodology as above. Age-adjusted rates of non-fatal inpatient hospitalizations were then calculated and compared to the US average for available years.

2.1.2 Alaska Trauma Registry

The Alaska Trauma Registry (ATR) was established to collect data pertaining to hospitalizations involving the most seriously injured patients in Alaska. The ATR covers all 24 acute care hospitals (22 civilian and two U.S. Department of Defense) with the goal of evaluating the quality of trauma patient care and planning and evaluating injury prevention programs. Trauma admissions recorded in the ATR include all patients with a reported injury who are admitted to, or held for observation in, an Alaska hospital; declared dead in the emergency department; and/or transferred to another acute care hospital. Clinical notes from all trauma injury admissions are converted into ICD-10 codes to record both patient injuries and external causes of injury.

Population-based rates of TBI hospitalization are likely underestimated when relying solely on administrative databases for case ascertainment, particularly if relying on data from billing rather than clinical purposes (i.e., administrative claims).[11,12,13] This is especially relevant for polytrauma patients, where TBIs may not be appropriately documented/coded unless relevant for reimbursement.[14,15] Further, TBI case definitions based exclusively on ICD-10 codes may miss codes indicative of a TBI (e.g., fracture of face bones [S02.2], other open wound of head [S01.0], dislocation of jaw [S03.0], injury to blood vessels of head and neck [S09.0], crushing injury of face and scalp [S07.0]) if not part of the ICD-10 based definition.

The ATR addresses the limitation of ICD code-based definitions by incorporating clinical hospital data capturing a range of patient information including clinical text descriptions of patients' injuries. This source enabled identification of TBI-related hospitalizations without relying exclusively on billing data and ICD-10-based case definitions. TBI-related hospitalization records from the ATR were identified in three ways. Firstly, ATR data were queried for all records containing a TBI-related ICD-10 code (Appendix B) in any of the diagnoses fields. Secondly, all records that had a TBI diagnosis mentioned in the clinical notes were included. Thirdly, data were queried for all records containing the ICD-10 code S09.9 (unspecified injury of the head). This code has high sensitivity but low specificity in capturing TBIs.[16] To balance overall accuracy, records with S09.90 listed along with the any of following in clinical notes were included; a recorded loss of consciousness >30 minutes; post traumatic retrograde amnesia; worst Glasgow Coma Scale in first 24 hours <13 (not attributable to intoxication, sedation, or documented systemic shock); or death from injury.

Injury mechanism for each patient record was assigned a single cause of injury based on the first valid external cause of injury using the same methodology as described above for HFDR data using the defined injury categories of interest (Appendix E).

We compared the rates of non-fatal TBI hospitalizations in the ATR using the methodology above to those calculated using Alaska's HFDR inpatient discharge database, which relies on TBI-related ICD-10 codes obtained from billing. This provided an estimate of the impact on TBI rates of relying exclusively on billing ICD-10 codes for case ascertainment.

Finally, we used ATR data to identify independent risk factors for mortality in all hospitalized patients with a recorded TBI. We selected age, sex, race, initial GCS upon admission, injury severity score (ISS), and injury mechanism as variables for analysis based on previous research findings examining risk factors for TBI-related mortality.[17,18] Differences between patients who died and those who survived were compared for each variable of interest using the X^2 test for categorical variables and Mann–Whitney U test for continuous variables. To quantify independent (adjusted) relative association of the selected variables, those demonstrating a significant relationship ($p<0.05$) in univariate (unadjusted) analysis were added to a multivariable logistic regression model to calculate adjusted odds ratios.

2.2 Mortality

2.2.1 Alaska Vital Statistics

Death certificates from the Alaska Vital Statistics system, managed by the Health Analytics and Vital Records Section were obtained for years 2016–2021. TBI-related mortality was calculated using the same methodology as established national surveillance reports.[8] Deaths were included as a TBI-related death if the record included an injury-related ICD-10 underlying cause of death code (V01–Y36, Y85–Y87, Y89, U01–U03) and a TBI-related ICD-10 code (Appendix C) corresponding to the established TBI death surveillance definition in one of the multiple causes of death fields.[19] To determine injury mechanism, underlying cause of death fields were searched for the codes listed in Appendix D, and grouped into categories consistent with the ICD-10 external cause of injury matrix.[9] (Appendix F). Age-adjusted rates of TBI-related mortality in Alaska were also compared to the national average for available corresponding years.

2.3 Medicaid Expenditure

To assess the economic impact of TBIs on the Medicaid program in Alaska, we obtained Medicaid claims data for all Alaskans enrolled in Medicaid during 2017–2021 with a recorded TBI-related health care event. TBI-related health care events were defined as any Medicaid claim containing a TBI-related ICD-10 hospitalization code (Appendix B) as the principal diagnostic field with an external cause of injury (Appendix A) reported. We defined Medicaid expenditure as the amount paid by Medicaid (payer perspective) for TBI-related health care events during 2017–2021. Other injuries without TBI-related ICD-10 codes that may have occurred either simultaneously to (e.g., polytrauma cases), or because of a TBI (e.g., cognitive sequelae or post-concussion syndrome) were not included in expenditure estimation.

We calculated total and annual Medicaid expenditures for all TBI-related claims. To compare TBI-related Medicaid expenditure by the type of service utilized, we also calculated average expenditure by service type (e.g., inpatient, outpatient, professional expenses, transportation, and long-term care).

2.4 Population Needs Assessment

TBIs can affect numerous aspects of a person's life. Chronic neurobehavioral and psychosocial difficulties following TBIs are common. People living with a TBI, and their families often require ongoing services and supports, ranging from acute rehabilitation to long-term assistance with housing and employment-related activities. Individual needs are different and can change over time requiring that systems provide person-centered services and support. Various services exist for people living with TBI in Alaska; however, no research to date has been conducted on understanding the perceived barriers that people living in Alaska face in accessing these services.

We summarize the results of a Brain Injury Needs Assessment conducted in 2019 by the University of Alaska Anchorage, Center for Human Development in order to present some of the short and long-term service needs of people living with TBIs in Alaska. This assessment gathered information from three groups of participants across Alaska: adults with a TBI; family members, caregivers, or guardians of people with a TBI; and health care professionals. The survey was conducted using a snowball sampling design and was sent to people via email and listservs. Specific listservs included the Center for Human Development, the Alaska Brain Injury Network (ABIN), the Statewide Independent Living Council (SILC), the Governor's Council on Disabilities and Special Education, the Alaska Mental Health Trust Authority, Access Alaska, the Disability Law Center (DLC), and the Joint Base Elmendorf-Richardson (JBER) TBI Clinic.

Participants were asked questions about their demographic characteristics, and multiple-choice questions were developed to assess participants' reported needs relating to their TBIs. Self-report Likert scale statements were used to evaluate participant satisfaction with TBI services in Alaska, with zero being 'extremely dissatisfied' and five being 'extremely satisfied'. We summarized survey results using basic descriptive statistics which included frequency counts and proportions. Mean averages of the Likert scales were also calculated to give broad estimates of satisfaction across all respondents. Finally, open-ended questions were used to collect additional qualitative information relating to the perceived experiences of living with TBIs.

3.0 Results

3.1 Morbidity

3.1.1 Non-Fatal Emergency Department Visits

During 2016–2021, 12,251 TBI ED visits were identified statewide. Annual rates were highest in 2016 (303.4 per 100,000 population) and lowest in 2020 (233.5 per 100,000 population) (Figure 1). The median age (based on initial health care visit date) was 31 years (IQR: 33).

The average annual incidence was highest in people aged 15–19 years (517.4 per 100,000 population).

Fifty-three percent of TBI ED visits were in males; considerable sex-based differences in rates of TBI ED visits occurred by injury mechanism (Table 1). Males had 1.6 times the rate of TBIs attributable to assault relative to females (45.2 vs. 28.3 per 100,000 population, respectively), while females had a higher rate of unintentional falls (114.9 vs. 102.8 per 100,000 population, respectively). Unintentional falls were the most common injury mechanism for all TBI ED visits, with a rate of 108.8 visits per 100,000 population (Table 1). Rates by injury mechanism also differed by age (Figure 2). For people aged 15–34 years, motor vehicle crashes were the most common mechanism of injury. For all other ages, unintentional falls were the most common mechanism of injury.

Rates of TBI ED visits by region of residence were highest in the Southeast region and lowest in the Interior region (363.1 vs. 217.5 cases per 100,000 population, respectively). Unintentional falls were the most common mechanism of injury across all regions apart from the Southwest region where the most common injury mechanism was assault (71.3 per 100,000 population) (Figure 3). Ninety-two percent of people were evaluated at an ED in their corresponding region of residence.

The rate of TBI ED visits among AI/AN people was twice that of White people (488.8 vs. 244.0 per 100,000 population, respectively). The most common mechanism of injury in AI/AN people was unintentional falls, with a rate 1.6 times higher than the rate observed in White people (168.9 vs. 102.7 per 100,000 population, respectively). Rates of TBI ED visits attributable to assault were more than five times higher among AI/AN people compared to White people (116.0 vs. 19.7 per 100,000 population, respectively) (Figure 4). For TBI ED visits attributable to motor vehicle crashes 41% (214/522) and 16% (215/1330) were attributable to ATVs/snowmachines in AI/AN and white people, respectively.

3.1.2 Non-Fatal Inpatient Hospitalizations

During 2017–2021, 2,821 non-fatal TBI hospitalizations were identified through the ATR. Annual rates of TBI hospitalization during the observation period ranged from 83.8 per 100,000 population in 2017 to 70.5 per 100,000 population in 2021 (Figure 5). The median age at hospitalization was 46 years (IQR: 41); age-specific incidence was highest in those aged ≥85 years (453.4 per 100,000 population) (Figure 6).

Sixty-five percent of all non-fatal TBI hospitalizations occurred in males who had a TBI hospitalization rate 1.8 times that of females. When comparing injury mechanism by sex, the greatest rate difference was observed for TBI hospitalizations attributable to assault where males had a rate 3.7 times that of females (Table 2). Unintentional falls were the most common injury mechanism accounting for 44% of all non-fatal TBI hospitalizations with a rate of 34.0 per 100,000 population; this was followed by motor vehicle crashes (23.3 per 100,000 population) (Table 2).

The highest rates non-fatal TBI hospitalization were observed in the Northern region (109.4 hospitalizations per 100,000 population), where the most common mechanism of injury was motor vehicle crashes, representing 48% of all hospitalizations (Figure 7); 26% and 13% of TBI hospitalizations in the Northern region were due to ATVs and snowmachines, respectively (Figure 8). In the Southwest region, motor vehicle crashes were also the most common injury mechanism, representing 41% of TBI-related hospitalizations. In all other regions, the most common mechanism of injury was unintentional falls (Figure 7). For 86% of people hospitalized with a TBI, the injury occurred in their region of residence.

The rate of TBI hospitalization among AI/AN people was 2.3 times that of White people (158.3 vs. 67.0 per 100,000 population, respectively) (Figure 9). While unintentional falls were the most common injury mechanism in all races, motor vehicle crashes were the most common cause of TBI hospitalization among AI/AN people (Figure 9). This was due predominantly to ATV/snowmachine-related injuries, which were involved in 47% (146/312) of all motor vehicle crashes among AI/AN people.

Thirty-nine percent (1107/2821) of people with a non-fatal TBI hospitalization were admitted to the intensive care unit (ICU), with a median ICU stay of 3 days. Of all patients with a non-fatal hospitalization, the majority (59%) had temporary disability but were expected to return to normal level of function (Table 3).

Rates of TBI hospitalization were significantly higher when using the expanded TBI case definition to query ATR data than when using ICD-10 billing data from the HFDR (Figure 10). On average, the HFDR underestimates TBI incidence by approximately 33%. This discrepancy remained relatively stable by year, ranging from 24% in 2020 to 38% in 2021. This finding suggests that rates of TBIs detected in hospitalized patients are considerably underestimated if relying on ICD-10 billing data alone.

During 2017–2021, 324 patients died after being hospitalized with a TBI, representing 11% of all TBI hospitalizations. After controlling for predictor variables significantly related to mortality (Table 4), the greatest independent risk factor for death following a TBI in hospitalized patients was self-inflicted injury most likely due to the use of immediately lethal means (i.e., firearms). Patients with a TBI attributed to self-harm were over eight times as likely to die compared to patients hospitalized due to an unintentional injury (adjusted odds ratio = 8.96; 95% CI: 5.11-16.12]) (Table 5). Patients who died following a TBI-related injury were also more likely to be older (adjusted odds ratio = 1.04; 95% CI: 1.03–1.05), have a lower GCS upon admission (adjusted odds ratio = 0.74; 95% CI: 0.71–0.76), and a higher injury severity score upon admission (adjusted odds ratio = 1.07; 95% CI: 1.06–1.09).

Age-adjusted TBI hospitalization rates calculated using CDC's ICD-10 case definition applied to HFDR data appeared lower in Alaska than the national average for 3 of the 4 corresponding years (Figure 11). The largest difference was observed in 2018, when the average rates nationally were 1.2 times that of Alaska (62.4; 95% CI: 61.0–63.7 vs. 50.4; 95% CI: 45.2–55.6 per 100,000 population, respectively).

3.2 Mortality

3.2.1 TBI-related Fatalities

During 2016–2021, 1,527 TBI-related deaths were identified in Alaska yielding an annual average mortality rate of 34.7 deaths per 100,000 population. TBI-related deaths represented 5% of all deaths and 25% of all deaths in people aged <30 years.

During the observation period, age-adjusted rates of TBI-related mortality in Alaska were up to 2.2 times as high as the national average (Figure 12). There was variability in TBI-related mortality rates within Alaska, with age-adjusted rates being highest in the Northern region (57.1 per 100,000 population; 95% CI: 45.3–69.0) and lowest in the Southeast region (28.2 per 100,000 population; 95% CI: 23.2–33.3) (Table 6).

Seventy-five percent of all TBI-related deaths were among males, with an age-adjusted rate of TBI-related mortality over three times that of females (Table 6). Rates of TBI-related mortality were highest among those aged ≥85 years (146.0 per 100,000 population); of which, most injuries resulted from unintentional falls (Figure 13). Among adults aged <75 years, 20–24-year-olds had the highest rate of TBI-related mortality (61.3 per 100,000 population); 61% of the deaths in this age group were attributable to suicide.

Suicide was the largest single cause of TBI-related mortality in Alaska across all regions (Figure 14). Forty-three percent of all TBI-related deaths were attributable to suicide; of which, 98% involved a firearm. The rate of TBI-related mortality attributable to suicide in Alaska was 2.2 times as high as the latest 2019 national average (15.7 vs. 7.2 per 100,000 population).[8] Rates of TBI-related mortality attributable to suicide varied by sex (Table 7) and age (Figure 13), with the highest rates observed among males (24.5 per 100,000 population) and those aged 20–24 years (37.5 per 100,000 population). Among people aged 25–34 years in Alaska, the rate of TBI-associated mortality attributable to suicide was over three-times that of the 2019 national average (22.4 vs 7.2 per 100,000 population, respectively).

AI/AN people had an age-adjusted rate of TBI-related mortality two-times that of White people (67.3; 95% CI: 61.0–73.6 per 100,000 vs. 32.9; 95% CI: 30.8–35.0 per 100,000 population) (Table 6) and over three-times that of the 2019 national average.[8] Age-adjusted rates of TBI-related mortality attributable to suicide were highest among AI/AN people (23.6 deaths per 100,000 population; 95% CI: 20.0–27.2), who had a rate 1.6 times that of White people (14.6 deaths per 100,000 population; 95% CI: 13.2–16.0) (Table 8) and 3.3 times that of the national average.[8] AI/AN people also had the highest age-adjusted rate of TBI-mortality attributable to motor vehicle crashes in Alaska (16.3 deaths per 100,000 population; 95% CI: 13.4–19.4). However, the rate of TBI-related mortality attributable to homicide was highest amongst Native Hawaiian and Other Pacific Islanders (NHOPI) (14.5 deaths per 100,000 population; 95% CI: 5.9–23.1) and was eight times that of the 2019 national average.[8]

3.3 Medicaid Costs

During 2017–2021, 4,726 Medicaid enrollees submitted 11,576 TBI-related Medicaid claims. Total Medicaid expenditures on TBIs in Alaska during this period were $29,016,558. Total Medicaid expenditures on TBI during each year of the study ranged from $5,501,908 in 2017 to $6,276,793 in 2019 (Table 9). Inpatient services were the largest contributor to TBI-related Medicaid expenditures, with an average cost per claim of $26,048, followed by long-term care which had an average cost per claim of $18,052 (Figure 16).

3.4 Population Needs Assessment

A total of 311 people completed or partially completed the population needs assessment survey, consisting of 74 adults with a self-reported TBI; 72 family members, caregivers, or guardians of people with a TBI; and 165 health care professionals.

3.4.1 People with a TBI

Sixty-three (85%) of the 74 respondents with a reported TBI answered demographic questions. Of those, 38% were male, 65% lived in urban areas, and 12% were military veterans. Sixty (81%) of the 74 respondents completed survey questions relating to health care access. Of those, 43 (72%) reported difficulties in accessing health care services because of their TBI. Participants listed multiple services they desired but were unable to access, including neuropsychological exams (28%, n=17) and vision assessment/therapy (25%, n=15). They also cited multiple barriers to service utilization, including finding a medical provider (40%, n=24) and paying for appointments (35%, n=21) (Table 10). Participants from rural communities also frequently relayed concerns about having to fly to Anchorage for treatments.

Overall, service utilization was low for participants with a reported TBI. The most utilized services were the Brain Injury Association of Alaska and vocational rehabilitation services, with 22 (29%) and 21 (28%) of participants, respectively, having ever utilized these services (Table 11). Of the 64 participants who responded, 63% (n=40) were unaware of the existence of the Traumatic and Acquired Brain Injury (TABI) mini grant program used to meet the needs of those who have sustained a traumatic or acquired brain injury.[20]

Overall, service satisfaction levels were also low. Participants were least satisfied with services surrounding benefits and financial support (mean; 2.15, n=48) and legal assistance (mean; 2.17, n=35). Through open-ended questioning, the following themes emerged for why people felt dissatisfied with services in Alaska. Firstly, the limited access to services, particularly for participants located in rural Alaska who "have a hard time accessing care without having to pay for flights out of town." Secondly, perceived need for provider and community education surrounding TBIs, specifically on timely diagnoses of brain injuries with several participants stating "there are very few providers that understand brain injury." Finally, the financial difficulties experienced following a TBI with costs of healthcare, housing, and appointment transportation with "more affordable health care" being commonly cited among participants.

3.4.2 Family Members, Caregivers, or Guardians of People with TBIs

Participants in the family member, caregiver, and guardian group were asked about their relationship to the individual with a TBI that they were representing. Of the 65 participants who responded, most were the individual's parent (37%, n=24) or partner/spouse (32%, n=21). When asked about training or education in brain injuries that they had received to assist them in supporting their relative/client, 53% (n=29) of the participants who responded reported completing informal self-study only.

Like people in the TBI group, overall service utilization was also low for participants in the family member, caregiver, and guardian group. The most utilized services were the Brain Injury Association of Alaska and vocational rehabilitation services used by 30% (n=22) and 20% (n=15) of participants, respectively. However, most participants reported that their relative/client had never used the agencies listed (Table 12). Eighty-seven percent (n=53) of participants reported experiencing difficulties in accessing health care for their relative/client with a brain injury. Specific difficulties included understanding the information given (44%, n=32) and managing prescription medications (30%, n=22). Services accessed most commonly over the last 6 months by participants were neurology services (29%, n=21), physical therapy (26%, n=19), and neuropsychological exams (26%, n=19). Health care services that participants had desired over the past 6 months but were unable to access included neurology services (28%, n=20), mental health counselling (26%, n=19), chiropractic services (26%, n=19), and relationship counselling (26%, n=19). Neurology services are both the most accessed services and the most needed, implying that the demand for this service is much higher than the current capacity allows.

Overall, satisfaction level with services were low for participants. Services with the lowest overall satisfaction were those involving legal assistance (mean; 1.78, n=37), employment (mean; 1.97, n=37), and respite/caregiver support (mean; 2.03, n=34). The main reasons listed for service dissatisfaction through open questioning were lack of clarity on how to access services, financial difficulties with costs of care, lack of providers, and community education.

3.4.3 Health care Professionals

The highest proportion (28%) of health care professionals surveyed worked in the medical field, followed by mental/behavioral health services (25%) (Table 13). Sixty-two percent (n=97) of surveyed participants worked in urban areas (Municipality of Anchorage, City and Borough of Juneau, and Fairbanks North Star Borough). Areas that health care professionals served were spread relatively evenly through local community or villages (27%, n=44), statewide (25%, n=41), regions (23%, n=38), and borough or census areas (22%, n=36). The average reported amount of time for health care professionals working in their field was 15 years.

When asked about brain injury prevention topics discussed within their workplace, the most discussed topics were risks associated with alcohol use and TBI (68%, n=112), risks associated with repeated or multiple TBIs (66%, n=109), and fall prevention (64%, n=105). The least discussed topics were safe return to sports/activity after a TBI (24%, n=39) and ATV/snowmachine safety (21%, n=35). Forty-five percent (n=75) of medical professionals stated that the importance of brain injury training in their job was “very” or “extremely” important. When asked which training topics were needed or of interest to them, 64% (n=105) of health care professionals wanted training in emotional and behavioral difficulties following a TBI.

Health care professionals cited four main themes when asked about perceived barriers to providing care for TBIs. Firstly, providers expressed a need for TBI-specific training on screening, co-occurring disorders, and resources/services that are appropriate for referrals. One provider emphasized the need for, “training on how to best case manage people who experience TBI, specifically including behavioral health training on how to best interact with people who have memory loss, aggression issues, substance abuse.” Secondly, many patients experience difficulties in accessing services and coordinated case management needed for good continuity of care, with one provider stating, “TBI case management in our area would be life changing to many of the folks we work with.” Thirdly, TBIs are frequently undiagnosed or misdiagnosed, resulting in patients not receiving the correct answers to their questions or appropriate treatment plans. This is exemplified by one provider’s statement that, “brain injuries often do not get identified or appropriately evaluated in my region of the state. We do not have qualified specialists to do this.” Finally, the cost of care often prevents people from receiving services. Some states offer brain injury waivers, which can help people needing extra support to continue living in their communities by providing Medicaid-funded home- and community-based services to people who, but for the provision of such services, would require institutional care. In addition, insurance barriers were frequently reported by providers who are unable to bill Medicare/Medicaid as primary insurance.

Through open-ended questioning, health care professionals also spoke about the link they have observed between vulnerable populations and TBIs, such as people experiencing domestic violence, homelessness, and incarceration. Some providers also underscored the lack of targeted programs to adequately treat vulnerable populations known to suffer from high rates of TBIs.

4.0 Prevention

TBIs are largely preventable. TBI prevention saves lives, reduces associated disabilities, and saves costs both inside and outside of the health care system. Preventative strategies should include primary, secondary, and tertiary prevention. Primary prevention aims to prevent injury occurrence with interventions that range from changing public policies (e.g., speed limits, helmet and seatbelt requirements, vehicle safety standards) to influencing societal factors (e.g., suicide prevention, reducing alcohol misuse, helmet use compliance in recreational activities). Secondary prevention aims to mitigate the severity of consequences in the case of a TBI. This can include increasing awareness for people to recognize signs and symptoms to reduce delay in care seeking behavior, improving the trauma care system (e.g., advances in prehospital care or transport) and interventions directed at secondary injuries (e.g., preventing hypotension and hypoxia beginning during prehospital care). Finally, tertiary prevention aims to maximize patients' functional abilities and restore their daily life following a TBI.

National primary prevention programs for TBIs specifically include 1) CDC’s “Heads Up” initiative,[21] aimed at providing information on preventing, recognizing, and responding to a concussion in youth sports, and 2) CDC’s Stopping Elderly Accidents, Deaths and Injuries (STEADI) initiative,[22] which helps health care providers develop a standardized process for screening patients for fall risk, assessing the at-risk patient’s modifiable risk factors, and intervening to reduce this risk using effective interventions.

Within Alaska, TBI prevention programs have focused predominantly on primary prevention via public information campaigns, educational programs, and safety gear distribution aimed at reducing injury occurrence.

TBI-specific prevention programs have included the "Helmets On" campaign,[23] which was started in 2018 with the Bristol Bay Area Health Corporation Injury Prevention Program, the ANMC Trauma Department, and the ANTHC Injury Prevention Program. Campaign staff disseminated public information surrounding bike and ATV safety and the protective measures that can reduce TBI occurrence. Campaign staff also provided educational programs to rural communities on ATV safety, including a grant-funded pilot project for ATV safety skills and an ATV Safety 6–12 grade curriculum. Given the burden of brain injury attributable to unintentional falls in Alaska, there have also been several efforts around the state to prevent falls including the provision of free ice cleats to elders,[24] establishing on-going exercise or walking programs suitable for elders to promote strength and balance,[25] and developing and distributing kits to give elders and caregivers with reminders of ways to prevent falls.[26]

TBI prevention campaigns in Alaska have also included free ATV helmets for people that are provided by brain injury non-profit groups.[27] Numerous public information campaigns on TBI risk reduction have also occurred, including a Concussion Legacy "Team Up Speak Up" speech, which was circulated by the Alaska School Activities Association in 2021 as an educational tool for athletes to spot concussion in their teammates, the Alaska Department of Health's "Defend Your Brain" campaign in 2021, and several radio PSAs by the Brain Injury Association of Alaska.

In addition to TBI-specific prevention efforts, there are several other injury prevention topics that also help to reduce the frequency of TBIs, as described below.

4.1 Suicide Prevention

Suicide prevention programming in Alaska generally falls into four broad categories: 1) school-based (e.g., the Northwest Arctic School District's Teck John Baker Youth Leaders Program, a student led program teaching youth about suicide, sexual assault, domestic violence, and substance abuse), 2) tribal-focused (e.g., the Substance Abuse and Mental Health Service Administration's Native aspirations program which supports grantees in reducing youth suicidal behavior), 3) community-based (e.g., "Choose to Live", "Walk for Life"), and 4) mental health-based (e.g., behavioral health aides who serve as counselor, health educator, and advocate within the community both preventatively and in times of crisis).

At the state-level, the Statewide Suicide Prevention Council (SSPC; established in 2001) collaborates with communities, faith-based organizations, and public-private entities, to reduce the rates of suicide and its effects on people and communities. SSPC's 5-year statewide suicide prevention plan outlines specific strategies for ways that people, communities, and governmental agencies can act together to prevent suicide.[28] For Alaska Native communities specifically, ANTHC's suicide prevention program collaborates with community partners and Tribal health organizations within the Alaska Native Tribal Health System to provide evidence-based education and training about suicide prevention, intervention, and postvention.[29] The ANTHC Behavioral Health Wellness Clinic also offers telehealth counselling assessments and referral support to adult beneficiaries anywhere in Alaska.[30]

4.2 Firearm Storage

Household firearm ownership is associated with an increased risk of violent death and suicide, often involving head wounds among adults and adolescents.[31,33] Promotion of community-based programs to improve the safe storage of household guns is one strategy to mitigate injury risk associated with high rates of access to household firearms, particularly among large multigenerational households. Gun cabinet installation in rural Alaska has been shown to significantly reduce the prevalence of unlocked firearms in homes.[34] Furthermore, the probability of people attempting suicide decreases when access to a preferred lethal means is decreased.[35] Therefore, reductions in unlocked firearms is one strategy that can help to reduce firearm-related suicide within communities.[36]

4.3 Intimate Partner Violence

It is estimated that most intimate partner violence (IPV) victims suffer from blunt force to the head, neck, and face area,[37] with IPV being common enough to be classified as an injury mechanism for TBI.[38,39] Within Alaska, 57.7% of women have experienced IPV, sexual violence, or both within their lifetime.[40] Alaska has the highest rates of IPV deaths in women nationwide, with Alaska Native women being disproportionately affected.[41] As such, a variety of IPV prevention programs exist in Alaska that, while not specifically aimed at TBI reduction, could result in a reduction of TBI incidence -- particularly in women.

The Alaska Network on Domestic Violence and Sexual Assault that works to support domestic violence and sexual assault programs in Alaska through legal advocacy, pro bono attorney services, legislative and legal advocacy and resources, and statewide coordination for victim advocacy and violence prevention programming.[42] For Alaska Native communities specifically, the Domestic Violence Prevention Initiative (DVPI) is a federally funded program implemented by ANTHC to prevent domestic violence and sexual assault. DVPI programs are initiated by community invitation and include activities aimed at raising awareness about domestic violence and sexual assault and providing culturally-appropriate prevention, intervention, and postvention education and training.[43]

The Alaska Division of Public Health also houses the Alaska Family Violence Prevention Project, which aims to raise awareness about intimate partner violence as a public health issue in Alaska.[44] A range of statewide population-level prevention programs have also been implemented for Alaska youths, including 1) “Stand Up, Speak Up,” a media and engagement campaign that was developed for teenagers to learn how to more effectively speak up and encourage other youth to stand up to end violence in relationships;[45] 2) “Coaching Boys into Men,” a comprehensive violence prevention curriculum for coaches and their athletes developed by Futures without Violence;[46] and 3) Talk Now Talk Often AK, a statewide effort developed by parents and caregivers to help increase conversations with teenagers around healthy relationships.[47]

4.4 Motor Vehicle Safety

A variety of prevention programs exist in Alaska to reduce the number of injuries, including head trauma attributable to motor vehicle crashes. This includes the Center for Safe Alaskans, which provides a variety of initiatives to help Alaskans make safer choices regarding transportation, including education on child passenger safety, free child seat fitting appointments, resources for teenager drivers to empower them to make safe driving decisions, and a variety of projects to promote safe walking and cycling throughout Alaska.[48] Other programs include those offered by the Department of Transportation, such as the Alaska Statewide Highway Safety Media Campaigns, which regularly educates road users about designated safety corridors and raises awareness about specific driver behaviors.[49]

5.0 Discussion

TBIs represent a considerable source of morbidity and mortality in Alaska. During 2016–2021, 1,527 TBI-related deaths occurred in Alaska, accounting for approximately 25% of all deaths among Alaskans aged <30 years. Alaska’s TBI-related mortality rate was double the 2020 national average (36.2; 95% CI: 31.8–40.6 vs. 18.0; 95% CI: 17.8–18.1, respectively) and represents the highest state-reported estimate nationwide.[3] Despite Alaska’s high TBI mortality rate, age-adjusted non-fatal TBI hospitalization rates were lower in Alaska than the national average for most corresponding years.[19,50] Several factors likely contribute to Alaska’s relatively low TBI hospitalization rate despite its high TBI mortality rate.

Firstly, Alaska’s clinical guidelines for managing acute blunt head trauma in adults (excluding those with penetrating TBI injuries) are considerably different than those used in many other states.[51] Alaska-specific guidelines were developed with special consideration for Alaska’s limited neurosurgical specialty care and unique patient transport complexities. The Alaska guidelines aim to utilize Alaska’s transport and limited subspecialty resources more efficiently and reduce secondary overtriage (i.e., the interfacility transfer of patients who are rapidly discharged home without surgical intervention by the receiving institution). As a result, many TBI patients in Alaska, particularly those with an adequate GCS score and an absence of risk factors for significant intracranial injury, are discharged to home from the emergency room. This contrasts with many other states where patients are often admitted to the hospital for clinical observation or undergo interfacility neurosurgical consults, as specialized neurosurgical care is often more geographically accessible. Eighty-four percent of the U.S. population lives within 60 minutes by ground ambulance or helicopter to a level 1 or 2 trauma center versus just 52% of Alaskans (for level 2 trauma centers only).[52]

Secondly, for patients with moderate to severe TBI, delays in required specialized care may be associated with higher mortality risk.[53] Evidence suggests that increasing access to care reduces injury mortality from TBIs.[54:56] Thirdly, out-of-state aeromedical transport of patients with a severe TBI is more common in Alaska than other parts of the US, meaning these hospitalizations would not be counted in the calculation of Alaska’s TBI hospitalization rates. Fourthly, during the time period of this review, suicide was the largest contributor to TBI-related mortality rates in Alaska. Higher rates of severe TBIs attributed to suicide may result in fewer hospitalizations due to the limited capacity for life-saving medical interventions. Finally, substantial variation likely exists between hospitals in capturing the high-acuity ICD-10 codes used to calculate TBI hospitalization rates, making accurate comparisons between regions challenging. Further research is needed to examine the complex network of factors that determine TBI-related injury outcomes for Alaskans.

We observed a disproportionate impact of TBI-related morbidity and mortality among AI/AN people in Alaska. AI/AN people make up 15%–20% of Alaska's population, but represented 27%, 32%, and 29% of TBI ED visits, hospitalizations, and deaths, respectively during the study period. Rates of TBI ED visits, hospitalizations, and deaths among AI/AN people were double those observed among White people. We also observed differences in the mechanisms for injury, by race. For example, rates of ED visits and hospitalizations attributable to motor vehicle crashes were 3.2 and 2.9 times higher, respectively, for AI/AN people compared to White people. Of those AI/AN people with TBIs attributed to motor vehicle crashes, ATVs and snowmachines were the most common vehicles involved for both ED visits (214/522; 41%) and hospitalizations (146/312; 47%). By comparison, of all TBIs attributed to motor vehicle crashes in the White population, ATVs and snowmachines were involved in 16% (215/1330) of ED visits and 23% (103/446) of hospitalizations. ATVs and snowmachines are critical lifelines for both transport and subsistence practices throughout Alaska. Research has demonstrated that helmet use while riding ATVs and snowmachines can reduce the risk of death from head injury by up to 42% and head injury occurrence by 64%.[57]

These data clearly suggest that continued promotion of helmet use and the funding of free helmet provision programs remain important in reducing the impact of TBIs attributable to ATVs and snowmachines in Alaska. This is particularly important within Alaska Native communities and rural areas of the state. For example, 39% of all TBI hospitalizations were attributable to ATVs/snowmachines in the Northern region. Furthermore, only 27% of health care providers in a recent population needs assessment stated that ATV/snowmachine safety was a topic discussed within their workplace. This suggests that additional educational materials promoting ATV/snowmachine safety would be beneficial to share in areas of Alaska with high rates of TBIs attributable to ATV/snowmachine use, such as the Northern region. Finally, although not specifically examined in this report, alcohol and drug abuse are known risk factors for domestic violence and motor vehicle crashes. Efforts should be made to reduce alcohol and drug abuse in general and use in relation to motor vehicles (including ATVs and snowmachines).

Males experienced higher rates of TBI morbidity and mortality in Alaska than females. This is consistent with the national research, which has shown males are nearly twice as likely to be hospitalized and three times as likely to die following a TBI than females in the general population.[2,19] This is likely due to a higher likelihood of males being involved in physical altercations, military service, contact sports, and suicide by firearm compared to females. However, certain risk factors for TBIs in women, such as IPV and assault, often result in TBIs that remain unreported and undetected. For example, a recent study found that more than 80% of IPV victims referred from homeless or domestic violence shelters sustained multiple TBIs and 84% had clinically significant symptoms, yet only 21% sought medical attention at the time of the injury.[58] We were unable to look at TBIs attributable to IPV specifically in this analysis but it's likely the rates of TBIs in women are much higher in Alaska than the estimates presented in this report. It is therefore important that gender-neutral messaging goes out that emphasizes the signs and symptoms of a TBI and the need to seek medical consultation following head injuries.

Forty-three percent of TBI-related deaths in Alaska were due to suicide by a firearm. For males aged 15–30 years, this proportion was 63%. Among people aged 25–34 years in Alaska, the rate of TBI-associated mortality attributable to suicide was over three-times that of the national average. By contrast, rates of TBI-related injury attributable to self-harm were low for TBI ED visits and hospitalizations. This is likely due to the use of firearms in TBI-related suicide (98% of all deaths involved a firearm). Penetrating firearm-inflicted TBIs often leave very little chance for life-saving intervention. This was illustrated by our finding that for all people hospitalized with a TBI in Alaska, those with intentionality to their injuries indicative of self-harm were over eight times as likely to die following hospitalization. Therefore, within Alaska, efforts should focus on primary prevention programs to reduce TBIs attributable to suicide. Ideally, this should also be combined with community-based interventions and rapid suicide surveillance data to monitor changing trends.

The economic consequences of TBIs impact society-at-large in terms of health care costs and disability funding. During 2017–2021, over $11 million was spent by the Medicaid program in Alaska, with costs increasing each year. The highest expenditure was seen for inpatient services, where the more significant medical needs likely reflect higher expenditures. This was followed by long-term care, where the duration of service likely contributes to increased expenditures.

Based on the results of our population needs assessment, the following recommendations may help address both short and long-term service needs of people living with TBIs in Alaska.

Improve access to clinical services

- Increase provider awareness of available health care services.
- Ensure people and families are aware of all available resources.
- Reduce financial, structural, and other barriers to accessing both acute and chronic services.

Financial support

- Many participants spoke of difficulties paying for medical treatment, housing, and transportation. Many brain injury participants had also lost work because of their brain injury.
- Some states (e.g., Colorado and Indiana) offer a Medicaid waiver for brain injury care that provides home- and community-based services to people who, for the provision of such services, would usually require institutional care.[59:61]

Improve provider education

- Develop additional TBI training programs for health care providers in Alaska that include information on brain injury screening, referral guidance, and cognitive/behavioral health sequalae of TBIs.

Community awareness

- Improve community awareness of TBIs by offering educational resources on signs and symptoms and the need for seeking prompt medical care.
- Offer educational resources to people with a TBI and their family members about what to expect following at TBI.
- Provide community-specific education programs. For example, in the Northern region where 39% of all TBI-related hospitalizations are due to ATVs/snowmachines, additional education on ATV/snowmachine safety and free helmet provision programs would be beneficial.

Vulnerable populations

- Increase awareness and training in the context of vulnerable populations that are at elevated risk for TBIs (e.g., incarcerated people and people experiencing IPV or homelessness).

6.0 Limitations

This report utilized several existing surveillance sources to present an epidemiological summary of TBI in Alaska. For TBI morbidity, records of ED admissions and inpatient hospitalizations were obtained from Alaska's HFDR and Trauma Registry, respectively. However, each of these sources is subject to limitations.

The HFDR as an administrative claim database that provides timely and readily accessible surveillance data on moderate to severe TBIs requiring medical intervention in Alaska. However, it is subject to several limitations as a TBI surveillance data source. Firstly, as demonstrated in this report and the existing evidence base, administrative claim databases based on ICD-10 codes can have limited sensitivity in TBI case ascertainment, leading to the undercounting of true TBI cases. Secondly, limited data elements on specific injury-related and clinical details prevent more detailed analysis of factors associated with injury. This would be particularly beneficial for parts of the state where rates of ED visits attributable to TBIs were particularly high (e.g., Southeast Alaska). Thirdly the HFDR does not include data on military personnel who seek care at DOD facilities. Military personnel are known to have a substantially higher risk of TBI-related injuries than the general population,[62] which may result in a further underestimate of overall population incidence of TBI in Alaska.

For inpatient hospitalizations, the ATR provided clinical hospital data capturing a range of patient information including clinical text descriptions. This detailed information on patient injuries allowed the identification of TBIs, which would have been missed if relying on ICD-10 codes alone. Including these TBI cases may reduce the underreporting of TBI incidence as shown in this report. However, extracting clinical information was a timely and labor-intensive process. One recommendation is to develop an automated text-based algorithm to extract TBI information from patient records in the ATR using the methodology used in this report. This would enable patients to be counted in statewide TBI estimates that would otherwise be missed if relying on ICD-10 codes alone. Finally, TBI records obtained from the ATR depend on the quality of clinical data entered. Therefore, clinicians should make every effort to document TBIs accurately as possible along with all corresponding signs and symptoms in patient notes.

A further limitation of both the HFDR and ATR is that these data sources only include people who access higher levels of medical care. The HFDR includes hospital emergency department visits and/or inpatient services. While the ATR only includes people with injuries who are admitted to an Alaska hospital, held for observation, transferred to another acute care hospital, or declared dead in the emergency department, and for whom contact occurred within 30 days of the injury are included. As discussed throughout this report, there are numerous reasons why Alaskans may not seek higher levels of health care services or health care services at all following a TBI. These include inability to pay, geographic distance to higher-level care reflective of both time and financial constraints, and the often-acute nature of TBI symptoms such as transient neurophysiologic brain dysfunction contributing to the idea that the TBI may not be that bad (e.g., the "sleep it off" mentality). Therefore, many Alaskans with TBIs do not get counted in existing TBI surveillance systems, resulting in considerable underestimates of incidence rates. One suggestion to mitigate this and capture a wider spectrum of TBI severity through statewide surveillance is the creation of an all-payer claims database that could systematically capture all medical and pharmacy claims from private and public payers. This would provide a more comprehensive picture of TBI incidence in Alaska and capture a wider spectrum of TBI severity.

To fully understand the public health burden of TBIs it is important to measure their prevalence across a population. TBI prevalence consists of all newly diagnosed TBI patients (incidence) plus those people with residual physical and neuropsychologic problems pertaining to a TBI in a population. This report only examined TBI incidence in Alaska due to a lack of available data sources to capture patients with a pre-existing TBI. This is a substantial limitation of this report as the true burden of TBI morbidity is underestimated in the absence of prevalence data.

One recommendation to better estimate the prevalence of TBIs in a population is the use of household surveys.[63,64] These can consist of implementing a TBI-specific household survey or adding questions about current or previous TBIs to a pre-existing survey such as CDC's Behavioral Risk Factor Surveillance System (BRFSS).

There are additional limitations to this report. Firstly, costs of TBI-related injury were calculated among Medicaid enrollees to estimate costs incurred by the Medicaid system. To determine the economic impact of TBI-related injury in Alaska, we would need to account for the lifetime medical (e.g., clinical office visits, drugs, and medical supplies) and non-medical (e.g., travel costs for obtaining care) costs of a TBI. We would also need to account for the total productivity loss for the patient and those family members/caregivers/guardians involved in providing care.

The population needs assessment has several limitations. Firstly, with a sample size of only 311, responses cannot be generalized to all people living with TBIs, their families, or health care professionals in Alaska. Response bias may impact results. Participants were allowed to skip questions they did not wish to answer, thereby reducing the overall number of responses. Finally, the use of an online survey and convenience sampling may have resulted in selection bias with only those people with internet access or with different types of TBI able or willing to complete the survey.

Lastly, information on the race and ethnicity of patients may not be systematically or accurately collected in all datasets. AI/AN people are frequently misclassified in surveillance and administrative data systems and have the lowest level of agreement between self-reported race and race assigned in medical records compared to other race groups. It is unknown if this potential for misclassification impacts the interpretation of these results. More research is needed to better understand the magnitude and direction of this potential source of bias. Disparities by race should not be misinterpreted as casually associated with race. The underlying factors and differences related to historical exposures and daily living in different environments should be the focus when interpreting the casual mechanisms contributing to disparities.

7.0 Conclusions

The data presented here underscore the substantial impact that TBIs have on morbidity and mortality in Alaska. During 2016–2021 in Alaska, one in four deaths in people aged <30 years occurred following a TBI. Suicide is the most common attributable mechanism of TBI-associated mortality among Alaskans, with males aged 25–34 years and AI/AN people being disproportionately affected.

Mechanisms of injury attributed to TBI morbidity and mortality varied substantially by sex, race, age, and location. Overall, suicide and unintentional falls were the largest contributors to TBI mortality and morbidity, respectively, statewide. However, mechanisms of injury attributable to TBIs vary substantially by sex, race, age, and location.

The findings of the report indicate that increasing TBI-prevention activities and improving access and continuity of care are warranted to improve TBI outcomes in Alaska.

8.0 Figures and Tables

Figure 1. Rate of Non-Fatal TBI Emergency Department Visits — Alaska, 2016–2021

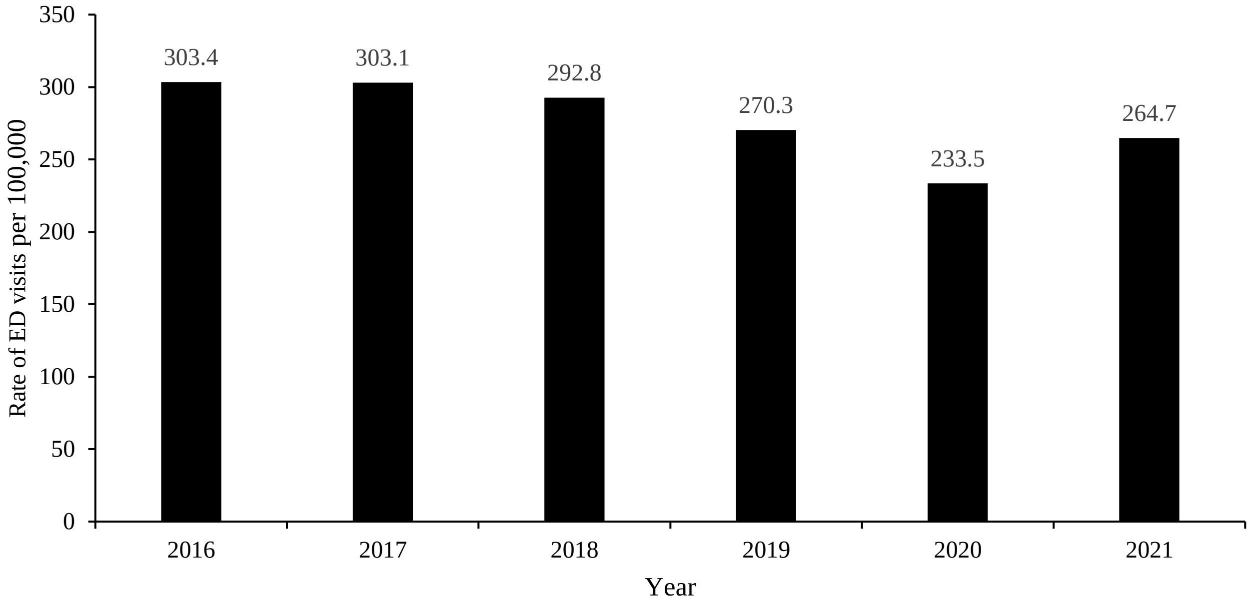


Figure 2. Rate of Non-Fatal TBI Emergency Department Visits by Age and Injury Mechanism — Alaska, 2016–2021

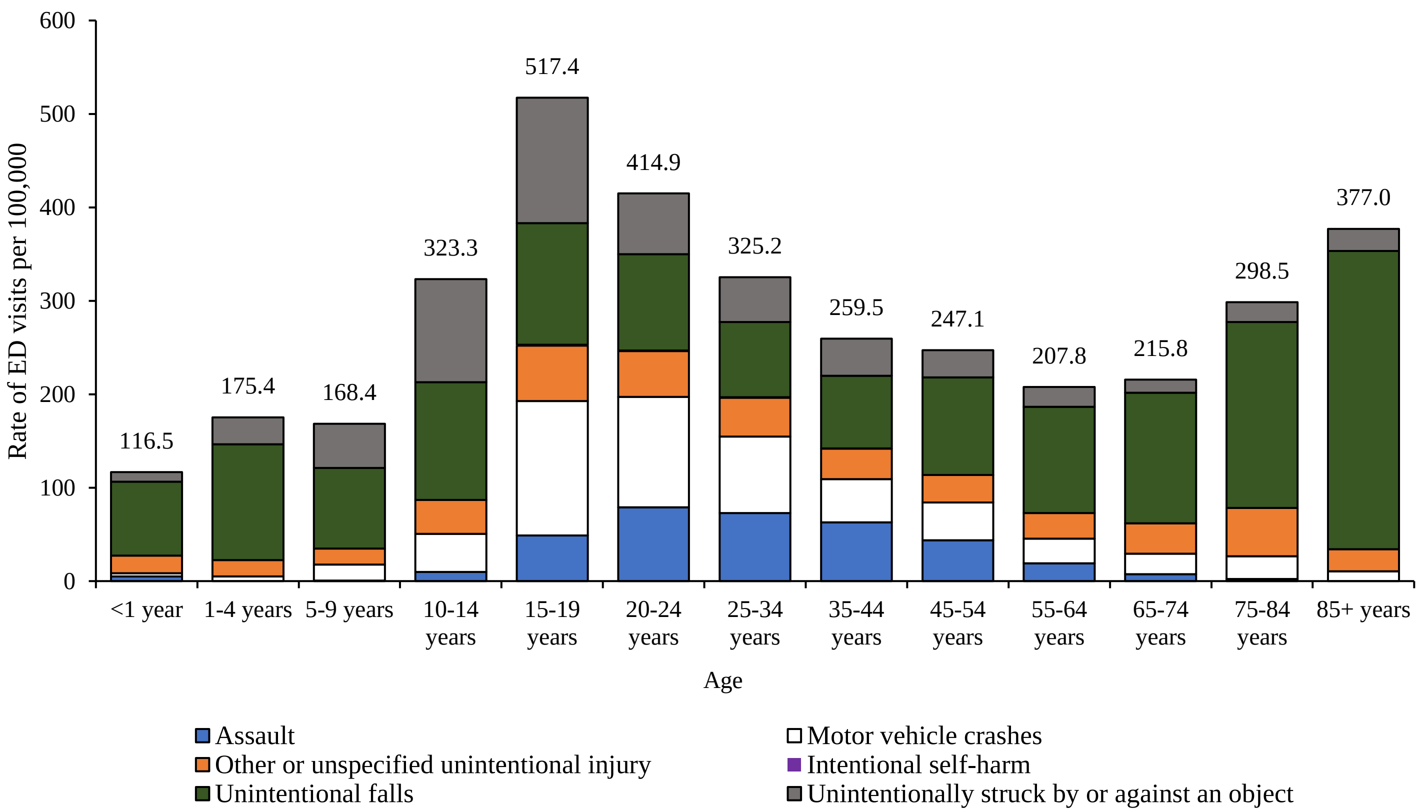


Table 1. Rate of Non-Fatal TBI Emergency Department Visits by Sex and Injury Mechanism — Alaska, 2016–2021

Injury Mechanism	Male (N=6,498)		Female (N=5,751)		All (N=12,251)	
	Rate	Count	Rate	Count	Rate	Count
Assault	45.2	1027	28.3	601	37.0	1628
Motor vehicle crashes	50.3	1141	51.9	1108	51.1	2249
Other or unspecified unintentional injury	38.1	864	30.2	645	34.3	1511
Intentional self-harm	0.31	7	0.14	3	0.2	10
Unintentional falls	102.8	2334	114.9	2455	108.8	4789
Unintentionally struck by or against an object	49.6	1125	43.9	939	46.9	2064
Total	286.2	6498	269.1	5751	277.9	12,251*

**Includes two patients with missing sex data. Rates calculated per 100,000 population.*

Figure 3. Rate of Non-Fatal TBI Emergency Department Visits by Region of Residence — Alaska, 2016–2021

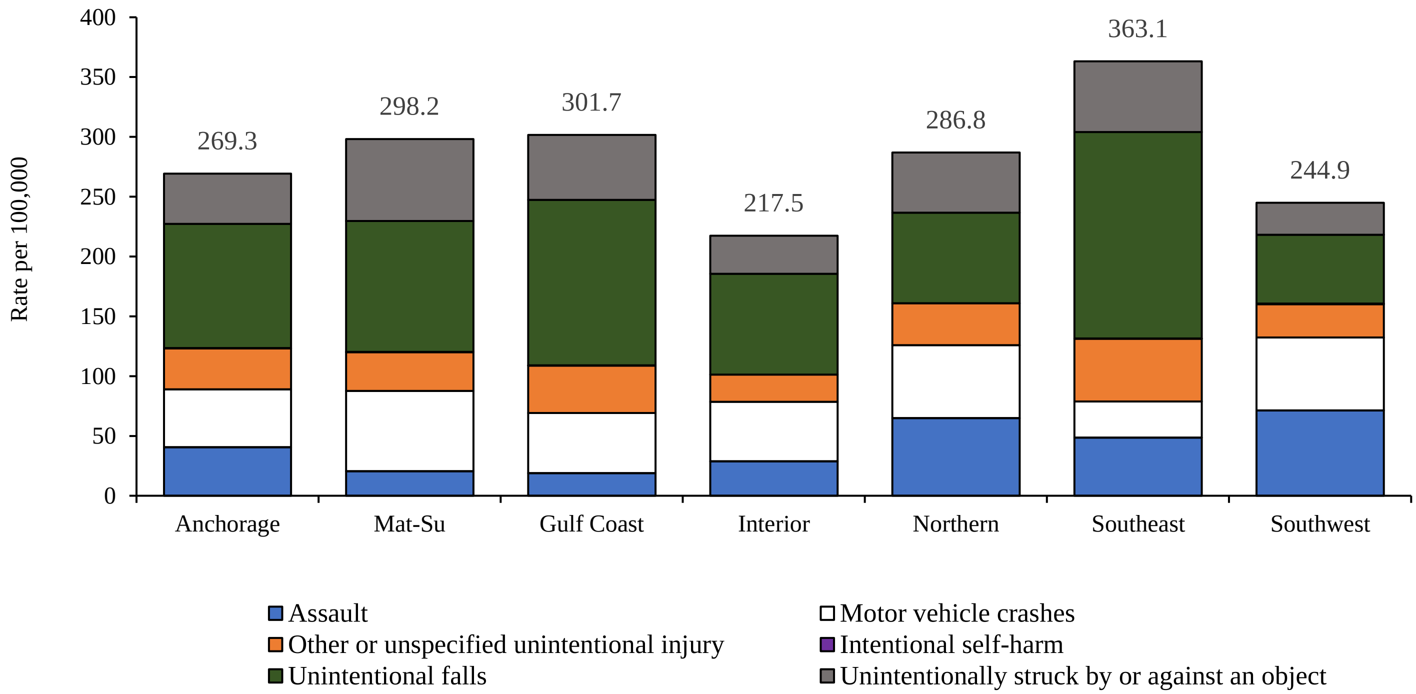


Figure 4. Rate of Non-Fatal TBI Emergency Department Visits by Race — Alaska, 2016–2021

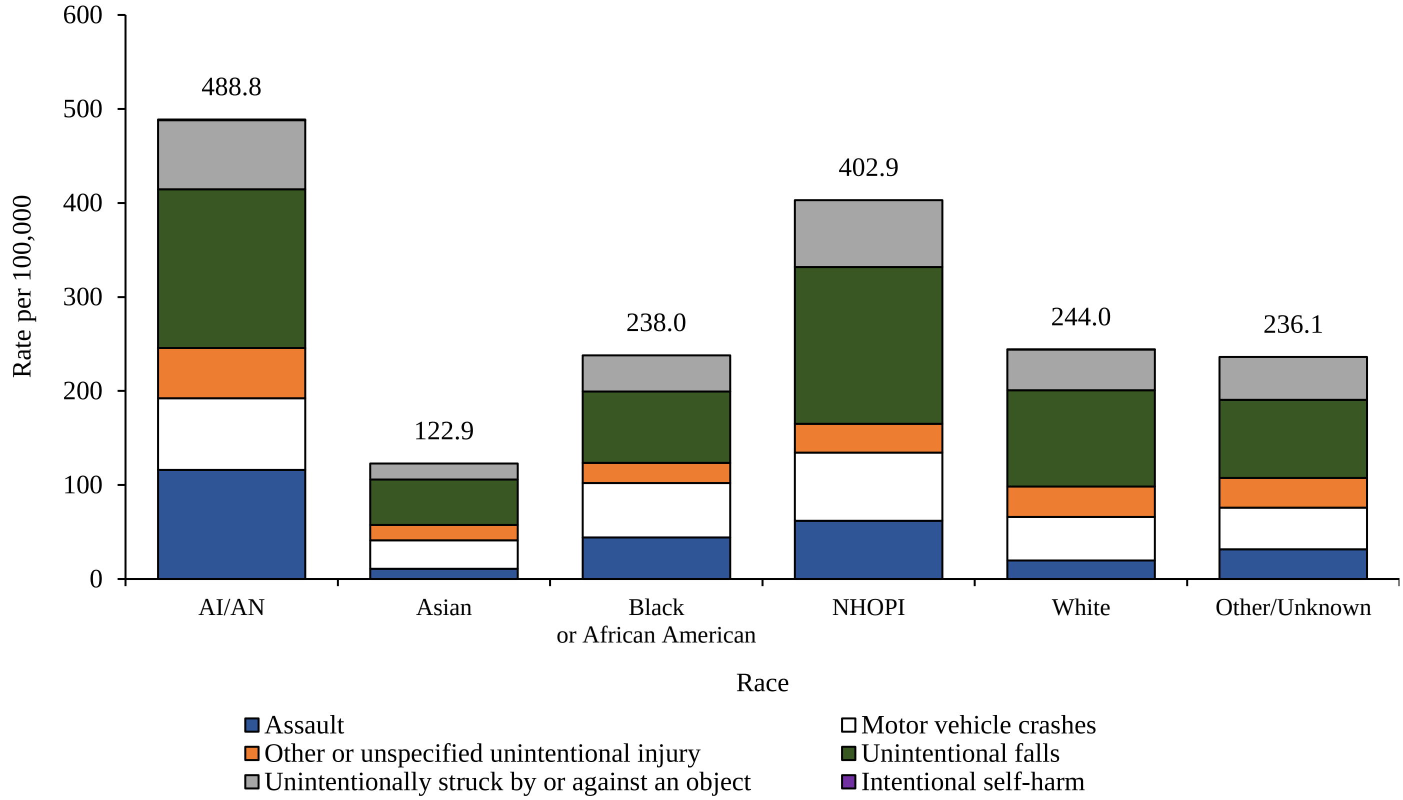


Figure 5. Rate of Non-Fatal TBI Hospitalizations — Alaska, 2017–2021

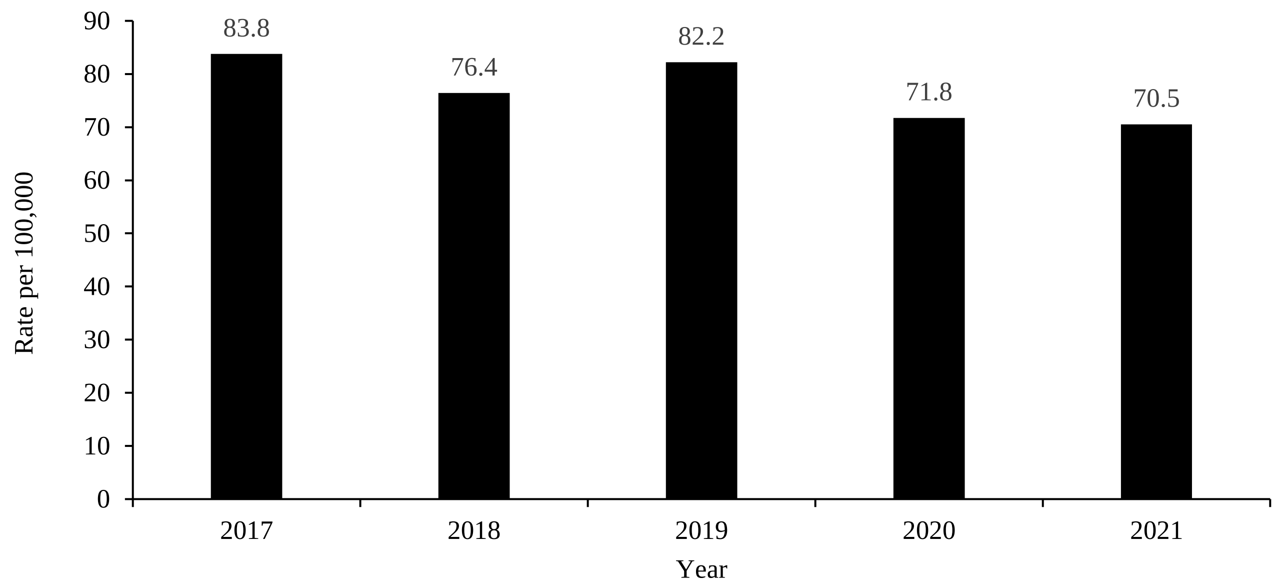


Figure 6. Rates of Non-Fatal TBI Hospitalizations, by Age and Mechanism — Alaska, 2017–2021

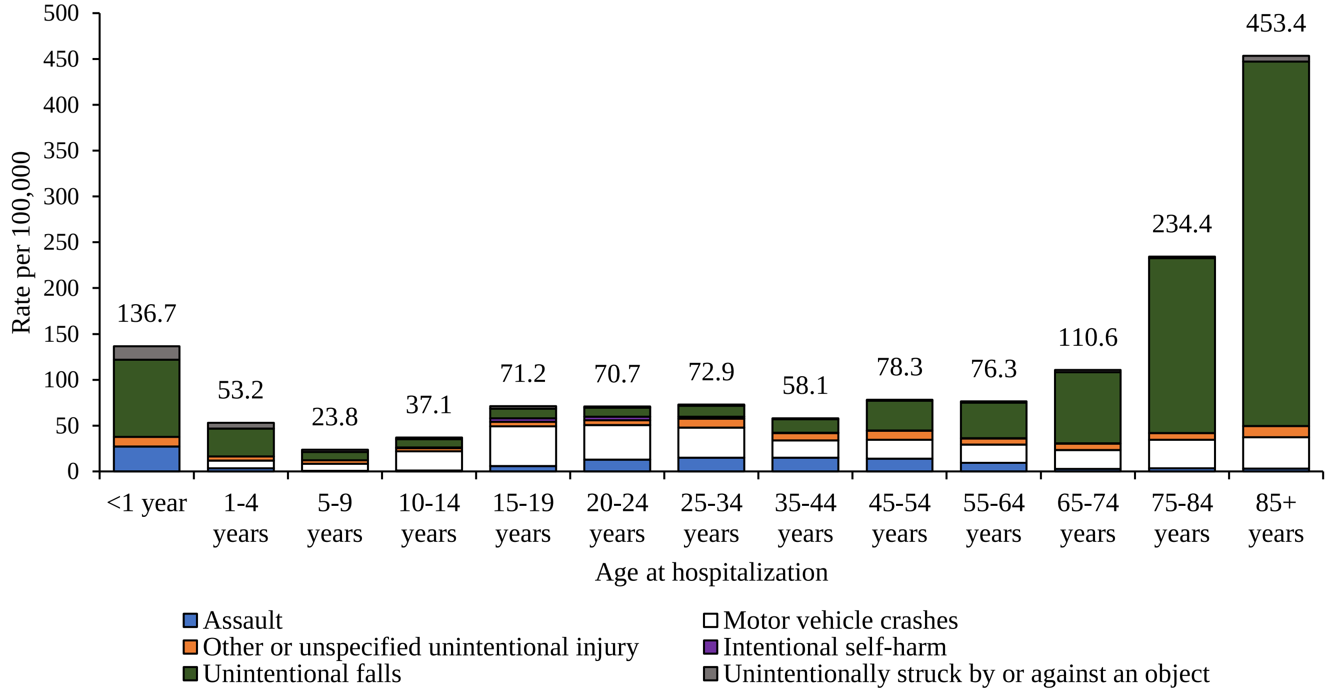


Table 2. Rate of Non-Fatal Hospitalizations, by Sex and Injury Mechanism — Alaska, 2017–2021

Injury Mechanism	Male (N=1,841)		Female (N=980)		All (N=2,821)	
	Rate	Count	Rate	Count	Rate	Count
Assault	14.6	275	3.9	70	9.4	345
Motor vehicle crashes	29.0	548	17.3	307	23.3	855
Other or unspecified unintentional injury	10.1	191	3.9	69	7.1	240
Intentional self-harm	1.5	28	0.6	10	1.0	38
Unintentional falls	39.3	743	28.2	502	34.0	1245
Unintentionally struck by or against an object	3.0	56	1.2	22	2.1	78
Total	97.5	1841	55.1	980	76.9	2821

Rates calculated per 100,000 population.

Figure 7. Rate of Non-Fatal TBI-Related Hospitalizations, by Region and Mechanism — Alaska, 2017–2021

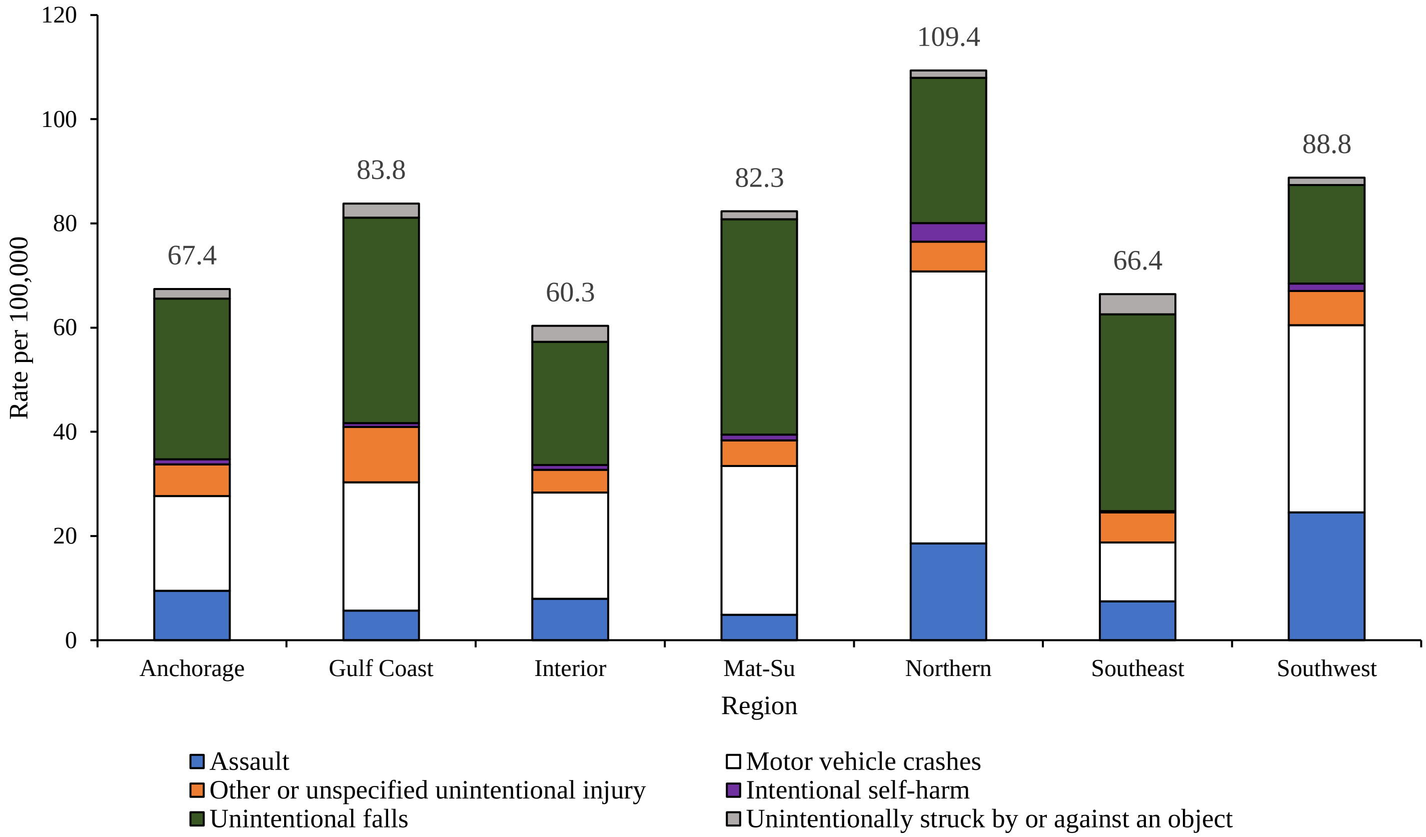


Figure 8. Rate of Non-Fatal TBI-Related Hospitalizations Attributable to ATVs and Snowmachines, by Region — Alaska, 2017–2021

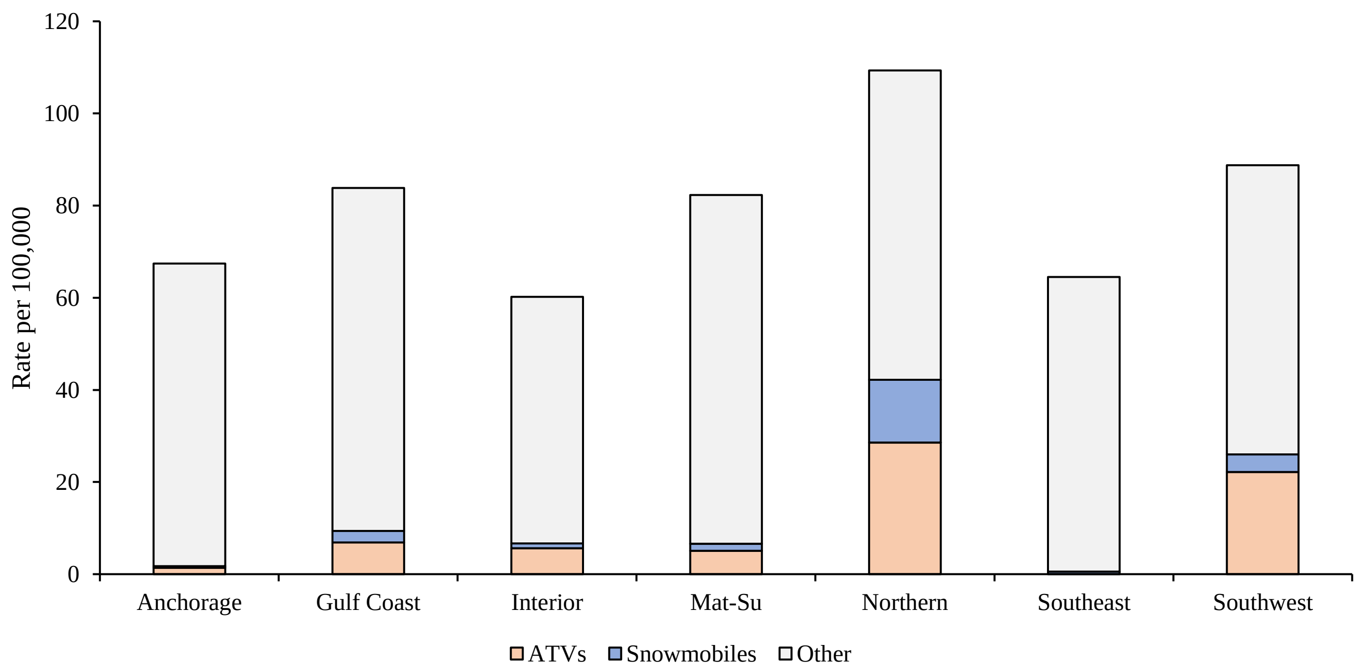


Figure 9. Rates of Non-Fatal TBI-Related Hospitalizations, by Race and Mechanism — Alaska, 2017–2021

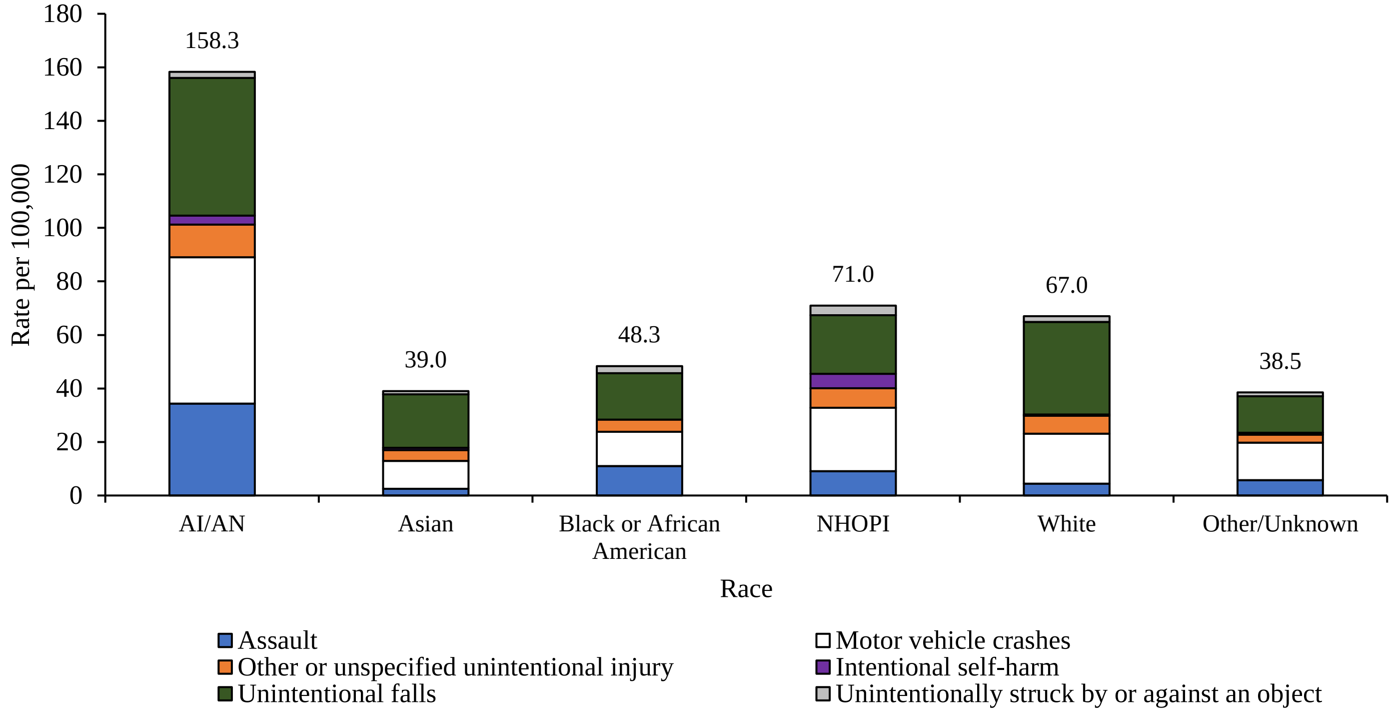


Figure 10. Rate of Non-Fatal TBI-Related Hospitalizations, by Data Source — Alaska, 2017–2021

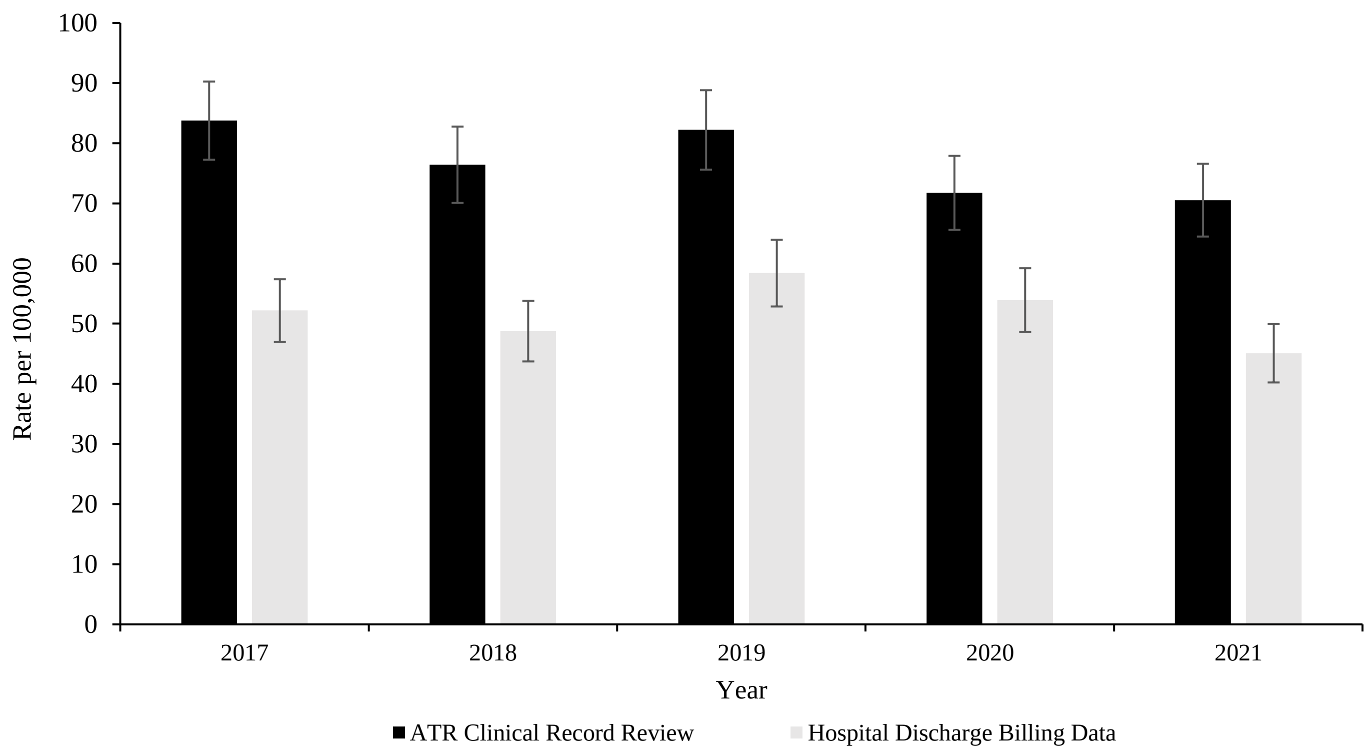


Table 3. Outcomes Following Treatment for Non-Fatal TBI-Related Hospitalizations — Alaska, 2017–2021

Outcome	Count	%
Returned to previous level of function	622	22
Temporary disability, expected to return to previous level of function	1658	59
Moderate disability with self-care	216	8
Severe disability, dependent on others for care	91	3
Unknown	234	8

Table 4. Characteristics of Hospitalized Patients with Fatal TBI-related Injuries Compared to Patients with Non-fatal TBI-related Injuries — Alaska, 2017–2021

Characteristics	Died (N=324)	Survived (N=2808)	p-value
Age (years)			
Median (range)	54 (0-98)	46 (0-100)	<0.001
Initial GCS Score	3 (4.4)	15 (3.7)	<0.001
ISS Score	25 (12.7)	10 (8.2)	<0.001
Sex			
Male	204 (10%)	1837 (90%)	0.45
Female	119 (11%)	971 (89%)	
Unknown	1 (0.3%)	0	
Race			<0.01
AI/AN	76 (7.8%)	904 (92.2%)	
White	198 (11.1%)	1589 (88.9%)	
Others	50 (13.7%)	315 (86.3%)	
Intentional Injury			
Yes	62 (62.0%)	38 (38.0%)	<0.001
No	262 (8.6%)	2770 (91.4%)	

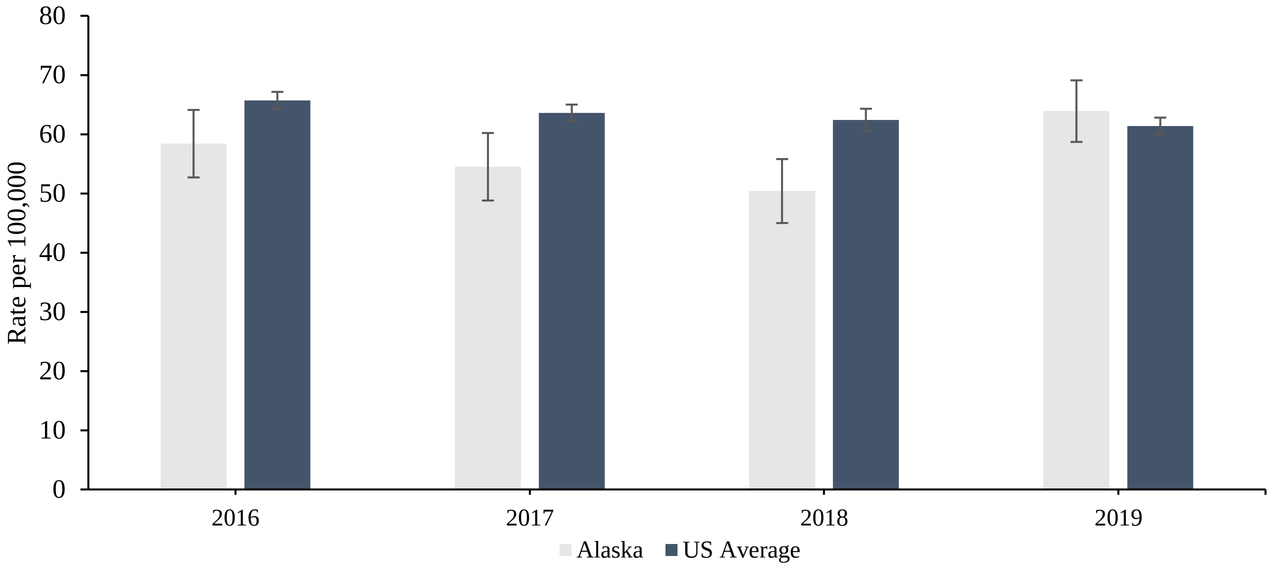
GCS; Glasgow Coma Scale; ISS, Injury Severity Score; AI/AN, American Indian/Alaska Native

Table 5. Multivariable Analysis of Risk Factors Associated with Fatal TBIs in Inpatient Hospitalizations — Alaska, 2017–2021*

Characteristics	Adjusted odds ratio	(95% confidence intervals)
GCS	0.74	(0.71, 0.76)
ISS	1.07	(1.06, 1.09)
Age	1.04	(1.03, 1.05)
Intentional Injury	8.96	(5.11, 16.12)

**Multivariable logistic regression model mutually adjusted for age, sex, GCS score, ISS score, race, and injury mechanism*
GCS; Glasgow Coma Scale; ISS, Injury Severity Score

Figure 11. Age-adjusted Rate of Non-fatal Traumatic Brain Injury (TBI) Hospitalizations, by Year — Alaska and the United States, 2016–2019*



**2020–2021 national data pending*

Figure 12. Age-adjusted Rates of Traumatic Brain Injury-related (TBI) Deaths, by Year — Alaska and the United States, 2016–2021

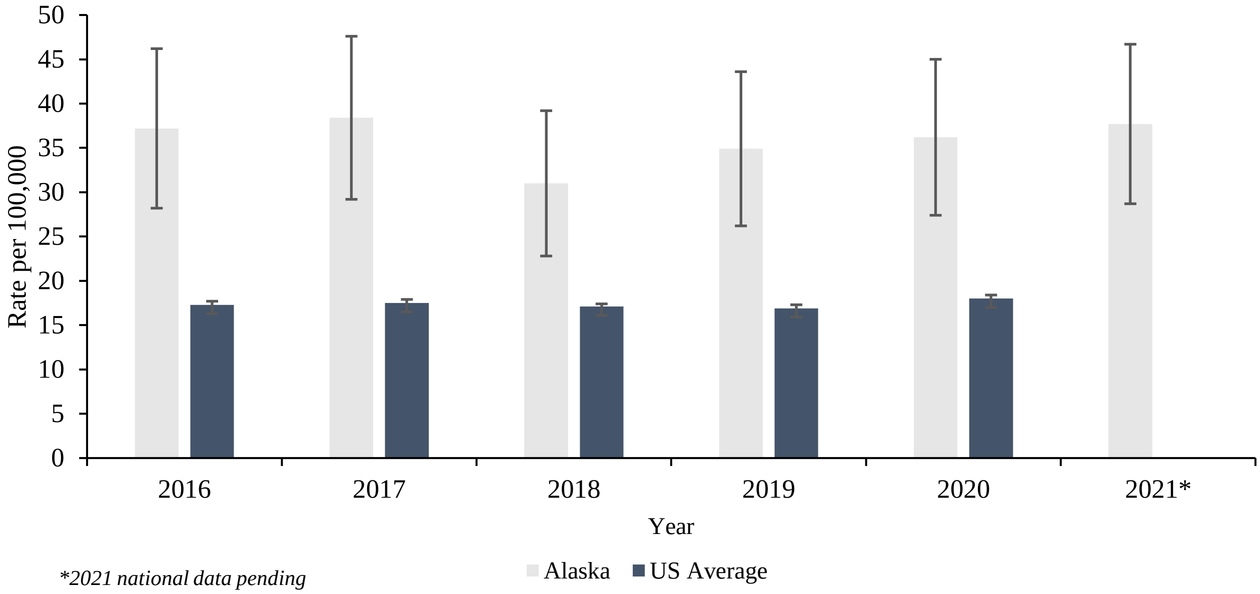


Table 6. Age Adjusted Rates of Traumatic Brain Injury-related (TBI) Deaths, by Sex, Region, and Race — Alaska, 2016–2021

Characteristic	Count (%)	Age-adjusted mortality rate (95% CI)
Sex		
Male	1149 (75.2)	55.1 (51.2, 58.3)
Female	378 (24.8)	18.3 (16.5, 20.1)
Region		
Anchorage	517 (33.9)	30.0 (27.4, 32.6)
Mat-Su	233 (15.3)	39.3 (34.2, 44.3)
Gulf Coast	185 (12.1)	38.8 (33.2, 44.4)
Interior	262 (17.2)	39.8 (35.0, 44.7)
Northern	89 (5.8)	57.1 (45.3, 69.0)
Southeast	119 (7.8)	28.2 (23.2, 33.3)
Southwest	116 (7.6)	46.0 (37.6, 54.3)
Race		
White	947 (62.0)	32.9 (30.8, 35.0)
AI/AN	442 (28.9)	67.3 (61.0, 73.6)
Black	57 (3.7)	34.3 (25.4, 43.2)
NHOPI	19 (1.2)	31.4 (17.3, 45.6)
Asian	35 (2.3)	13.4 (8.9, 17.8)

AI/AN; American Indian/Alaska Native, NHOPI; Native Hawaiian or Other Pacific Islander. Rates calculated per 100,000 population.

Figure 13. Rates of TBI-Related Mortality, by Age Mechanism — Alaska, 2016–2021

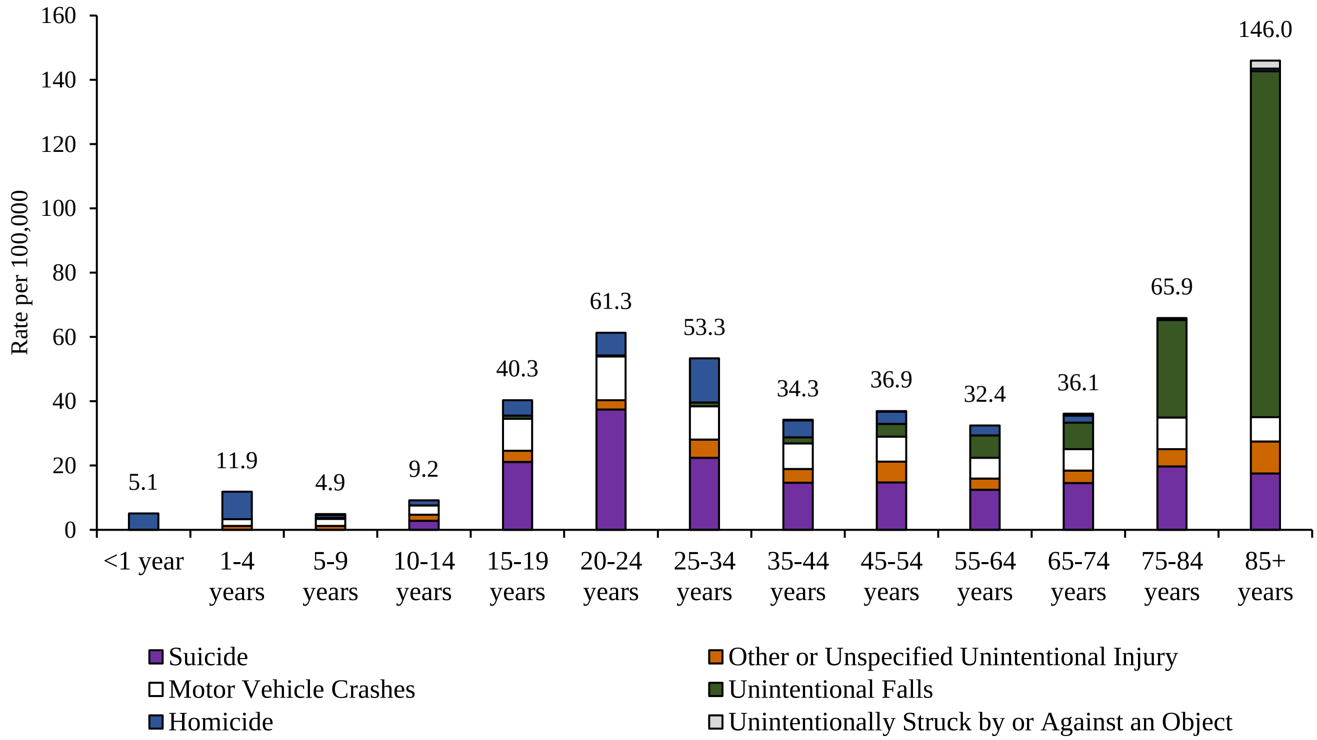


Table 7. Rates of TBI-related Mortality, by Sex and Injury Mechanism — Alaska, 2016–2021*

	Male (N=1149)		Females (N=368)		All (N=1527)	
Injury Mechanism	**Rate**	**Count**	**Rate**	**Count**	**Rate**	**Count**
Homicide	4.6	104	3.5	75	4.1	179
Motor vehicle crashes	9.0	204	5.6	119	7.3	323
Other or unspecified unintentional injury	5.9	135	1.7	36	6.1	171
Suicide	24.5	557	4.3	92	14.7	649
Unintentional falls	6.3	143	2.6	56	4.5	189
Unintentionally struck by or against an object	0.3	6	0	0	0.1	6
Total	50.6	1149	17. 2	368	34.7	1527

Rates calculated per 100,000 population.*

Figure 14. Rates of TBI-Related Mortality, by Region and Injury Mechanism — Alaska, 2016–2021

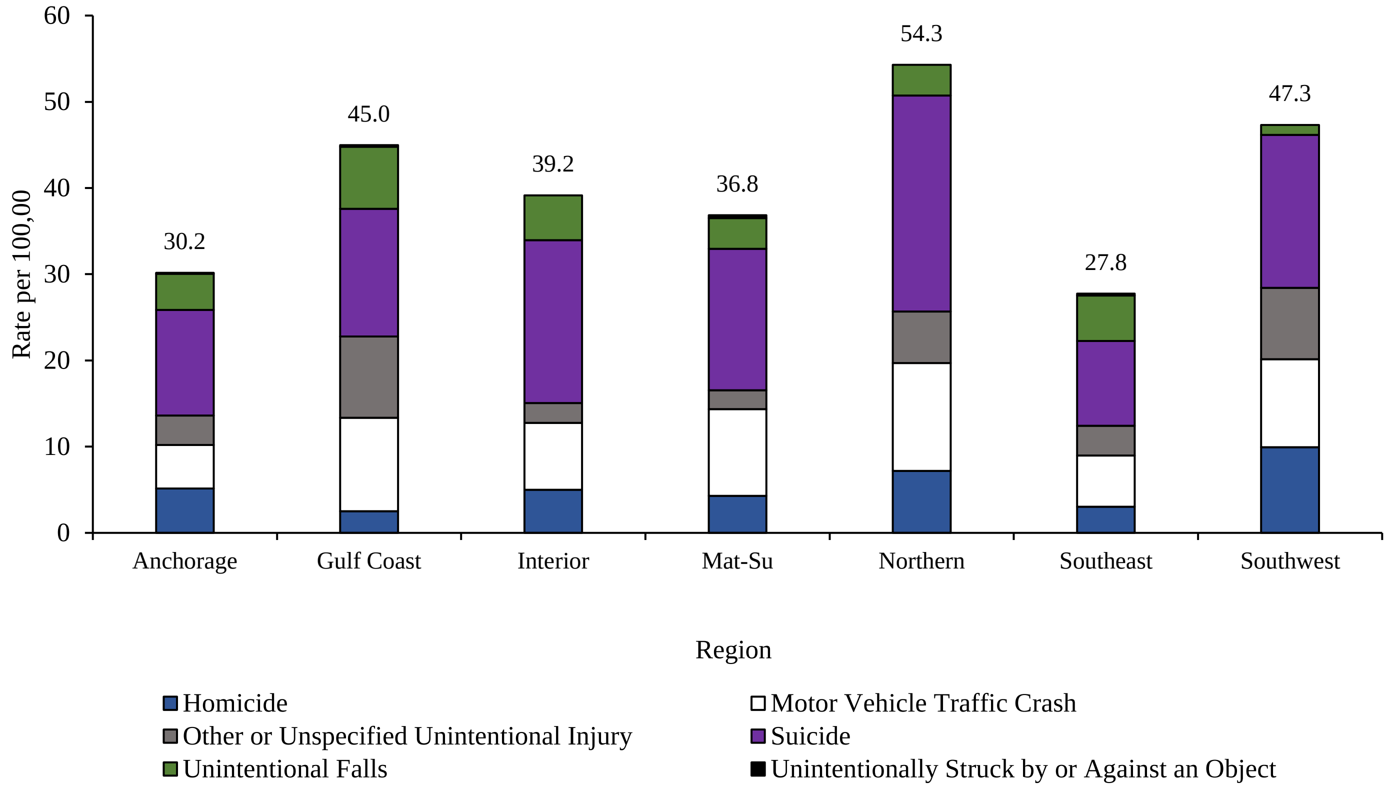


Figure 15. Rates of TBI-Related Mortality Attributable to Suicide, by Age — Alaska, 2016–2021

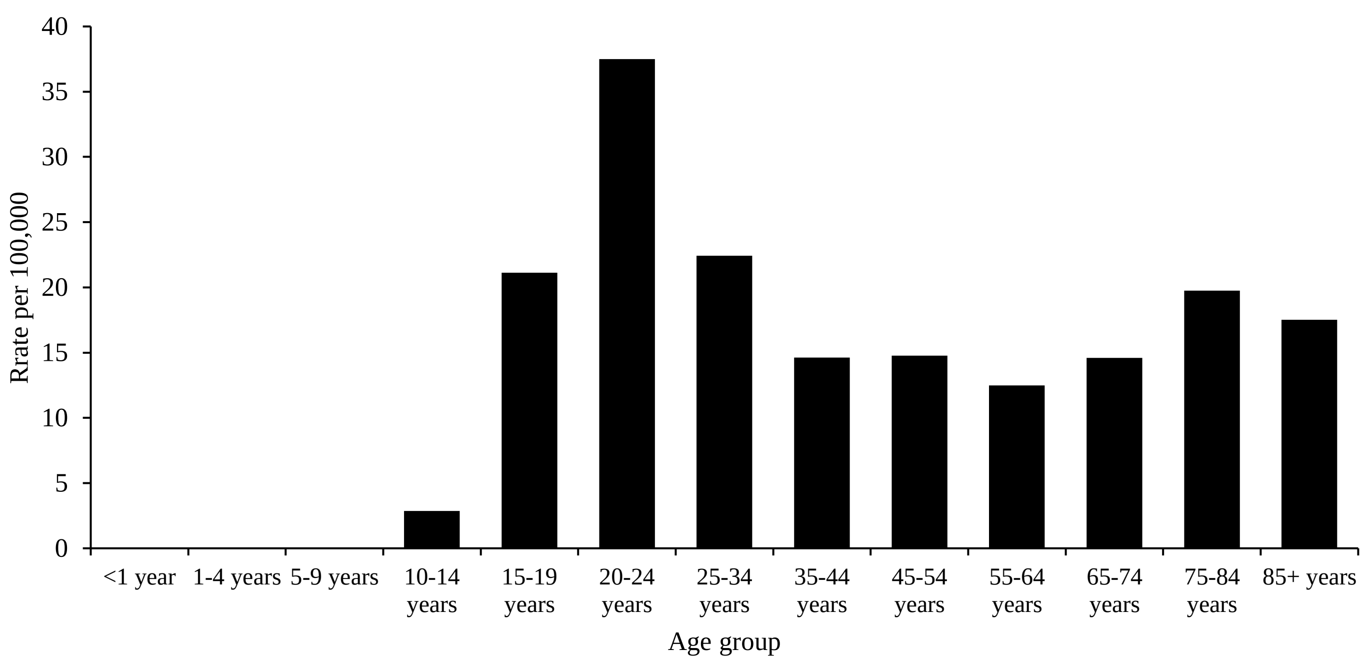


Table 8. Age-Adjusted Rates of TBI-related Mortality, by Race and Injury Mechanism — Alaska, 2016–2021

Injury Mechanism	Age-Adjusted Rate (95% CI)				
	AI/AN	Asian	Black	NHOPI	White
Homicide	10.8 (8.2, 13.3)	0.7* (0.3, 3.1)	10.7* (5.9, 15.5)	14.5* (5.9, 23.1)	2.5 (1.9, 3.1)
Motor vehicle crashes	16.3 (13.4, 19.4)	3.7* (1.1, 6.3)	2.5* (0.1, 5.0)	2.3* (0, 5.6)	6.6 (5.7, 7.5)
Other or unspecified unintentional injury	10.6 (8.0, 13.1)	1.0* (0.1, 2.3)	5.3* (1.4, 9.1)	1.3 (0, 3.8)	3.3 (2.7, 4.0)
Suicide	23.6 (20.0, 27.2)	4.4* (2.0, 6.8)	11.5 (6.8, 16.2)	4.9* (0.1, 9.8)	14.6 (13.2, 16.0)
Unintentional falls	7.1 (4.7, 9.4)	2.5* (0.3, 4.7)	4.3* (0.1, 8.5)	8.3* (0, 16.0)	5.6 (4.7, 6.5)
Unintentionally struck by or against object	0.2* (0, 0.6)	0	0	0	0.2* (0, 0.3)

Rates based on <20 events are statistically unreliable and should be interpreted with caution. Rates calculated per 100,000 population.

Table 9. TBI-Related Medicaid Expenditures in Medicaid Enrollees — Alaska, 2017–2021

	Total Claims	Total Enrollees	Total expenditure
Total	11,576	4726	$29,016,558
2017	2384	1053	$5,501,908
2018	2471	1032	$5,660,591
2019	2381	1038	$6,276,793
2020	2016	845	$5,774,146
2021	2324	978	$5,794,120

Figure 16. Average TBI Medicaid Claim Expenditure, by Service Utilized — Alaska, 2017–2021

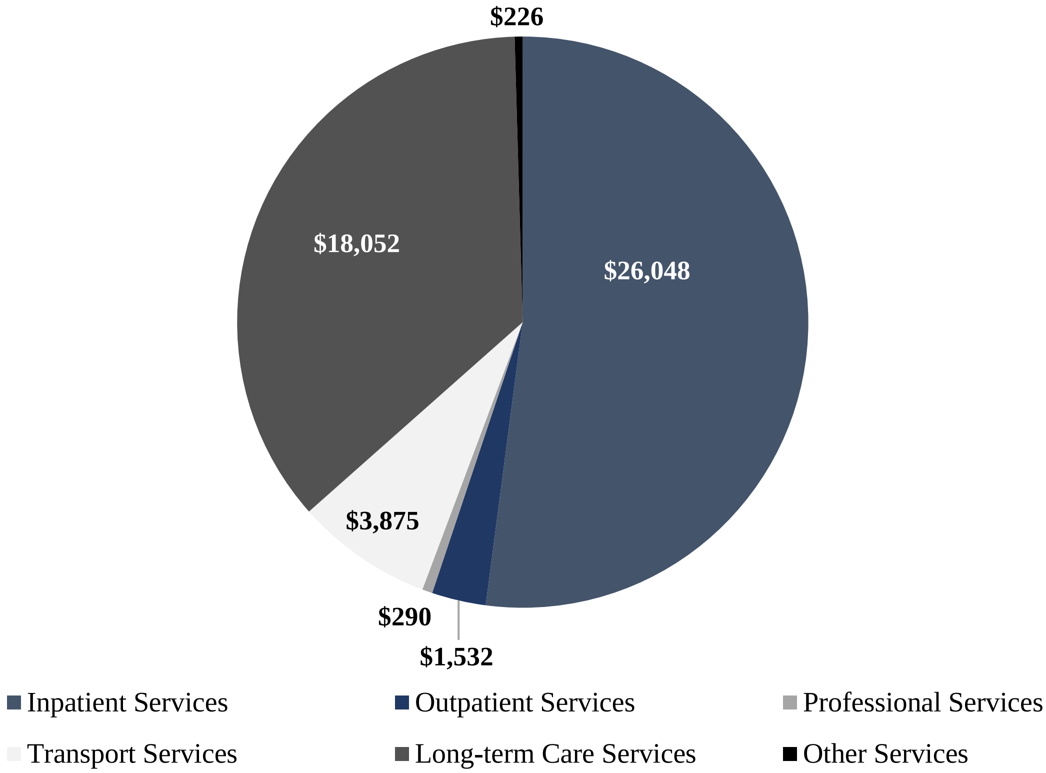


Table 10. Barriers Experienced in Accessing Health Care Because of Brain Injury from Responses in the 'Individual with Brain Injury' Participant Group (N=60)

Barrier	n= (%)
Finding a medical provider	24 (40%)
Paying for appointments	21 (35%)
Health insurance	17 (28%)
Finding a mental health provider	15 (25%)
Understanding the information that they are given	14 (23%)
Managing prescription medication	14 (23%)
Transportation to appointments	14 (23%)
Scheduling appointments	11 (18%)
A provider would no longer see me	8 (13%)

Table 11. Reported Services Received by Participants with a TBI (N=74)

Organization Used	Participants (N=74)			
	Using currently	**Used in past**	**Not applicable**	**No response**
Brain Injury Association of Alaska	9 (12%)	13 (17%)	29 (39%)	21 (28%)
Vocational Rehabilitation	3 (4%)	18 (24%)	33 (44%)	18 (24%)
TBI Case management	4 (5%)	8 (11%)	39 (53%)	21 (28%)
Veteran Affairs	6 (8%)	1 (1%)	41 (55%)	26 (35%)
Independent Living Center	4 (5%)	3 (4%)	42 (57%)	25 (32%)
Disability Law Center	2 (3%)	5 (7%)	38 (51%)	29 (39%)
Aging & Disability Resource Center	2 (3%)	2 (3%)	44 (60%)	26 (35%)
Tribal Vocational Rehabilitation	1 (1%)	2 (3%)	46 (62%)	25 (34%)
Developmental Disabilities Agency	0 (0%)	2 (3%)	44 (60%)	28 (38%)
Long-Term Care Ombudsman	1 (%)	1 (1%)	45 (61%)	27 (36%)
Other agencies	3 (4%)	3 (4%)	26 (35%)	42 (57%)

Table 12. Reported Services Received by Participants in the Family Members, Caregivers, or Guardians' Group (N=72)

Organization	Participants (N=72)				
	Using currently	**Used in past**	**Not sure**	**Never used**	**No response**
Brain Injury Association of Alaska	4 (6%)	18 (24%)	5 (7%)	29 (39%)	16 (22%)
Vocational Rehabilitation	3 (4%)	12 (16%)	3 (4%)	36 (49%)	18 (25%)
TBI Case management	3 (4%)	3 (4%)	10 (14%)	36 (49%)	20 (28%)
Veteran Affairs	2 (3%)	1 (1%)	1 (1%)	47 (64%)	21 (29%)
Independent Living Center	1 (1%)	4 (5%)	2 (3%)	46 (62%)	19 (26%)
Disability Law Center	0 (0%)	6 (8%)	3 (4%)	44 (59%)	19 (26%)
Aging & Disability Resource Center	2 (3%)	1 (1%)	4 (5%)	45 (61%)	20 (28%)
Tribal Vocational Rehabilitation	0 (0%)	1 (1%)	2 (3%)	48 (65%)	21 (29%)
Developmental Disabilities Agency	5 (7%)	4 (6%)	1 (1%)	44 (59%)	18 (25%)
Long-Term Care Ombudsman	1 (1%)	0 (0%)	1 (1%)	50 (68%)	20 (28%)
Other agencies	6 (8%)	7 (9%)	8 (11%)	15 (20%)	36 (50%)

Table 13. Characteristics of Health care Professionals Surveyed (N=165)

Characteristics	N = (%)
Position	
Medical	41 (28%)
Mental Health/Behavioral Health	36 (25%)
Social Services/Disability Services	32 (22%)
Other	36 (25%)
Work Location	
Urban*	97 (62%)
Rural	60 (38%)
Area's providers serve	
Local community or village	44 (27%)
Statewide	41 (25%)
Region	38 (23%)
Borough or census area	36 (22%)
More than one region	4 (3%)

**Municipality of Anchorage, City and Borough of Juneau, and Fairbanks North Star Borough*

9.0 Appendices

Appendix A. Injury Classification ICD-10 Codes

ICD-10 code(s)	Description
S00-S99	Anatomic Injuries
T07-T34	Foreign bodies, burns, corrosions, frostbite
T36–T50: with a 6th character of 1, 2, 3, or 4	Poisoning by drugs, medicaments, and biological substances
T51–T65	Toxic effects of substances nonmedicinal as to source
T66–T76	Other and unspecified effects of external causes
T79	Certain early complications of trauma, not elsewhere classified
O9A.2–O9A.5	Traumatic injuries and abuse complicating pregnancy, childbirth, and the puerperium
T84.04	Mechanical complication of other internal orthopedic devices, implants, and grafts.
M97	Periprosthetic fracture around internal prosthetic joint

Appendix B. TBI-related Hospitalization ICD-10 Codes

ICD-10 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

Appendix C. TBI-related ICD–10 Codes Corresponding to the Established TBI Death Surveillance Definition.

ICD-10 code(s)	Description
S01	Open wound of head
S02.0, S02.1, S02.3, S02.7-S02.9	Fracture of the 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

Appendix D. Mechanisms of Injury ICD-10 Codes

ICD-10 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 interventions, operations of war, military operations, and suicide
T14.91	Suicide attempt
T15-T19	Effects of foreign body entering through natural orifice
T36-T50 with a 6th character of 1, 2, 3, or 4. Including 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

Appendix E. Injury Mechanism Categories of Interest for Morbidity

Code(s)	Description
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
Motor vehicle 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-V85(.0-.3), V86 (.0-.9) V87.0-V87.8, V89.2,
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. [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
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
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 or 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

Appendix F. Injury Mechanism Categories of Interest for Mortality

Code(s)	Description
Motor vehicle 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 or 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

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