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## Disparities in traumatic brain injury-related deaths—the United States, 2021

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### Abstract

**Objectives:** This manuscript describes traumatic brain injury (TBI)-related mortality in the United States during 2021, by geography, sociodemographic characteristics, mechanism of injury, and injury intent.

**Method:** Multivariable modeling of TBI mortality was performed to assess the simultaneous effect of multiple factors (geographic region, sex, race and ethnicity, and age) included in the model. Authors analyzed multiple-cause-of-death data from the National Vital Statistics System and included records when an International Classification of Diseases, Tenth Revision (ICD-10) underlying cause of death injury code, and a TBI-related ICD-10 diagnosis code were both listed.

**Results:** During 2021, there were 69,473 TBI-related deaths. Rates were highest among older adults, males, and non-Hispanic American Indian/Alaska Native persons. A large proportion of all TBI-related deaths were attributed to unintentional falls and suicides. Model-based rates of TBI mortality revealed a divergent pattern with increasing rates by age group, while rate ratios simultaneously declined with age among specific racial/ethnic groups when compared with non-Hispanic White persons.

**Conclusion:** Findings indicate unintentional falls and suicides remain a common cause of fatal TBI and specific groups are disproportionately affected by such injuries. Health care providers can play a role by assessing patients at increased risk for TBI and providing referrals for care and culturally tailored interventions when warranted.

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<sup>5</sup>See e.g., 45 C.F.R. part 46.102(l) (2), 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

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Disclaimer

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

## Keywords

Traumatic brain injury; fatal injury; ICD-10; health disparities; surveillance

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## Introduction

Traumatic brain injury (TBI) remains a leading diagnosis associated with injury-related death in the United States. In 2020, approximately one-fourth of all injury-related deaths (64,362 of 278,345) among U.S. residents included a diagnosis indicating TBI (1). TBI is caused by a bump, blow, or jolt to the head such as a closed head injury or a penetrating head injury, which results in disruption of normal brain function (2). An occurrence of TBI can be self-inflicted, unintentional, or a result of assault and can affect the life of anyone at any age. Epidemiological data show that some groups are affected unequally and experienced worse outcomes (3–6). National surveillance of TBI-related deaths routinely reveals sex and age differences of this health event, with males having higher age-adjusted rates than females and older adults aged  $\geq 75$  years displaying the highest rates when compared with all other age groups (4–7). Further, when examining TBI-related deaths by race and ethnicity, higher age-adjusted rates have been observed among non-Hispanic American Indian/Alaska Native (AI/AN) individuals when compared to other racial and ethnic groups (3).

Racial and ethnic disparities in TBI-related deaths are associated with differences in the U.S. geographic location of the decedent, injury intent (i.e., unintentional vs. intentional injury), and the mechanism of injury (MOI) contributing to the injury event. Level of geographic rurality plays a role in fatal outcomes of TBI, with higher rates observed among people residing in rural areas when compared with people residing in urban areas (8,9). One hypothesis for such geographic disparities in fatal outcomes of TBI includes barriers in access to emergency medical care (including Level I trauma centers) (10) and specialized TBI care (11) that residents in rural areas may experience. National surveillance of TBI-related deaths also suggests racial and ethnic disparities persist with contributing differences in MOI and injury intent. In 2020, suicide (all mechanisms) was the leading external cause of injury contributing to TBI-related deaths among AI/AN individuals (7). Notably, in the United States approximately half of all suicides involve the use of a firearm (12,13). Additionally, an analysis of 20 years of national death data (2000–2019) revealed that firearm-related TBI homicides disproportionately affected non-Hispanic Black individuals when compared to other racial and ethnic groups (14). Firearm-related TBIs, whether due to suicide or homicide, are associated with a poorer prognosis than nonpenetrating injuries (15,16). Taken together, the underlying reasons for racial and ethnic disparities in TBI-related deaths due to suicide and homicide are multifactorial and likely include conditions (e.g., physical characteristics of the community and individual accessibility of medical care) in an individual's environment and an individual's opportunity for education and economic stability (17). For example, lower economic stability and lower levels of formal education can serve as barriers to quality care and symptom management following non-fatal TBI.

The Centers for Disease Control and Prevention (CDC) annually examines data from the National Vital Statistics System (NVSS) to determine counts and rates of TBI-related deaths among population subgroups (e.g., geographic location, sex, race and ethnicity, age) by injury intent and MOI. Aims of the current study are to: 1) describe counts and rates (crude and age-adjusted) of TBI-related deaths by geographic and demographic characteristics, injury intent, and MOI during the 2021 data year and 2) estimate model-based rates of TBI-related deaths simultaneously stratified by multiple factors including geographic area, sex, race and ethnicity, and age. In addition to consideration of such factors simultaneously, as well as their possible interactions, model-based rates can help illuminate and describe inherent variability in national death data. Findings from this analysis may be used by public health officials to identify priority areas for TBI prevention programs aimed at disproportionately affected population subgroups.

## Methods

TBI-related deaths were examined using 2021 NVSS multiple-cause-of-death data. Through a partnership between state and local jurisdictions and the National Center for Health Statistics (NCHS), NVSS collects data for all deaths occurring in the United States (18). For this analysis, the set of all injury-related deaths was first identified if the record included an underlying cause of death coded as an injury (ICD-10 codes: V01–Y36, Y85–Y87, Y89, U01–U03; (19); selected records were also restricted to those representing U.S. residents. From this set of injury-related resident deaths, TBI-related deaths were identified if a TBI-related ICD-10 diagnosis code was listed in one of the 20 multiple-cause-of-death fields. The following TBI-related ICD-10 codes were used and correspond to CDC'S established TBI mortality surveillance case definition: S01, S02.0, S02.1, S02.3, S02.7–S02.9, S04.0, S06, S07.0, S07.1, S07.8, S07.9, S09.7–S09.9, T90.1, T90.2, T90.4, T90.5, T90.8, T90.9 (6). Injury intent and MOI categories focused on motor vehicle crashes, unintentional falls, unintentional strikes by/against an object, other or unspecified unintentional injury, all mechanisms of suicide (e.g., intentional self-harm by firearm and intentional self-harm by falling), all mechanisms of homicide (e.g., assault by firearm and assault by bodily force), and other, which includes TBIs of undetermined intent and those due to legal intervention or war. During the 2021 data year, no deaths due to operations of war were recorded in the NVSS U.S. resident death data. Intent and MOI were identified by searching the underlying cause of death field for codes listed in Appendix A. These codes are consistent with the ICD-10 external cause of injury matrix (20).

Most of this analysis relied on the public-use multiple-cause-of-death file (21), while the stratification of TBI-related deaths by census division of decedents' residence was accomplished using the multiple-cause-of-death data available through CDC WONDER<sup>1</sup> for analytical ease. Census divisions include New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific as defined by the U.S. Census Bureau (22). Restricted-use NVSS data were linked with U.S. Census Bureau population data to generate model-based rates of TBI-related

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<sup>1</sup>.Wide-ranging Online Data for Epidemiologic Research (WONDER) 2018. Available at: <https://wonder.cdc.gov>. Accessed on May 23, 2023.

deaths when multiple factors including decedent's census region of residence, sex, race and ethnicity, and age group were considered simultaneously. Census regions (geographically larger than divisions) include Northeast, Midwest, South, and West.

Nominal (crude) rates (per 100,000 population) were estimated using single-race population estimates obtained from the U.S. Census Bureau as the denominators. Nominal rates of TBI-related deaths among children aged from birth to 17 years were analyzed separately from other age groups. All-ages rates were further age-adjusted (i.e., 12 age groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, 74–84, and ≥85 years) to the year 2000 U.S. standard population using the direct method (23). Model-based rates (also per 100,000 population) were estimated by dividing the model-based counts by corresponding at-risk population estimates and multiplying the results by 100,000. Model-based counts of TBI-related deaths were generated for all combinations of census region, sex, ethnicity/race (Hispanic, any race; non-Hispanic Asian/Pacific Islander (A/PI); non-Hispanic American Indian/Alaska Native (AI/AN); non-Hispanic Black; non-Hispanic White), and age group (0–14 years old, 15–34 years old, 35–54 years old, 55–74 years old, ≥75 years old). Authors recognize that race and ethnicity are distinct social constructs; for the purposes of this analysis race and ethnicity were combined into a single construct. During the modeling phase, we employed 5 age groups, as opposed to the 12 generally narrower age groups used in calculating our descriptive statistics, for stability of our model. Due to substantial over-dispersion detected during the preliminary modeling phase, a negative binomial regression modeling framework was adopted instead of a Poisson regression framework. An initial semi-saturated model included the four predictive factors listed above along with all possible two-way interactions; a slightly reduced model was ultimately adopted. To model population-based counts, a log-population offset term was included in the model. Modeling was carried out using PROC GENMOD in SAS V 9.4. Model-based rate ratios (RRs) and corresponding 95% CIs were generated using PROC GENMOD ESTIMATE statements during the modeling run. Model-based RRs inform readers whether the model-based rate for the group examined is higher or lower than the rate for the referent group and whether the difference is statistically significant. Within each census region × sex × age group block, RRs were calculated by ethnicity/race with the non-Hispanic White group as the referent. RRs were ruled statistically significant at the  $\alpha = 0.05$  level if the corresponding 95% CIs excluded the value 1.0.

Final model-based rate estimates were subject to three screening (exclusion) criteria:

- an underlying count < 10 (similar to the NVSS count-based suppression rule);
- a standardized Pearson residual > 3 in absolute value (indicating poor fit);
- a relative standard error (RSE) > 0.30 (indicating statistical instability).

Model-based RRs with either model-based rate component (numerator or denominator [referent]) masked under the criteria indicated above were similarly screened out.

## Results

During 2021, TBI contributed to 69,473 deaths, which equates to approximately 190 TBI-related deaths occurring each day in the United States (Table 1). Children aged from birth to 17 years accounted for 2,977 of TBI-related deaths with known age. Older adults aged  $\geq 75$  years (86.6 per 100,000 population) and 65–74 years (25.6) had the highest rates of TBI-related deaths when compared with other age groups. Males had an age-adjusted rate of TBI-related deaths that was more than three times that of females (30.5 versus 9.4, respectively). When compared to other racial and ethnic groups, non-Hispanic AI/AN individuals had the highest age-adjusted rate (31.5) of TBI-related deaths.

There were 37,635 TBI-related deaths categorized as unintentional injuries (i.e., motor vehicle crashes, unintentional falls, unintentionally struck by or against an object, other unintentional injury, or mechanism unspecified), while 30,801 were categorized as intentional injuries (i.e., all mechanisms of suicide and homicide) during 2021 (Table 2). Nearly 98% of TBI-related deaths listing suicide as the external cause were due to a firearm-related injury (data not shown). Suicide, unintentional falls, and motor vehicle crashes contributed to the highest age-adjusted rates of TBI-related death (6.8, 5.4, and 3.5, respectively). The injury intent and MOI that most often contributed to a TBI-related death varied by age group of the decedent. Among children aged birth to 17 years (analyzed separately from other age groups) the highest rates of TBI-related deaths were due to motor vehicle crashes, homicide, and suicide<sup>2</sup> (1.2, 1.2, and 1.1, respectively). Among older adults aged  $\geq 75$  years, unintentional TBIs, combined across MOI, contributed to a rate of TBI-related deaths that was more than five times as high as that associated with intentional injuries (72.3 and 14.0, respectively). The difference in injury intent of TBI-related deaths was particularly driven by the rate of unintentional falls (62.7) among older adults. Suicide was the leading contributor of TBI-related deaths among individuals aged 15–24 years, 25–34 years, 35–44 years, 45–54 years, and 55–64 years (7.9, 8.8, 7.9, 8.2, and 7.9 respectively).

Among male decedents, intentional injuries contributed to a higher age-adjusted rate of TBI-related death than unintentional injuries, combined across MOI (15.5 compared with 14.6) during 2021 (Table 3). The difference was particularly driven by the age-adjusted rate of suicide (12.2) contributing to TBI-related death among males. Among female decedents, unintentional injuries (combined across MOI) contributed to a higher age-adjusted rate of TBI-related death than intentional injuries (6.3 compared with 2.9). This difference was particularly driven by the age-adjusted rate of unintentional falls (3.8) contributing to TBI-related death among female decedents. Among all the external causes of injury (e.g., motor vehicle crashes, unintentional falls, unintentionally being struck by or against an object, suicide, and homicide) that contributed to a TBI-related death, males displayed higher counts and age-adjusted rates compared with females (Table 3).

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<sup>2</sup>.Age <10 years were excluded because determining intent in younger children can be difficult. Rates for TBI-related deaths due to suicide were age-adjusted to the population 10 years and older.

When examining the leading cause of TBI-related death, with respect to injury intent and MOI, variation by race and ethnicity was observed (Table 4) during 2021. Unintentional injuries, combined across MOI, contributed to a higher age-adjusted rate of TBI-related death than intentional injuries among non-Hispanic White (10.8 compared with 9.8), Hispanic all races (8.3 compared with 5.0), non-Hispanic AI/AN (16.9 compared with 13.0), and non-Hispanic A/PI (6.0 compared with 2.4) persons. However, among non-Hispanic White persons, suicide (includes all MOI) was the leading cause of TBI-related deaths. Among Hispanic (includes all races) and non-Hispanic A/PI persons, unintentional falls were the leading cause of TBI-related deaths (4.0 and 4.2, respectively). The leading external causes of TBI-related death among non-Hispanic AI/AN persons were motor vehicle crashes and suicide (8.9 and 8.5, respectively). In contrast, among non-Hispanic Black persons, the age-adjusted rate of TBI-related death due to intentional injuries was higher than that due to unintentional injuries, combined across MOI (12.9 compared with 9.2). This difference was driven by the age-adjusted rate of homicide (8.2) leading to TBI-related death among non-Hispanic Black persons.

In the model-based phase of the analysis, the initial semi-saturated model was reduced to a slightly simpler model via removal of one nonsignificant two-way interaction term (census region  $\times$  sex). This simplified model served as the basis for all subsequent estimation of model-based rates and RRs. After applying the screening rules described in the methods section, 38 of the 200 model-based rates were excluded from presentation. Correspondingly, 41 of the 160 model-based RRs were similarly screened out. Of the 119 RRs that cleared the screening criteria, 107 were ruled to be statistically significant. Table 5 presents the final screened results. During 2021, the model-based rate of TBI-related death among non-Hispanic Black males aged birth-14 years and residing in the Northeast region was significantly different and nearly three times as high as the model-based rate among non-Hispanic White (referent group) males in the same age group and geographic region (4.74 compared with 1.65), over three times as high in the Midwest (9.91 compared with 3.07), and over two times as high in the South (8.04 compared with 3.53), and West (6.10 compared with 2.78). For this same age group, the model-based rate of TBI-related death among Hispanic males was significantly different and lower than the model-based rate among non-Hispanic White males in the Midwest (2.51 compared with 3.07), South (2.58 compared with 3.53), and West (2.35 compared with 2.78). Although model-based rates were lower for females in this age group, model-based RRs comparing the ethnicity/race groups show patterns comparable to those observed for males across geographic regions.

Among non-Hispanic Black males aged 15–34 years residing in the Northeast region the model-based rate of TBI-related death was significantly different and higher than the model-based rate among non-Hispanic White males in the same age group and geographic region (38.54 compared with 16.73), as well as in the Midwest (70.57 compared with 27.23), South (61.95 compared with 33.96), and West (51.50 compared with 29.22). For this same age group, the model-based rate of TBI-related death among Hispanic males was significantly different and lower than the model-based rate among non-Hispanic White males in the Midwest (23.02 compared with 27.23), South (25.67 compared with 33.96), and West (25.58 compared with 29.22). Non-Hispanic A/PI males aged 15–34 years residing in the Northeast region displayed a model-based rate of TBI-related death significantly different and lower

than the model-based rate among non-Hispanic White males in the same age group and geographic region (6.99 compared with 16.73), as well as in the Midwest (10.61 compared with 27.23), South (12.69 compared with 33.96), and West (9.47 compared with 29.22). Non-Hispanic AI/AN males aged 15–34 years residing in the Midwest region had a model-based rate of TBI-related death significantly different and higher than the model-based rate among non-Hispanic White males in the same age group and geographic region (70.23 compared with 27.23), as well as in the South (42.35 compared with 33.96) and West (84.32 compared with 29.22). Although model-based rates were also lower for females in this age group, model-based RRs comparing the ethnicity/race groups again show patterns quite comparable to those observed for males across geographic regions.

Notably, among non-Hispanic Black males in the oldest study age group ( $\geq 75$  years) and residing in the Northeast region the model-based rate of TBI-related deaths was significantly different and lower than the model-based rate among non-Hispanic White males in the same age group and geographic region (59.16 compared with 114.70), as well as in the Midwest (81.58 compared with 140.56), South (61.74 compared with 151.16), and West (54.84 compared with 138.99). Although model-based rates were once again lower for females, non-Hispanic Black females aged  $\geq 75$  years show a similar pattern in model-based RRs to that observed for males across geographic regions. Among non-Hispanic AI/AN males in this oldest age group and residing in the South region the model-based rate of TBI-related death was significantly different and lower than the model-based rate among non-Hispanic White males in this same age group and geographic region (50.84 compared with 151.16). Considered collectively, the model-based rates of TBI-related death demonstrate that comparisons by geographic region and sex, without also accounting for decedent age, can conceal important differences in relative population-based rates across ethnicity and race groupings.

## Discussion

In 2021, there were more than 69,000 TBI-related deaths that occurred in the United States and rates varied by age group, sex, MOI, race and ethnicity, and geographic area. The age-adjusted rate of TBI-related death per 100,000 population in 2021 (19.5) represents an 8.8% increase from 2020 (18.0) (7). In this analysis, the highest rates of TBI-related deaths occurred among older adults aged  $\geq 75$  years, males, and non-Hispanic AI/AN individuals which is consistent with previously published epidemiological research (3,7) and CDC surveillance reports (4,5). Suicide was the leading cause of TBI-related deaths in 2021. Unintentional falls were the second leading cause of this health event in 2021. Stratification of TBI-related deaths by injury intent and within each MOI also revealed differences by age group, sex, and race and ethnicity. Further, model-based rates of TBI-related death demonstrated that comparisons by geographic region and sex without also accounting for decedent age can conceal important differences across ethnicity and race groupings.

Older age is a known risk factor for TBI. Geriatric and neurotrauma researchers have identified preexisting comorbidities as one of the significant determinants during recovery after injury including TBI (24,25). Older adults with preexisting comorbidities (e.g., coronary heart disease, hypertension, and diabetes mellitus) at the time of a TBI have

shown increased mortality risk within 1 year of their injury (26). As the population ages, U.S. trauma centers are seeing a greater proportion of elderly patients with more comorbid diseases (27). Further, management of chronic conditions among older adults routinely involves aspirin and anticoagulant therapies (warfarin [Coumadin], non-vitamin K oral anticoagulants), which can result in an increased likelihood of intracranial hemorrhage and further complications from a TBI (28). In this analysis, an unintentional fall was the most common MOI for TBI-related deaths among older adults aged  $\geq 75$  years. This finding is consistent with older age being a known risk factor for falls (29,30) due to functional declines in balance, vision, and muscle strength. CDC's Compendium of Effective Fall Interventions (31) was created to help clinicians, public health practitioners, senior service providers, and others implement either single interventions (exercise, home modification, and clinical interventions) or multifaceted interventions (addressing multiple risk factors) to address older adult falls. Active fall prevention strategies that the public can engage in for themselves or on behalf of loved ones include screening for fall risk using the Falls Free Checkup<sup>3</sup>; having an annual eye exam; talking to their health care provider about their own or a loved one's fall risk; performing balance and strength exercises; and modifying the home environment to increase safety (e.g., removing tripping hazards).

This report adds to previous epidemiological literature that has consistently observed higher counts and age-adjusted rates of TBI-related death among males compared with females for overall incidence and across all unintentional and intentional MOI. One study that analyzed the National Trauma Data Bank records found that in the general adult population, males are more likely than females to die from a TBI (32). Further, systematic reviews of epidemiological research reveal that males have an increased propensity to sustain more severe TBIs when compared with females (33,34) which may contribute to the higher age-adjusted rates of TBI-related death across all unintentional and intentional MOI examined in this analysis. Authors focused on a broad categorization of the causes contributing to a TBI-related death and recognized that without stratifying homicide-related TBIs by mechanism and sex differences driven by intimate partner violence (IPV) may not adequately be captured. Research shows that women are at greater risk for IPV and women who experience IPV often do not report their injuries (35,36). Further when women do report IPV-related injuries, head injuries are one of the most common injuries (37,38) reported and an observational study (39) found that among a sample of women who experienced IPV 30% experienced loss of consciousness and 67% experienced residual symptoms consistent with a brain injury (e.g., concentration difficulties, memory loss, and dizziness).

Age-adjusted rates of TBI-related death stratified by injury intent and MOI revealed racial and ethnic differences that corroborate a prior epidemiological analysis of TBI-related deaths during an 18-year (2000 to 2017) study period (3) and the CDC's previous surveillance reports (4,5). While the overall age-adjusted rate of suicide declined from 2018 to 2021 among non-Hispanic White persons (40), the present analysis found that suicide and unintentional falls contributed most prominently to TBI-related deaths in this

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<sup>3</sup>. Available here: Falls Free Check Up (<https://www.ncoa.org>.)

population. CDC's Suicide Prevention Resource for Action (41) provides strategies with the best available evidence to support states and communities to reduce suicide.

Among non-Hispanic AI/AN persons, suicide and motor vehicle crashes contributed most prominently to TBI-related deaths. In addition to the Suicide Prevention Resource for Action and other best practice guides (e.g., Task Force for Community Preventive Services Motor Vehicle Injury Prevention Recommendations<sup>4</sup>), it is critical to consider the unique cultural values and contexts, resources, and challenges of tribes and tribal organizations when adapting, implementing, and evaluating evidence-based suicide and motor vehicle crash prevention programs to reduce these common causes of TBI-related deaths among this population. Identification of evidence-based programs that include AI/AN cultural values and practices (e.g., storytelling) (42) is needed to help prevent the common causes of fatal TBI among this population.

The CDC annually examines NVSS data to calculate rates of TBI-related deaths among population subgroups with factors such as a decedent's geographic location, sex, race and ethnicity, or age examined individually. This straightforward approach does not account for possible interactions of the aforementioned factors in the calculation of the rate of TBI-related deaths. Model-based rates can help illuminate such interactions and characterize inherent variability in national death data when such factors are considered simultaneously. Model-based rates of TBI-related deaths were included in this analysis to help assess fatal TBI disparities by multiple factors, including geographic area, sex, race and ethnicity, and age. Notably, across all four census regions, among non-Hispanic Black males, model-based rates followed a clear bimodal pattern across the age spectrum, while model-based RRs with non-Hispanic White persons as the referent steadily decreased, indicating a differential burden shifting from the former population group to the latter with increasing age. Non-Hispanic Black females displayed patterns in model-based rates and model-based RRs of TBI-related death across the age spectrum similar to those of non-Hispanic Black males. One likely explanation for these findings is that the role of injury intent and MOI of TBI-related deaths in these populations differentially changes over the lifespan. For example, firearm-related homicides (a major contributor of intentional TBI-related homicides; 14) disproportionately affect non-Hispanic Black youth and young adults when compared with other racial/ethnic groups of the same age (12,43). Underlying reasons for the disparity in firearm-related homicides and intentional TBIs attributed to homicide are complex and are underscored by longstanding systemic inequities (economic, social, and various aspects of the physical environment) among various racial and ethnic groups. Improving outcomes among youth and young adults who are exposed to violence can be facilitated when strengths within individuals, families, and communities are fostered (44,45). CDC's Technical Packages for Violence Prevention (46) can help communities implement evidence-based violence prevention efforts including changes to the physical environment (e.g., remediation of vacant lots to enhance safe spaces), programs to teach coping and problem-solving skills and enhance positive social connections, encouragement of secure firearm storage, and access to crisis intervention and treatment to address trauma.

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4.<https://www.thecommunityguide.org/topics/motor-vehicleinjury.html>.

Although not assessed directly, the authors recognize the COVID-19 pandemic could have impacted our analysis of 2021 national data for TBI-related deaths. Retrospective studies comparing pre-pandemic and pandemic TBI data demonstrate the burden of TBI remained present (47) but there were drastic changes in the number of TBI referrals and TBI patient management, as well as deleterious consequences for those needing neurorehabilitation (48). All three factors (i.e., changes in patient referrals, management, and rehabilitation) could have impacted the TBI-related deaths observed in this analysis as a case may not have died immediately from the TBI, but their death was at least caused in part by it.

## Limitations

This analysis is subject to several limitations. First, instances of multiple injuries listed on a death record, such as non-TBI diagnoses, might have also contributed to the deaths examined in this analysis. Second, misclassification or incomplete documentation of the cause of death field on death certificates could lead to the potential of overestimation or underestimation of TBI-related deaths. Third, race and Hispanic origin endorsed on death certificates can be misclassified, particularly for A/PI, AI/AN, and Hispanic populations (49,50). The misclassification of race and Hispanic origin on death certificates could lead to misestimation of TBI-related deaths and rates among these populations. Fourth, authors recognize that race and ethnicity are distinct social constructs; for the purposes of this analysis race and ethnicity were combined into a single construct. As this analysis utilized race and ethnicity as a proxy for broader and likely more complex social determinants of health, future work is needed to better understand the structural elements that underscore racial and ethnic disparities in TBI-related deaths. Fifth, this analysis included broad categorization of the principal MOIs and intents of TBI-related deaths, which limits the specificity of conclusions drawn regarding the leading contributors to this health outcome. Sixth, the use of NVSS as a mortality data source is subject to population or cell size limitations that may require suppression of some numbers. Finally, this analysis focuses only on deaths and the findings might not be generalizable to less severe TBIs.

This report describes the leading unintentional and intentional MOI of TBI-related deaths and identifies population groups with the greatest rates of this injury, to promote development of focused prevention efforts. Health care providers can play a crucial role by assessing patients at increased risk for fatal or nonfatal TBI (e.g., persons at risk for unintentional falls or suicide) and by providing referrals for care or culturally sensitive interventions when warranted.

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## Data availability statement

Data supporting descriptive statistics of TBI-related deaths presented in the paper can be found using the public-use multiple-cause-of-death file located at [https://www.cdc.gov/nchs/nvss/mortality\\_public\\_use\\_data.htm](https://www.cdc.gov/nchs/nvss/mortality_public_use_data.htm). Results focused on stratification of TBI-related deaths

by census division of decedents' residence can be found using the multiple-cause-of-death data available through CDC WONDER located at <https://wonder.cdc.gov>.

## Appendix A.: External cause of injury International Classification of Diseases-Tenth Revision (ICD-10) codes

| Mechanism/Intent of Injury          | ICD-10 Codes                                                                                                                                             |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unintentional 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/against   | W20–W22, W50–W52                                                                                                                                         |
| Unintentional, other                | All the other codes in the V01–X59, Y85–Y86 ranges                                                                                                       |
| Suicide (includes all mechanisms)   | U03, X60–X84, Y87.0                                                                                                                                      |
| Homicide (includes all mechanisms)  | U01–U02, X85–Y09, Y87.1                                                                                                                                  |
| Other                               | Y10–Y34, Y87.2, Y89.9, Y35–Y36, Y89(.0,.1)                                                                                                               |

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**Table 1.**

Number and rate\* of traumatic brain injury-related deaths<sup>†</sup> by selected socio-demographic characteristics — National Vital Statistics System, the United States, 2021.

| Socio-demographic characteristics           |                | Number | Rate* (95% CI)   |
|---------------------------------------------|----------------|--------|------------------|
| <b>Age (years)</b>                          |                |        |                  |
| 0–17                                        |                | 2,977  | 4.0 (3.9–4.2)    |
| 0–4                                         |                | 675    | 3.6 (3.3–3.9)    |
| 5–9                                         |                | 310    | 1.5 (1.4–1.7)    |
| 10–14                                       |                | 593    | 2.8 (2.5–3.0)    |
| 15–24                                       |                | 7,828  | 18.2 (17.8–18.6) |
| 25–34                                       |                | 8,846  | 19.4 (19.0–19.8) |
| 35–44                                       |                | 7,603  | 17.5 (17.1–17.9) |
| 45–54                                       |                | 7,290  | 17.9 (17.5–18.3) |
| 55–64                                       |                | 8,483  | 19.8 (19.4–20.2) |
| 65–74                                       |                | 8,623  | 25.6 (25.1–26.2) |
| ≥75                                         |                | 19,218 | 86.6 (85.4–87.9) |
| <b>Sex</b>                                  |                |        |                  |
| Male                                        | Crude §        | 51,321 | 31.2 (30.9–31.5) |
|                                             | Age-Adjusted ¶ | 51,318 | 30.5 (30.2–30.8) |
| Female                                      | Crude §        | 18,152 | 10.8 (10.7–11.0) |
|                                             | Age-Adjusted ¶ | 18,151 | 9.4 (9.2–9.5)    |
| <b>Race/ethnicity**</b>                     |                |        |                  |
| Non-Hispanic White                          | Crude §        | 49,238 | 25.0 (24.8–25.2) |
|                                             | Age-Adjusted ¶ | 49,236 | 20.9 (20.7–21.1) |
| Non-Hispanic Black                          | Crude §        | 9,503  | 22.7 (22.2–23.2) |
|                                             | Age-Adjusted ¶ | 9,503  | 22.6 (22.2–23.1) |
| Hispanic persons                            | Crude §        | 7,499  | 12.0 (11.7–12.2) |
|                                             | Age-Adjusted ¶ | 7,498  | 13.5 (13.2–13.8) |
| Non-Hispanic American Indian/Alaskan Native | Crude §        | 756    | 30.8 (28.6–33.0) |

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| Socio-demographic characteristics         |                | Number | Rate* (95% CI)   |
|-------------------------------------------|----------------|--------|------------------|
| Non-Hispanic Asian/Pacific Islander       | Age-Adjusted ¶ | 756    | 31.5 (29.2–33.8) |
|                                           | Crude §        | 1,738  | 8.6 (8.2–9.0)    |
| Non-Hispanic Multiple Races               | Age-Adjusted ¶ | 1,738  | 8.5 (8.1–8.9)    |
|                                           | Crude §        | 604    | 7.8 (7.1–8.4)    |
| U.S census region of decedent's residence | Age-Adjusted ¶ | 604    | 9.7 (8.8–10.5)   |
|                                           | Crude §        | 2,639  | 17.5 (16.8–18.2) |
| New England                               | Age-Adjusted ¶ | 2,639  | 15.0 (14.4–15.6) |
|                                           | Crude §        | 6,449  | 15.3 (15.0–15.7) |
| Middle Atlantic                           | Age-Adjusted ¶ | 6,449  | 13.5 (13.2–13.8) |
|                                           | Crude §        | 10,029 | 21.2 (20.8–21.7) |
| East North Central                        | Age-Adjusted ¶ | 10,029 | 19.6 (19.2–20.0) |
|                                           | Crude §        | 5,174  | 23.9 (23.3–24.6) |
| West North Central                        | Age-Adjusted ¶ | 5,174  | 22.2 (21.6–22.8) |
|                                           | Crude §        | 15,926 | 23.9 (23.5–24.3) |
| South Atlantic                            | Age-Adjusted ¶ | 15,925 | 21.9 (21.6–22.3) |
|                                           | Crude §        | 5,189  | 26.6 (25.9–27.4) |
| East South Central                        | Age-Adjusted ¶ | 5,188  | 25.6 (24.9–26.3) |
|                                           | Crude §        | 8,637  | 21.0 (20.5–21.4) |
| West South Central                        | Age-Adjusted ¶ | 8,637  | 21.0 (20.6–21.4) |
|                                           | Crude §        | 6,782  | 26.8 (26.2–27.5) |
| Mountain                                  | Age-Adjusted ¶ | 6,781  | 25.7 (25.1–26.3) |
|                                           | Crude §        | 8,648  | 16.2 (15.9–16.5) |
| Pacific                                   | Age-Adjusted ¶ | 8,647  | 15.3 (14.9–15.6) |
|                                           | Crude §        | 69,473 | 20.9 (20.8–21.1) |
| Total                                     |                | 69,469 | 19.5 (19.4–19.7) |

Abbreviations: CI = confidence interval.

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\* Per 100,000 population.

<sup>7</sup> Record-Axis Condition codes were used (usually includes conditions listed in both Part I and Part II of the death certificate).

<sup>§</sup> Deaths with missing age were included.

<sup>¶</sup> Deaths with missing age were excluded. Rates were age-adjusted to the 2000 U.S. Census population using 12 age groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, 74–84, and ≥85 years.

\*\* Deaths with unknown Hispanic ethnicity were excluded (135 deaths).

**Table 2.**

Brain injury – related deaths<sup>a</sup> by mechanism of injury, intent, and age group— National Vital Statistics System, the United States, 1998–2014

| 0–4    |               | 5–9    |               | 10–14  |               | 15–24         |                  | 25–34         |                  | 35–44         |                  | 45–54         |                 | 55–64         |                 | 65–74            |                  | ≥75              |                  | Total (All ages)    |                                         |
|--------|---------------|--------|---------------|--------|---------------|---------------|------------------|---------------|------------------|---------------|------------------|---------------|-----------------|---------------|-----------------|------------------|------------------|------------------|------------------|---------------------|-----------------------------------------|
| Number | Rate (95% CI) | Number | Rate (95% CI) | Number | Rate (95% CI) | Number        | Rate (95% CI)    | Number        | Rate (95% CI)    | Number        | Rate (95% CI)    | Number        | Rate (95% CI)   | Number        | Rate (95% CI)   | Number           | Rate (95% CI)    | Number           | Rate (95% CI)    | Number <sup>§</sup> | Age-Adjusted Rate (95% CI) <sup>¶</sup> |
| 349    | 1.9 (1.7–2.0) | 214    | 1.1 (0.9–1.2) | 238    | 1.1 (1.0–1.3) | 2,466         | 5.7 (5.5–5.9)    | 2,857         | 6.3 (6.0–6.5)    | 2,764         | 6.4 (6.1–6.6)    | 3,018         | 7.4 (7.2–7.7)   | 4,354         | 10.2 (9.9–10.5) | 5,325            | 15.8 (15.4–16.2) | 16,048           | 72.3 (71.2–73.5) | 37,633              | 10.2 (10.1–10.3)                        |
| 197    | 1.0 (0.9–1.2) | 143    | 0.7 (0.6–0.8) | 166    | 0.8 (0.7–0.9) | 2,105         | 4.9 (4.7–5.1)    | 2,250         | 4.9 (4.7–5.1)    | 1,786         | 4.1 (3.9–4.3)    | 1,572         | 3.9 (3.7–4.1)   | 1,547         | 3.6 (3.4–3.8)   | 1,034            | 3.1 (2.9–3.3)    | 847              | 3.8 (3.6–4.1)    | 11,647              | 3.5 (3.4–3.5)                           |
| 21     | 0.1 (0.1–0.2) | 12     | -             | -      | 79            | 0.2 (0.1–0.2) | 237              | 0.5 (0.5–0.6) | 469              | 1.1 (1.0–1.2) | 886              | 2.2 (2.0–2.3) | 2,011           | 4.7 (4.5–4.9) | 3,527           | 10.5 (10.1–10.8) | 13,898           | 62.7 (61.6–63.7) | 21,147           | 5.4 (5.3–5.5)       |                                         |
| -      | -             | -      | -             | -      | 20            | 0.0 (0.0–0.1) | 30               | 0.1 (0.0–0.1) | 52               | 0.1 (0.1–0.2) | 60               | 0.1 (0.1–0.2) | 69              | 0.2 (0.1–0.2) | 64              | 0.2 (0.1–0.2)    | 52               | 0.2 (0.2–0.3)    | 367              | 0.1 (0.1–0.1)       |                                         |
| 124    | 0.7 (0.5–0.8) | 52     | 0.3 (0.2–0.3) | 59     | 0.3 (0.2–0.4) | 262           | 0.6 (0.5–0.7)    | 340           | 0.7 (0.7–0.8)    | 457           | 1.1 (1.0–1.1)    | 500           | 1.2 (1.1–1.3)   | 727           | 1.7 (1.6–1.8)   | 700              | 2.1 (1.9–2.2)    | 1,251            | 5.6 (5.3–6.0)    | 4,472               | 1.2 (1.2–1.3)                           |
| -      | 1.5 (1.3–1.7) | 89     | 0.4 (0.4–0.5) | 340    | 1.6 (1.4–1.8) | 5,212         | 12.1 (11.8–12.4) | 5,793         | 12.7 (12.4–13.1) | 4,655         | 10.7 (10.4–11.0) | 4,123         | 10.1 (9.8–10.4) | 3,982         | 9.3 (9.0–9.6)   | 3,219            | 9.6 (9.2–9.9)    | 3,105            | 14.0 (13.5–14.5) | 30,800              | 9.0 (8.9–9.1)                           |
| 99     | 99            | 99     | 99            | 221    | 1.0 (0.9–1.2) | 3,420         | 7.9 (7.7–8.2)    | 3,985         | 8.8 (8.5–9.0)    | 3,408         | 7.9 (7.6–8.1)    | 3,343         | 8.2 (7.9–8.5)   | 3,400         | 7.9 (7.7–8.2)   | 2,899            | 8.6 (8.3–8.9)    | 2,922            | 13.2 (12.7–13.7) | 23,599              | 6.8 (6.7–6.9)                           |
| 282    | 1.5 (1.3–1.7) | 88     | 0.4 (0.3–0.5) | 119    | 0.6 (0.5–0.7) | 1,792         | 4.2 (4.0–4.4)    | 1,808         | 4.0 (3.8–4.2)    | 1,247         | 2.9 (2.7–3.0)    | 780           | 1.9 (1.8–2.1)   | 582           | 1.4 (1.2–1.5)   | 320              | 1.0 (0.8–1.1)    | 183              | 0.8 (0.7–0.9)    | 7,201               | 2.2 (2.2–2.3)                           |
| 44     | 0.2 (0.2–0.3) | -      | -             | 15     | -             | 150           | 0.3 (0.3–0.4)    | 196           | 0.4 (0.4–0.5)    | 184           | 0.4 (0.4–0.5)    | 149           | 0.4 (0.3–0.4)   | 147           | 0.3 (0.3–0.4)   | 79               | 0.2 (0.2–0.3)    | 65               | 0.3 (0.2–0.4)    | 1,036               | 0.3 (0.3–0.3)                           |

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\* Per 100,000 population.

<sup>†</sup> Record-Axis Condition codes were used (usually includes conditions listed in both Part I and Part II of the death certificate). <sup>§</sup>Deaths with missing age were excluded.

<sup>¶</sup> Rates were age-adjusted to the 2000 U.S. Census population using 12 age groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, 74–84, and ≥85 years.

\*\* Falls of undetermined intent were not included.

<sup>††</sup> External cause of injury codes specify that the injury was unintentional but do not specify the actual mechanism of injury.

<sup>§§</sup> Includes TBIs for which the intent was not determined as well as those caused by legal intervention or war.

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

<sup>–</sup> Suppressed for deaths < 10 and rates based on < 20 deaths.

Table 3.

Number and age-adjusted rate\* of traumatic brain injury – related deaths† by mechanism of injury, intent, and sex— National Vital Statistics System, the United States, 2021.

| Mechanism of Injury (MOI)                             | Sex           |                         |               |                      |
|-------------------------------------------------------|---------------|-------------------------|---------------|----------------------|
|                                                       | Male          |                         | Female        |                      |
|                                                       | Number§       | Rate (95% CI)           | Number§       | Rate (95% CI)        |
| <b>Total unintentional TBI-related deaths</b>         | <b>24,582</b> | <b>14.6 (14.4–14.8)</b> | <b>13,051</b> | <b>6.3 (6.2–6.4)</b> |
| Motor vehicle crashes                                 | 8,588         | 5.1 (5.0–5.2)           | 3,059         | 1.8 (1.7–1.9)        |
| Unintentional falls¶                                  | 12,505        | 7.4 (7.3–7.6)           | 8,642         | 3.8 (3.7–3.9)        |
| Unintentionally struck by or against an object        | 317           | 0.2 (0.2–0.2)           | 50            | 0.0 (0.0–0.0)        |
| Other unintentional injury or mechanism unspecified** | 3,172         | 1.8 (1.8–1.9)           | 1,300         | 0.7 (0.6–0.7)        |
| <b>Total intentional TBI-related deaths</b>           | <b>25,977</b> | <b>15.5 (15.3–15.6)</b> | <b>4,823</b>  | <b>2.9 (2.8–3.0)</b> |
| Suicide (includes all MOI)                            | 20,653        | 12.2 (12.0–12.3)        | 2,946         | 1.7 (1.7–1.8)        |
| Homicide (includes all MOI)                           | 5,324         | 3.3 (3.2–3.4)           | 1,877         | 1.2 (1.1–1.2)        |
| <b>Other ††</b>                                       | <b>759</b>    | <b>0.5 (0.4–0.5)</b>    | <b>277</b>    | <b>0.2 (0.1–0.2)</b> |

Abbreviations: CI = confidence interval.

\* Per 100,000 population, age-adjusted to the 2000 U.S. standard population, using 12 age groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, 74–84, and ≥85 years.

† Record-axis condition codes were used (usually includes conditions listed in both Part I and Part II of the death certificate).

§ Deaths with missing age were excluded.

¶ Falls of undetermined intent were not included.

\*\* External cause of injury codes specify that the injury was unintentional but do not specify the actual mechanism of injury.

†† Includes TBIs for which the intent was not determined as well as those caused by legal intervention or war.

**Table 4.**

Number and age-adjusted rate\* of traumatic brain injury (tbi) – related deaths<sup>†</sup> by mechanism of injury, intent, and race/ethnicity<sup>§</sup> — National Vital Statistics System, the United States, 2021.

| Mechanism of Injury (MOI)                                         | Race/ethnicity     |                  |  |                    |                  |  |          |               |                                             |        |                                     |  |                             |               |                   |
|-------------------------------------------------------------------|--------------------|------------------|--|--------------------|------------------|--|----------|---------------|---------------------------------------------|--------|-------------------------------------|--|-----------------------------|---------------|-------------------|
|                                                                   | Non-Hispanic White |                  |  | Non-Hispanic Black |                  |  | Hispanic |               | Non-Hispanic American Indian/Alaskan Native |        | Non-Hispanic Asian/Pacific Islander |  | Non-Hispanic Multiple Races |               |                   |
|                                                                   | Number             | Rate (95% CI)    |  | Number             | Rate (95% CI)    |  | Number   | Rate (95% CI) |                                             | Number | Rate (95% CI)                       |  | Number                      | Rate (95% CI) |                   |
| Total unintentional TBI-related deaths                            | 27,732             | 10.8 (10.7–11.0) |  | 3,777              | 9.2 (8.9–9.5)    |  | 4,202    | 8.3 (8.0–8.5) |                                             | 401    | 16.9 (15.2–18.6)                    |  | 1,214                       | 6.0 (5.6–6.3) | 245 4.5 (3.9–5.2) |
| Motor vehicle crashes                                             | 7,011              | 3.4 (3.4–3.5)    |  | 2,029              | 4.8 (4.6–5.0)    |  | 1,993    | 3.2 (3.1–3.3) |                                             | 217    | 8.9 (7.7–10.1)                      |  | 248                         | 1.2 (1.0–1.3) | 129 1.7 (1.4–2.1) |
| Unintentional falls <sup>¶</sup>                                  | 17,215             | 5.9 (5.8–6.0)    |  | 1,225              | 3.2 (3.0–3.3)    |  | 1,633    | 4.0 (3.8–4.2) |                                             | 130    | 5.7 (4.7–6.7)                       |  | 836                         | 4.2 (3.9–4.5) | 78 2.1 (1.6–2.6)  |
| Unintentionally struck by or against an object                    | 266                | 0.1 (0.1–0.1)    |  | 23                 | 0.1 (0.0–0.1)    |  | 62       | 0.1 (0.1–0.1) |                                             | –      | –                                   |  | –                           | –             | –                 |
| Other unintentional injury or mechanism unspecified <sup>**</sup> | 3,240              | 1.3 (1.3–1.4)    |  | 500                | 1.2 (1.1–1.3)    |  | 514      | 1.0 (0.9–1.1) |                                             | 48     | 2.1 (1.5–2.8)                       |  | 121                         | 0.6 (0.5–0.7) | 37 0.7 (0.5–1.0)  |
| Total intentional TBI-related deaths                              | 20,962             | 9.8 (9.7–10.0)   |  | 5,473              | 12.9 (12.5–13.2) |  | 3,140    | 5.0 (4.8–5.2) |                                             | 316    | 13.0 (11.6–14.5)                    |  | 499                         | 2.4 (2.2–2.6) | 346 5.0 (4.4–5.6) |
| Suicide (includes all MOI)                                        | 18,871             | 8.7 (8.6–8.9)    |  | 1,970              | 4.6 (4.4–4.8)    |  | 1,891    | 3.0 (2.9–3.2) |                                             | 210    | 8.5 (7.3–9.7)                       |  | 368                         | 1.8 (1.6–1.9) | 243 3.7 (3.2–4.2) |
| Homicide (includes all MOI)                                       | 2,091              | 1.1 (1.0–1.1)    |  | 3,503 <sup>‡</sup> | 8.2 (8.0–8.5)    |  | 1,249    | 1.9 (1.8–2.0) |                                             | 106    | 4.6 (3.7–5.4)                       |  | 131                         | 0.6 (0.5–0.7) | 103 1.3 (1.0–1.5) |
| Other <sup>††</sup>                                               | 542                | 0.3 (0.2–0.3)    |  | 253                | 0.6 (0.5–0.7)    |  | 156      | 0.2 (0.2–0.3) |                                             | 39     | 1.5 (1.1–2.1)                       |  | 25                          | 0.1 (0.1–0.2) | 13 –              |

Abbreviations: CI = confidence interval.

\* Per 100,000 population, age-adjusted to the 2000 U.S. standard population, using 12 age groups: 0–4, 5–9, 10–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 65–74, 74–84, and ≥85 years.

<sup>†</sup> Record-axis condition codes were used (usually includes conditions listed in both Part I and Part II of the death certificate).

<sup>§</sup> Deaths with unknown Hispanic ethnicity were excluded (135 deaths).

<sup>¶</sup> Falls of undetermined intent were not included.

\*\* External cause of injury codes specify that the injury was unintentional but do not specify the actual mechanism of injury.

<sup>††</sup> Includes TBIs for which the intent was not determined as well as those caused by legal intervention or war.

Suppressed for deaths < 10 and rates based on < 20 deaths.

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Table 5.

Multivariable model-based rates\* and rate ratios of traumatic brain injury-related deaths by selected geographic/demographic factors, the United States, 2021.

| Census Region | Sex    | Ethnicity/Race                | Age Group    |        |               |        |               |        |               |        |           |        |
|---------------|--------|-------------------------------|--------------|--------|---------------|--------|---------------|--------|---------------|--------|-----------|--------|
|               |        |                               | 0 – 14 Years |        | 15 – 34 Years |        | 35 – 54 Years |        | 55 – 74 Years |        | ≥75 Years |        |
|               |        |                               | Rate         | RR     | Rate          | RR     | Rate          | RR     | Rate          | RR     | Rate      | RR     |
| Northeast     | Male   | Hispanic                      | 1.61         | 0.98   | 16.89         | 1.01   | -             | -      | 20.36         | 0.68 † | -         | -      |
|               |        | Non-Hispanic A/PI             | -            | -      | 6.99          | 0.42 † | 5.31          | 0.26 † | 12.94         | 0.43 † | 84.55     | 0.74 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | -             | -      | -             | -      | -             | -      | -         | -      |
|               |        | Non-Hispanic Black            | 4.74         | 2.87 † | 38.54         | 2.30 † | 25.90         | 1.26 † | 25.18         | 0.84 † | 59.16     | 0.52 † |
| Northeast     | Female | Non-Hispanic White (referent) | 1.65         |        | 16.73         |        | 20.60         |        | 30.10         |        | 114.70    |        |
|               |        | Hispanic                      | -            | -      | 3.64          | 0.94   | 3.42          | 0.63 † | 5.28          | 0.63 † | 34.99     | 0.63 † |
|               |        | Non-Hispanic A/PI             | -            | -      | -             | -      | 1.65          | 0.31 † | 4.29          | 0.51 † | 48.57     | 0.88   |
|               |        | Non-Hispanic AI/AN            | -            | -      | -             | -      | -             | -      | -             | -      | -         | -      |
| Midwest       | Male   | Non-Hispanic Black            | 2.45         | 2.54 † | 7.91          | 2.03 † | 5.98          | 1.11   | 6.21          | 0.74 † | 25.26     | 0.46 † |
|               |        | Non-Hispanic White (referent) | 0.97         |        | 3.89          |        | 5.39          |        | 8.41          |        | 55.49     |        |
|               |        | Hispanic                      | 2.51         | 0.82 † | 23.02         | 0.85 † | 17.14         | 0.57 † | 21.52         | 0.57 † | 80.09     | 0.57 † |
|               |        | Non-Hispanic A/PI             | -            | -      | 10.61         | 0.39 † | 7.20          | 0.24 † | 15.23         | 0.40 † | 96.62     | 0.69 † |
| Midwest       | Female | Non-Hispanic AI/AN            | -            | -      | 70.23         | 2.58 † | 63.21         | 2.11 † | -             | -      | -         | -      |
|               |        | Non-Hispanic Black            | 9.91         | 3.23 † | 70.57         | 2.59 † | 42.34         | 1.41 † | 35.76         | 0.94   | 81.58     | 0.58 † |
|               |        | Non-Hispanic White (referent) | 3.07         |        | 27.23         |        | 29.92         |        | 37.99         |        | 140.56    |        |
|               |        | Hispanic                      | 1.36         | 0.76 † | 4.96          | 0.78 † | 4.16          | 0.53 † | 5.58          | 0.53 † | 35.91     | 0.53 † |
| South         | Male   | Non-Hispanic A/PI             | -            | -      | 2.93          | 0.46 † | -             | -      | -             | -      | 55.51     | 0.82 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | 20.38         | 3.22 † | -             | -      | -             | -      | -         | -      |
|               |        | Non-Hispanic Black            | 5.12         | 2.85 † | 14.48         | 2.29 † | 9.78          | 1.25 † | 8.82          | 0.83 † | 34.83     | 0.51 † |
|               |        | Non-Hispanic White (referent) | 1.79         |        | 6.33          |        | 7.83          |        | 10.62         |        | 68.00     |        |
| South         | Female | Hispanic                      | 2.58         | 0.73 † | 25.67         | 0.76 † | 19.80         | 0.51 † | 24.08         | 0.51 † | 77.01     | 0.51 † |
|               |        | Non-Hispanic A/PI             | -            | -      | 12.69         | 0.37 † | 8.91          | 0.23 † | 18.25         | 0.38 † | 99.56     | 0.66 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | 42.35         | 1.25 † | 39.47         | 1.02   | 22.70         | 0.48 † | 50.84     | 0.34 † |
|               |        | Non-Hispanic Black            | -            | -      | -             | -      | -             | -      | -             | -      | -         | -      |

| Census Region | Sex    | Ethnicity/Race                | Age Group    |        |               |        |               |        |               |        |           |        |
|---------------|--------|-------------------------------|--------------|--------|---------------|--------|---------------|--------|---------------|--------|-----------|--------|
|               |        |                               | 0 – 14 Years |        | 15 – 34 Years |        | 35 – 54 Years |        | 55 – 74 Years |        | ≥75 Years |        |
|               |        |                               | Rate         | RR     | Rate          | RR     | Rate          | RR     | Rate          | RR     | Rate      | RR     |
| South         | Female | Non-Hispanic Black            | 8.04         | 2.28 † | 61.95         | 1.82 † | 38.49         | 1.00   | 31.49         | 0.66 † | 61.74     | 0.41 † |
|               |        | Non-Hispanic White (referent) | 3.53         |        | 33.96         |        | 38.65         |        | 47.53         |        | 151.16    |        |
|               |        | Hispanic                      | 1.40         | 0.68 † | 5.53          | 0.70 † | 4.80          | -      | 6.24          | 0.47 † | 34.53     | 0.47 † |
|               |        | Non-Hispanic A/PI             | -            | -      | 3.50          | 0.44 † | 2.77          | -      | 6.06          | 0.46 † | 57.20     | 0.78 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | 12.29         | 1.56 † | 12.89         | -      | -             | -      | -         | -      |
|               |        | Non-Hispanic Black            | 4.15         | 2.01 † | 12.71         | 1.61 † | 8.89          | -      | 7.77          | 0.58 † | 26.36     | 0.36 † |
| West          | Male   | Non-Hispanic White (referent) | 2.07         |        | 7.90          |        | -             |        | 13.29         |        | 73.13     |        |
|               |        | Hispanic                      | 2.35         | 0.85 † | 25.58         | 0.88 † | 20.14         | 0.59 † | 23.93         | 0.59 † | 81.98     | 0.59 † |
|               |        | Non-Hispanic A/PI             | -            | -      | 9.47          | 0.32 † | 6.79          | 0.20 † | 13.60         | 0.33 † | 79.42     | 0.57 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | 84.32         | 2.89 † | 80.24         | 2.36 † | 45.09         | 1.11   | 108.18    | 0.78   |
|               |        | Non-Hispanic Black            | 6.10         | 2.20 † | 51.50         | 1.76 † | 32.67         | 0.96   | 26.12         | 0.64 † | 54.84     | 0.39 † |
|               |        | Non-Hispanic White (referent) | 2.78         |        | 29.22         |        | 33.96         |        | 40.81         |        | 138.99    |        |
| West          | Female | Hispanic                      | 1.27         | 0.78 † | 5.51          | 0.81 † | 4.89          | 0.55 † | 6.20          | 0.54 † | 36.76     | 0.55 † |
|               |        | Non-Hispanic A/PI             | -            | -      | 2.61          | 0.38 † | 2.11          | 0.24 † | 4.51          | 0.40 † | 45.63     | 0.68 † |
|               |        | Non-Hispanic AI/AN            | -            | -      | 24.47         | 3.60 † | 26.22         | 2.95 † | 15.74         | 1.38 † | 65.33     | 0.97   |
|               |        | Non-Hispanic Black            | 3.15         | 1.94 † | 10.56         | 1.56 † | 7.54          | 0.85 † | 6.44          | 0.56 † | 23.41     | 0.35 † |
|               |        | Non-Hispanic White (referent) | 1.62         |        | 6.79          |        | 8.89          |        | 11.41         |        | 67.24     |        |

Abbreviations: RR – rate ratio; A/PI – Asian/Pacific Islander; AI/AN – American Indian/Alaska Native.

\* Model-based rates are expressed per 100,000 persons.

† Rate ratio significantly different from 1.00 at  $\alpha = 0.05$ .