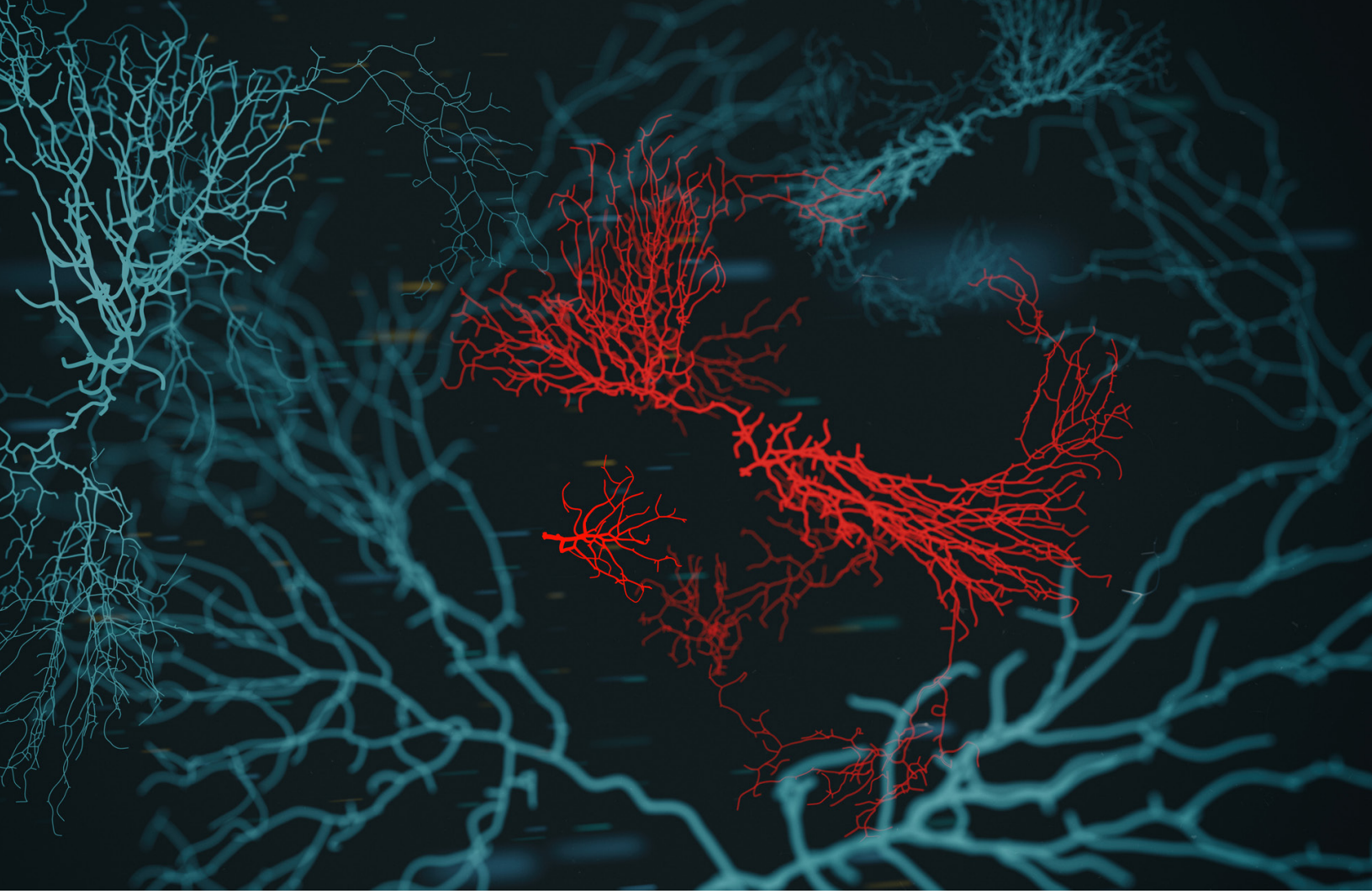
THE OHIO BRAIN INJURY PROGRAM AND THE BRAIN INJURY ADVISORY COMMITTEE'S

2019 BIENNIAL REPORT ON THE IMPACT OF TRAUMATIC BRAIN INJURY ON THE PEOPLE OF OHIO

Incidence, Prevalence, Cost and Personal Loss | December, 2020

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER



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Acknowledgements

This report was prepared in accordance with the requirement set forth in ORC 3335.60, which states that the Brain Injury Program of Ohio will prepare a biennial report on the impact of brain injury on the population of the state. It was developed by the staff of the Ohio Brain Injury Program and the Data Work Group of the Brain Injury Advisory Committee. The staff of the Ohio Brain Injury Program appreciate the work and commitment of the Brain Injury Advisory Committee members for their singular dedication and diligent efforts toward the development of a program within the state of Ohio that serves the needs of the population affected by this life-changing injury.

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Data Work Group Members of the Brain Injury Advisory Committee

- Committee Chair Stephanie Ramsey, Brain Injury Association of Ohio
- Sahithi Aurand, Ohio Department of Public Safety
- Kathryn Coxe, The Ohio State University
- Abby Hagemeyer, Ohio Department of Health
- Jeffrey Leonard, Nationwide Children's Hospital
- Kara Manchester, Ohio Department of Health
- Sue Morris, Ohio Department of Public Safety
- Gregory Wagner, Brain Injury Association of Ohio

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Copies of this report will be distributed by the Ohio Brain Injury Program staff to members of the Ohio Brain Injury Advisory Committee as required by statute for information and review. Additional copies of this report, as well as previous reports, may be obtained by contacting Monica Lichi at 614-293-3802 or **ohiobraininjury@osumc.edu**.

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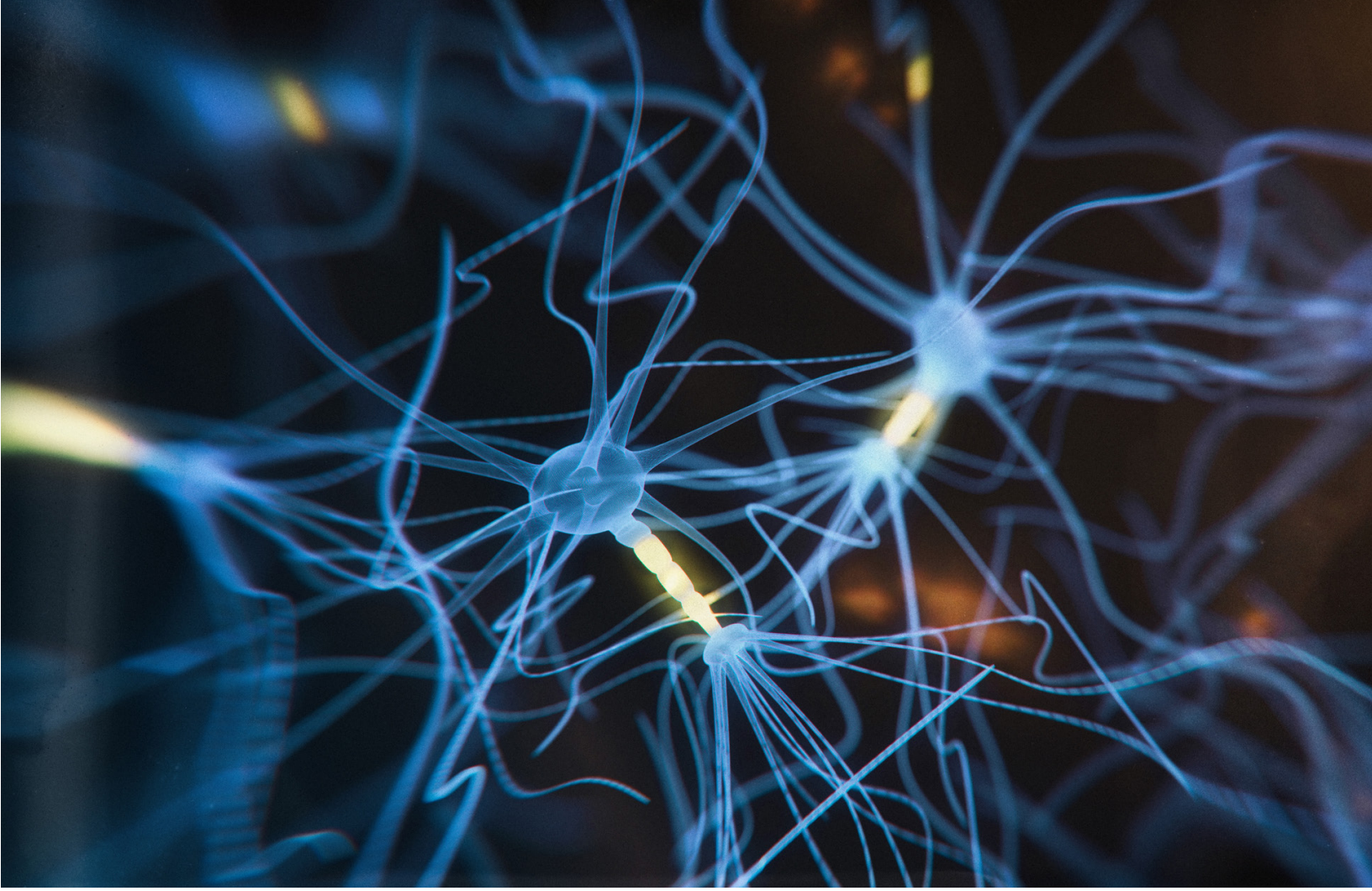


Executive Summary

This report fulfills the requirement of the Ohio Revised Code 3335.60 for the Brain Injury Program of Ohio to produce a statewide biennial report on the impact of traumatic brain injury (TBI) in Ohio. The information in this report comes from data that was collected from the years 2015 through 2017.

It is the eighth such report containing data from the Ohio Trauma Registry (OTR) collected by the Ohio Department of Public Safety. It is the third report to include data on inpatient hospital discharges, emergency room visits and deaths from Ohio hospital discharge data collected by the Ohio Hospital Association (OHA) and compiled by the Ohio Department of Health (ODH). It is the second report to include data on the prevalence of TBI in the state collected from the Ohio Behavioral Risk Factor Surveillance System (BRFSS) by the ODH.

Because the data sources differ substantially in methodology, the data sets differ as well so that direct comparisons and correlations are not always possible. Therefore, the data sets are presented and analyzed separately to present a comprehensive picture of experience across a number of dimensions.

This report uses the Centers for Disease Control and Prevention (CDC) definition of TBI: an injury caused by a bump, blow or jolt to the head, or a penetrating head injury that disrupts the normal function of the brain.

The Traumatic Brain Injury Model Systems National Data and Statistical Center provides a more detailed definition: TBI is defined as damage to brain tissue caused by an external mechanical force as evidenced by medically documented loss of consciousness or post-traumatic amnesia due to brain trauma or by objective neurological findings that can be reasonably attributed to TBI on physical examination or mental status examination.

For purposes of this report, these definitions are considered equivalent.

The information presented in this report provides a summary of TBI experience in the state of Ohio in terms of:

- **Incidence:** the actual number of injuries that occurred in the time period measured
- **Prevalence:** the number of individuals within the state who have a TBI
- **Costs:** the financial, societal and human costs of the injury
- **Personal loss:** a TBI survivor's story of a life changed

These distinct elements come together to provide a comprehensive summary of the brutal impact of this injury at the micro and macro level. **The major findings of this report include:**

1. In 2017—the most recent year for which data are available—more than 2,600 Ohioans died from TBI and more than 120,000 injuries were treated in emergency departments or required hospitalization. [Sources: ODH Bureau of Vital Statistics and OHA]

2. In 2017, for every 100,000 Ohio residents, 21 died due to TBI. Over the previous 10 years, the TBI death rate has increased by more than 17%. [Source: ODH Bureau of Vital Statistics]

3. In 2017, almost 28,000 children under the age of 15 were treated in emergency departments for TBI and nearly 650 were hospitalized. [Source: OHA]

4. While the largest proportion of TBI-related emergency department visits was among young adults 15 – 24 years old (17.6%), older adults 75 – 84 years old made up the largest proportion of TBI-related hospitalizations (18%) and deaths (14%). [Source: OHA]

5. Falls remained the most common cause of TBI. In 2017, twice as many injuries resulted from falls compared to motor vehicle transports, which was the second most common cause. [Source: OTR]

6. Among persons hospitalized for TBI from 2015 – 2017, the most frequent discharge status was "going home without services." [Source: OTR]

7. An estimated 1.9 million adult Ohioans (almost 1 in 4) have incurred at least one TBI in their lifetime, and nearly 250,000 (almost 1 in 30) have had a moderate or severe TBI. [Source: Ohio BRFSS]

8. Around 1.3 million Ohio adults have had a TBI severe enough to cause loss of consciousness—more than 60% of those injuries occurred before they were 20 years old. [Source: Ohio BRFSS]

9. More than 550,000 Ohio adults reported having both a disability and a history of TBI with loss of consciousness, and 135,000 Ohio adults reported having both a disability and a history of moderate or severe TBI. [Source: Ohio BRFSS]

10. The TBIs that occurred in 2017 in Ohio will have lifetime costs of $6 billion in medical expenses and lost wages. [Sources: CDC WISQARS Cost of Injury Reports, ODH Bureau of Vital Statistics and OHA]

These findings demonstrate that TBI remains not only a major issue but a growing public health problem in Ohio. Incidence trends are heading in the wrong direction, and costs will follow. The number of cases in the state's population can be expected to grow, and the implications of dealing with chronic disease and disability will increase the impact.

To reduce this impact, the following practical and effective means should be the basis of public policy direction in meeting the TBI challenge:

- Comply with best practices for TBI treatment
- Achieve optimal treatment outcomes and decrease disability through appropriate and timely rehabilitation regimens
- Provide long-term services and supports

Prologue: Spencer Smith, A Personal Narrative

This report on the incidence of traumatic brain injury (TBI) in Ohio offers an in-depth look at the numbers of deaths and injuries that occur over specific intervals of time. While the numbers are alarming, they fail to convey the realities of lives altered and new challenges introduced without warning. The work of recovery is demanding, and even when the outcome is successful, the lingering effects of injury to the brain often leave significant concerns about future health or other limitations. The fact that the brain injury is not seen can create dilemmas or unrealistic expectations of the survivor that interfere with relationships, employment, academics or, simply, ordinary daily encounters with others. The personal story that follows illustrates the reality of the "hidden injury" that defines TBI.

The Spencer Smith Story of a Future Changed

I knew I was going to face challenges in my first job after graduating college. I didn't expect those challenges to be life or death ones, though.

One day, while driving to run an errand for the high school where I was a ninth-grade math teacher, I was T-boned. I don't remember that collision or the following five weeks, which I spent in several different hospital units recovering from life-threatening injuries, including a traumatic brain injury.

What I do remember is the confusion numerous physicians caused me on my way to recovery.

After my hospital stays—but before I was able to live on my own—my parents took me to an appointment I had with a neurologist. There were things I really wanted to know. Since I had regained consciousness after the accident, I had mostly lived in a daze. My short-term memory wasn't working at full force, so I was unable to consolidate each day's events into my identity. This kind of fog made it impossible to ask the questions I really wanted to ask: What is my life going to look like when I fully recover? What can or should I do to recover my intellectual life from before the accident? How can I put my life back together living in my hometown—a place I had been away from for almost five years?

Because I was silent, the neurologist asked me questions about my social life. I presented as someone who was neuro-healthy—I was able to follow directions and hold conversations, and I had no noticeable physical injuries. To this neurologist, what I needed was to just get back into the swing of life.

When some of my internal injuries began to bother me, my family physician referred me to a surgeon. In that appointment, I again presented as neuro-healthy. This time though, there were questions that I definitely needed to ask about how the dosage of the anesthesia would affect my brain.

When I asked the question about anesthesia, the surgeon became confused.

"You are walking and talking. Your injury couldn't have been that bad," he said.

I wanted to yell at him that, a little over six months ago, I was in a hospital bed, and doctors were telling my parents that I may never recover, the trauma to my brain would stay with me forever and my brain would always look a little different from others'.

What's chilling about recalling and thinking about my recovery is the apparent randomness of it all and the luck of my recovery.

The accident itself was random. I was lucky for the accident to happen close to a hospital that was specially equipped to handle my injuries. I was there for a week before I had recovered past their ability to care for me. I was then lucky for my parents' many health care connections, which helped get me to Ohio State Dodd Rehabilitation Hospital where I started rehab about two weeks after my injury. When science shows the importance of early rehab for survivors of brain injury, I shudder to think about what would have happened if I had been alone in that first intensive care unit.

After three intense weeks of occupational, speech and physical therapy at Dodd, I was released to my hometown to live and recover with my parents. I began outpatient occupational, speech and physical therapy, which I attended for three months. I feel really lucky to have been around therapists to help me recover.

But despite how lucky I know I am to be fully recovered and living a fulfilling life, my recovery would've been better had I had resources to help me communicate my future aspirations to my doctors. This would have helped them see me as a person whose life had been derailed by a TBI instead of just a patient with an ailment. How much more quickly would I have recovered then? How much more successful might I be had I been given more tailored resources earlier in my recovery? What would have happened had my parents not known how to navigate medical facilities?

I try not to think about these questions too much. Now, I am a PhD student at The Ohio State University studying the philosophy of education. Many of my professors and peers don't know I was in a car accident, and if they know I suffered a brain injury, they don't fully realize the severity of it. I also am a brain injury survivor representative on the Brain Injury Advisory Committee and a co-founder and vice president of Smith Brain Connections. I hope to inform physicians, therapists, surgeons and all medical providers about brain injury so other survivors can be lucky like me.

Section 1

Ohio Department of Health Data From Death Certificates, Hospitalizations and Emergency Department Visits

Ohio Death Certificate Data:

- The Ohio death certificate data in this report was provided by the Ohio Department of Health (ODH) Bureau of Vital Statistics. The analysis was conducted by the ODH Violence & Injury Prevention Section.
- The analysis was restricted to Ohio residents and also includes Ohio residents who died out of the state.
- Rates were calculated by dividing the number of deaths related to traumatic brain injury (TBI) by the number of Ohio residents based on estimates from the National Center for Health Statistics. Where appropriate, rates were age-adjusted to the 2000 U.S. standard population.
- Injury deaths were defined as a death with an injury listed as the underlying cause of death from the International Classification of Diseases, Tenth Revision (ICD-10 codes V01-Y36, Y85-Y87, Y89 and *U01-*U03). From the injury death subset, TBI-related deaths included records with one of the following ICD-10 codes in any field of the multiple cause of death file: S01.0-S01.9, S02.0, S02.1, S02.3, S02.7-S02.9, S04.0, S06.0-S06.9, S07.0, S07.1, S07.8, S07.9, S09.7-S09.9, T01.0, T02.0, T04.0, T06.0, T90.1, T90.2, T90.4, T90.5, T90.8 and T90.9.

Ohio Hospitalization Data:

- The Ohio hospitalization discharge data in this report was provided by the Ohio Hospital Association (OHA). The analysis was conducted by the ODH Violence & Injury Prevention Section.
- The analysis includes nonfatal hospital inpatient visits of Ohio residents in nonfederal acute care facilities in Ohio. It does not include federal hospitals such as the Veterans Health Administration and other federally funded rehabilitation centers and psychiatric hospitals.
- Rates were calculated by dividing the number of TBI-related hospitalizations by the number of Ohio residents based on estimates from the National Center for Health Statistics. Where appropriate, rates were age-adjusted to the 2000 U.S. standard population.
- Injury hospital inpatient visits were defined as a hospital admission with an injury listed in the principal diagnosis discharge field—International Classification of Diseases, Tenth Revision, Clinical Modification [ICD-10-CM] S00-S99, T07-T34, T36-T50 with a sixth character of 1-4 (except for T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9 and T49.9, which are included if the fifth character is 1-4), T51-T65, T66-T76, T79, O9A.2-O9A.5, T84.04 and M97. From the injury hospital subset, TBI hospital inpatient visits included records with one of the following diagnosis codes: S02.0, S02.1, S02.8, S02.91, S04.02, S04.3, S04.04, S06, S07.1 and T74.4. Hospital inpatient visits related to unspecified injury of the head include records that have a diagnosis code of S09.90 and no other TBI diagnoses codes (defined above). TBI and unspecified injury of the head are presented separately in Figure 8 below and together in subsequent figures and tables.

Ohio Emergency Department Visit Data:

- The Ohio emergency department (ED) visit discharge data in this report was provided by the OHA. The analysis was conducted by the ODH Violence & Injury Prevention Section.
- The analysis includes nonfatal ED visits of Ohio residents in nonfederal acute care facilities in Ohio. It does not include federal hospitals and excludes ED visits that resulted in a hospital admission.
- Rates were calculated by dividing the number of TBI-related injuries by the number of Ohio residents based on estimates from the National Center for Health Statistics. Where appropriate, rates were age-adjusted to the 2000 U.S. standard population.

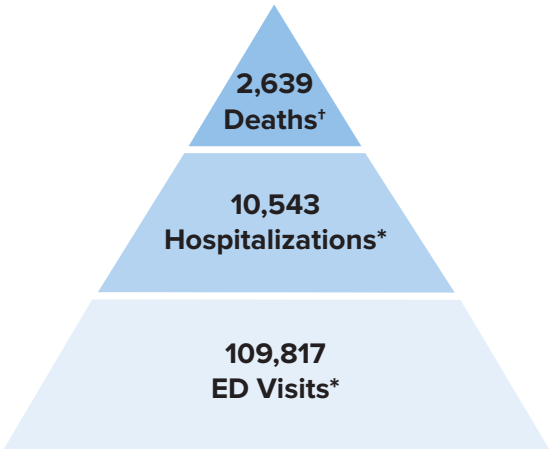
- Injury ED visits were defined as an ED visit with an injury listed in any diagnosis discharge field—or ICD-10-CM S00-S99, T07-T34, T36-T50 with a sixth character of 1-4 (except for T36.9, T37.9, T39.9, T41.4, T42.7, T43.9, T45.9, T47.9 and T49.9, which are included if the fifth character is 1-4), T51-T65, T66-T76, T79, O9A.2-O9A.5, T84.04 and M97—or a valid external cause code listed in any diagnosis discharge field—or V00-V99, W00-X58, X71-X83, X92-Y09, Y21-Y33 and Y35-Y38. From the injury ED subset, TBI ED visits included records with one of the following diagnosis codes: S02.0, S02.1, S02.8, S02.91, S04.02, S04.3, S04.04, S06, S07.1 and T74.4. ED visits related to unspecified injury of the head include records that have a diagnosis code of S09.90 and no other TBI diagnoses codes (defined above). TBI and unspecified injury of the head are presented separately in Figure 12 below and together in subsequent figures and tables.

Special Note Specific to Hospitalization and ED Visit Data

Prior to Oct. 1, 2015, the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) was used to report medical encounters in the hospital setting (e.g., hospitalizations, ED visits) when submitting electronic claims for administrative and financial transactions. Effective Oct. 1, 2015, the U.S. Department of Health and Human Services required health care organizations and providers covered by the Health Insurance Portability and Accountability Act of 1996 to use ICD-10-CM to report medical encounters. The major transition from ICD-9-CM to ICD-10-CM included a dramatic coding restructure that especially impacted injury surveillance using discharge data: The number of injury-related diagnosis codes (e.g., the TBI codes referenced above) increased from 2,600 to 43,000. Similarly, the number of injury-related external cause codes used to determine the intent (e.g., unintentional) and mechanism (e.g., fall) of an injury increased from 1,300 to 7,500. Consequently, comparisons should not be made between data before and after Oct. 1, 2015. Thus, hospitalization and ED visit trends and trend analysis spanning the transition period are not shown in this report. This transition is specific to hospitalization and ED visits data using ICD-10-CM codes; it does not impact death data, which uses ICD-10 codes.

Citation: CSTE ICD-10-CM Injury Surveillance Toolkit (Sept. 23, 2019). Toolkit Overview and Purpose. Retrieved from https://resources.cste.org/Injury-Surveillance-Methods-Toolkit/.

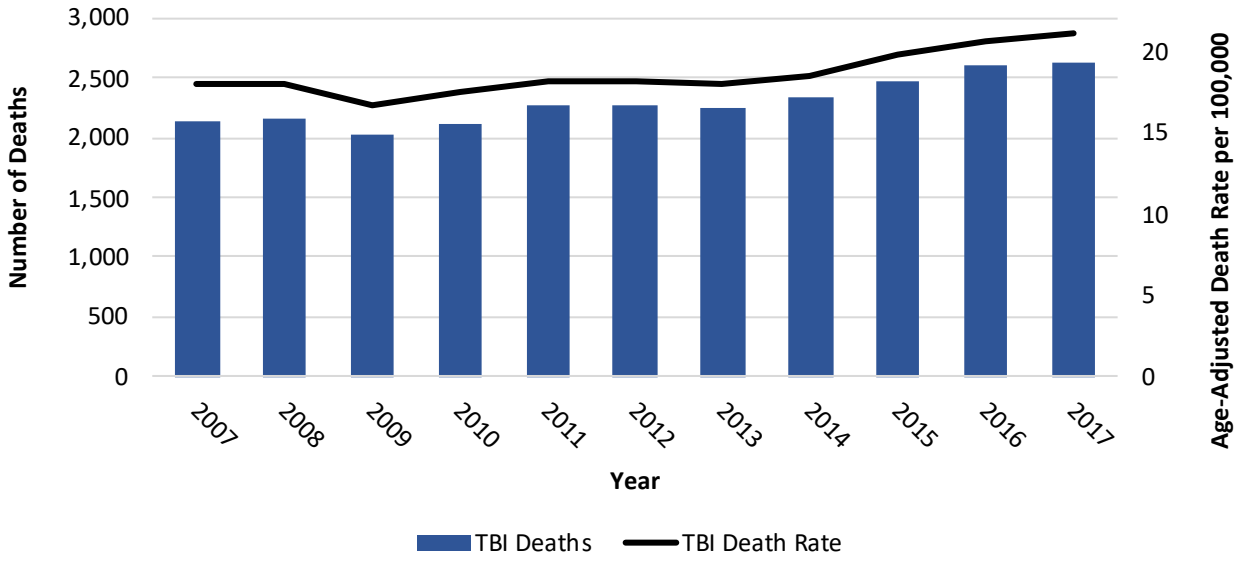
Figure 1. TBI Pyramid, Ohio, 2017



†Source: Ohio Department of Health Bureau of Vital Statistics
*Source: Ohio Hospital Association

Figure 1 depicts the number of TBI cases in 2017 among Ohioans broken down by deaths, hospitalizations and ED visits. In 2017, there were 2,639 TBI-related deaths, 10,543 TBI-related hospitalizations and 109,817 TBI-related ED visits.

Figure 2. Number and Age-Adjusted Rate of TBI Deaths by Year, Ohio, 2007 – 2017



TBI is a major cause of death and disability. From 2007 – 2017, the number of TBI deaths increased 23.5% (from 2,136 to 2,639), and the rate of TBI deaths increased 17.3% (from 17.9 to 21.0 per 100,000). A rate measures the frequency of an event (in this case, a TBI death) in a given population (Ohio resident population) over a specified period of time (one year) and is typically multiplied by 100,000 population for interpretability. In 2017, for every 100,000 Ohio residents, 21 died from a TBI-related injury.

Figure 3. Age-Adjusted TBI Death Rate by County of Residence, Ohio, 2013 – 2017

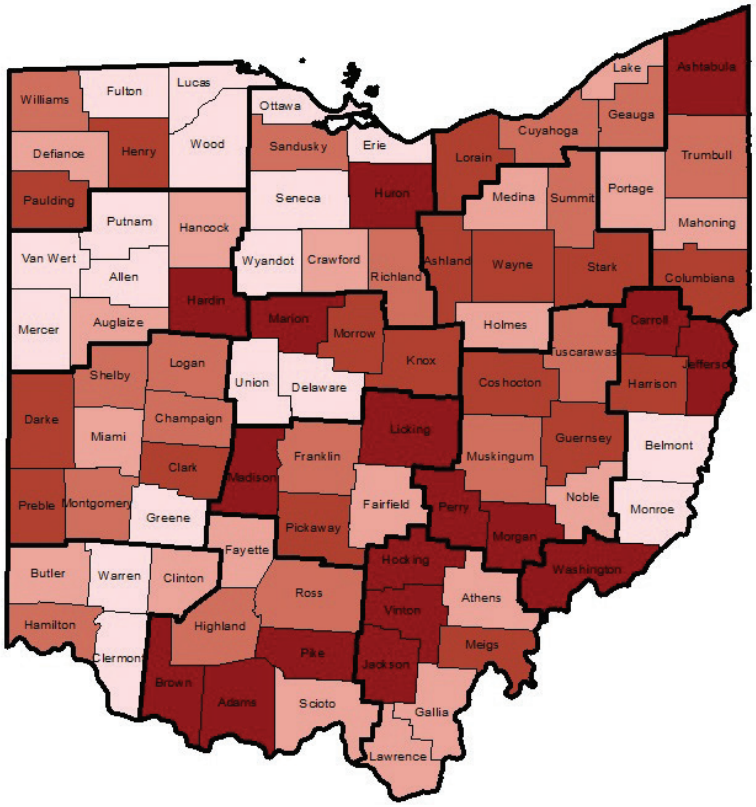


Figure 3 shows the age-adjusted TBI death rate by county from 2013-2017. During this time period, Morgan County had the highest rate in Ohio—for every 100,000 residents, nearly 42 died from a TBI-related injury. Counties in the Appalachian region of Ohio have the highest rates of TBI deaths.

Figure 4. Number of TBI Deaths by Age and Sex, Ohio, 2017

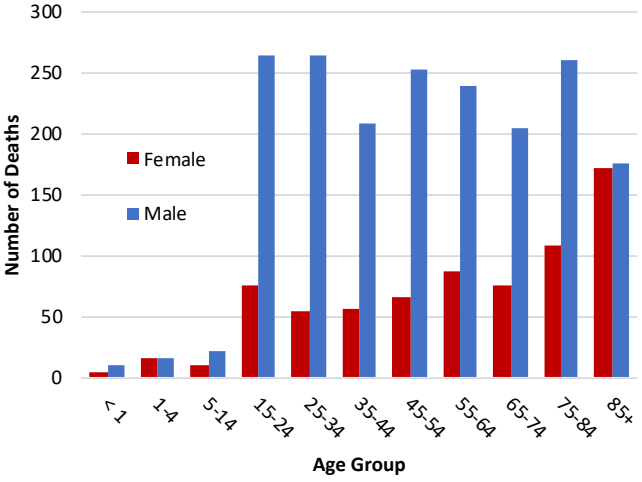
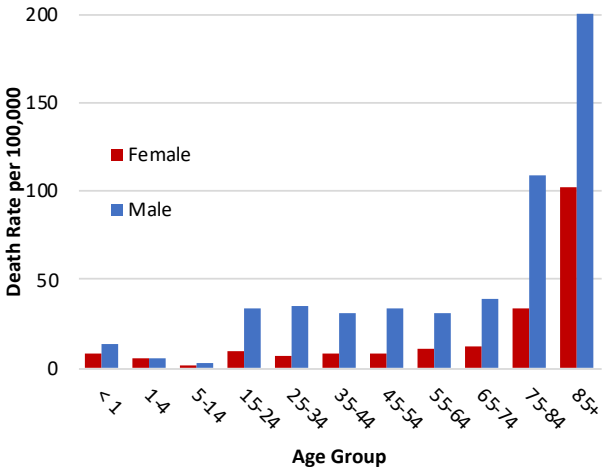


Figure 5. TBI Death Rates by Age and Sex, Ohio, 2017



Figures 4 and 5 show the number and rate of TBI deaths, respectively, among Ohioans in 2017. Males were disproportionately burdened by TBI death across the lifespan—rates were nearly three times higher among males 15 – 84 years of age when compared to females. The TBI death rate was highest among older adults and, in both males and females, increased with age for adults 65 years and older

Figure 6. Number of TBI Deaths by Intent/ Mechanism, Ohio, 2007 – 2017

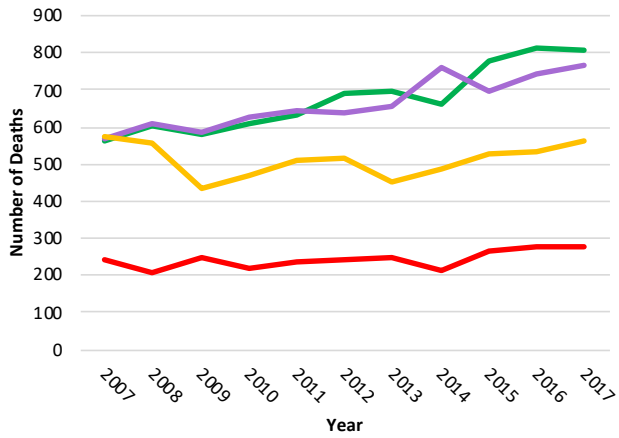
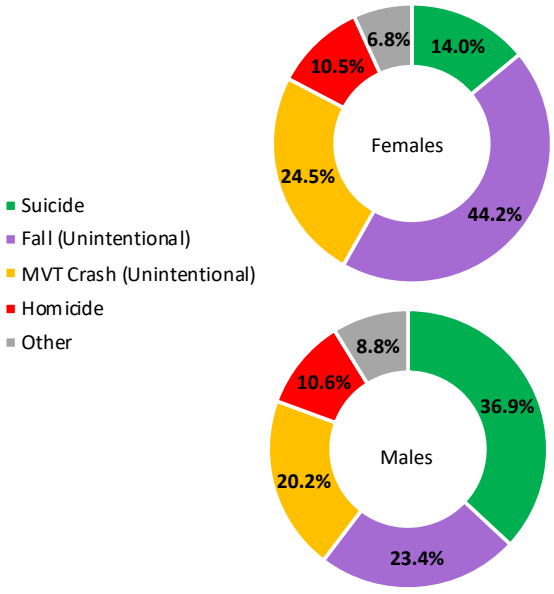
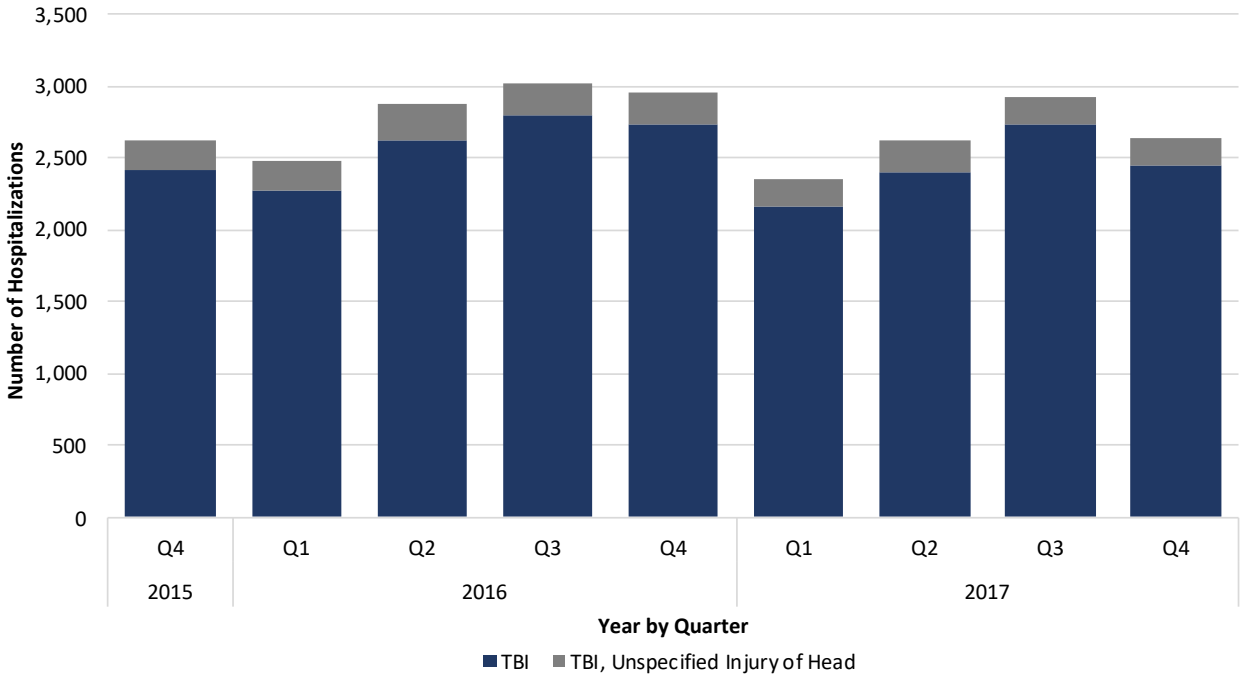


Figure 7. Percentage of TBI Deaths by Intent/Mechanism and Sex, Ohio, 2017



In 2007, unintentional motor vehicle traffic (MVT) crashes were the leading intent/mechanism for TBI deaths among Ohioans. In 2008, it dropped below unintentional falls and suicide. From 2007 – 2017, suicide-related TBI deaths increased 44% (from 562 to 809), and unintentional fall-related TBI deaths increased 35.2% (from 568 to 768). In 2017, unintentional falls were the leading intent/mechanism of TBI deaths (44.2%) among females followed by unintentional MVT crashes. Among males, the largest proportion of TBI deaths (36.9%) was attributed to suicide followed by unintentional falls.

Figure 8. Number of TBI-Related Hospitalizations by Quarter, Ohio, 2015 – 2017



*Due to the transition of ICD-9-CM to ICD-10-CM, data prior to the fourth quarter of 2015 are not presented. **TBI** includes diagnoses codes S02.0, S02.1, S02.8, S02.91, S04.02, S04.3, S04.04, S06, S07.1 and T74.4.

TBI, Unspecified Injury of Head includes diagnosis code S09.90.

Figure 8 includes Ohio residents and excludes fatal cases. The numbers represent all visits, not unique individuals.

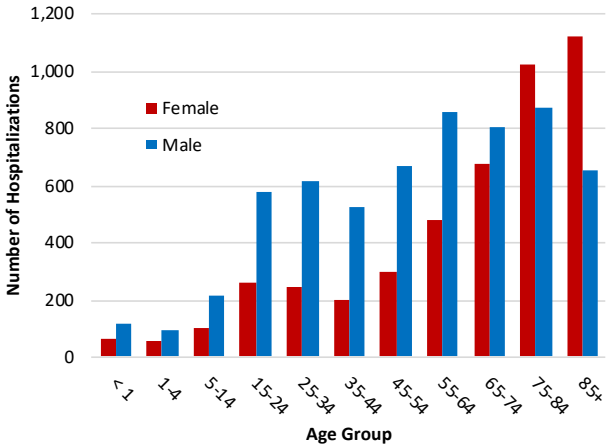
Source: Ohio Hospital Association, discharge diagnoses data. Analysis conducted by the Ohio Department of Health Violence & Injury Prevention Section.

Previously, the ICD-9-CM-based surveillance definition for TBI-related hospitalizations included the head injury unspecified code (959.01). National guidelines to define TBI-related hospitalizations following the transition are still being tested, but they currently propose to examine TBI and TBI, unspecified injury of the head (S09.90) separately. Therefore, TBI and TBI, unspecified injury of the head, are presented separately in Figure 8 for comparison. They are combined for all other figures and tables for conciseness.

Figure 8 shows the number of TBI-related hospitalizations by quarter, starting with the fourth quarter of 2015 when the transition to ICD-10-CM coding went into effect. These data include Ohio residents and exclude fatal cases. Overall, in 2016, there were 11,325 TBI-related hospitalizations (10,448 TBI visits and 877 TBI, unspecified injury of the head visits). In 2017, there were 10,543 TBI-related hospitalizations (9,747 TBI visits and 796 TBI, unspecified injury of the head, visits). As more data are collected using ICD-10-CM coding, trends across time will be assessed.

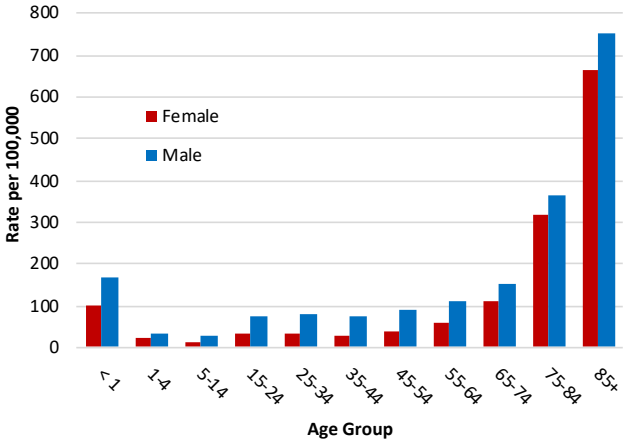
In both 2016 and 2017, the number of TBI-related hospitalizations increased by quarter, peaking in the third quarter (July – September) and then declining in the fourth quarter (October – December).

Figure 9. Number of TBI-Related Hospitalizations by Age and Sex, Ohio, 2017



Source: Ohio Hospital Association

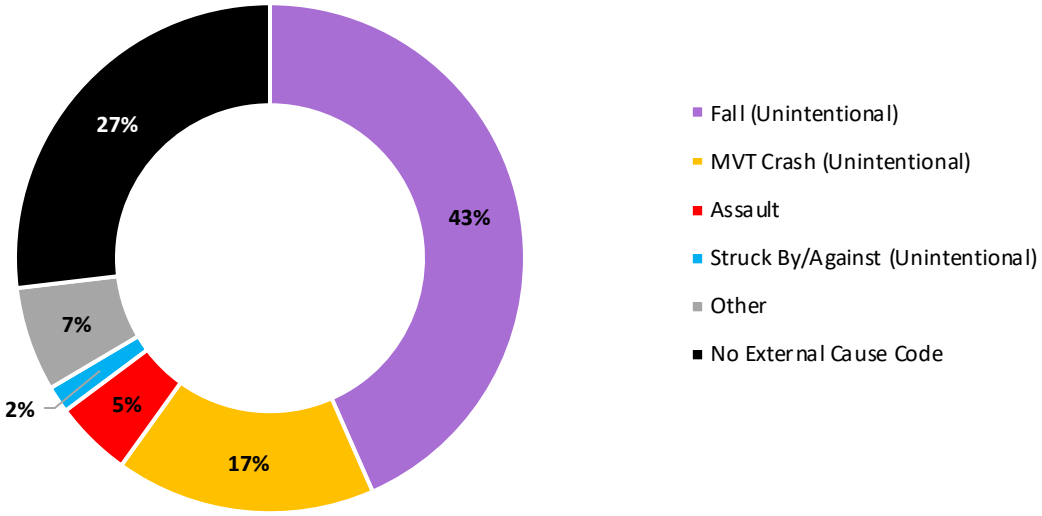
Figure 10. Rate of TBI-Related Hospitalizations by Age and Sex, Ohio, 2017



Source: Ohio Hospital Association

Figures 9 and 10 show the number and rate of TBI-related hospitalizations, respectively, by age and sex in Ohio in 2017. Prior to 75 years of age, males had a higher number of TBI-related hospitalizations than their female counterparts. Among adults 75 years and older, females contributed to the majority of hospitalizations. Males had a higher rate of TBI-related hospitalizations across the lifespan. TBI-related hospitalization rates were lowest for both females and males between the ages of 5 – 14 years old (14.3 per 100,000 and 28.9 per 100,000, respectively). Rates were highest among adults 75 years and older.

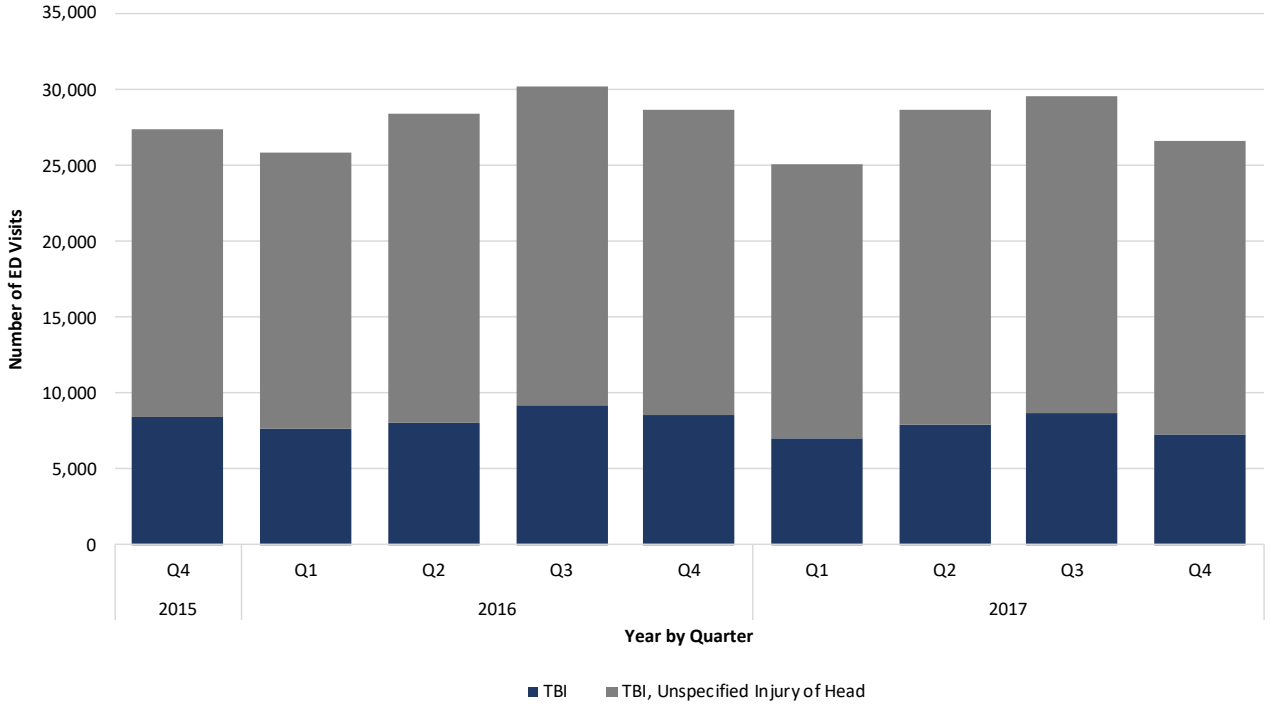
Figure 11. Percentage of TBI-Related Hospitalizations by Intent/Mechanism, Ohio, 2017



Source: Ohio Hospital Association

In 2017, unintentional fall was the leading intent/mechanism of TBI-related hospitalizations, accounting for 43% of visits (Figure 11). Unintentional MVT crashes accounted for 17% of visits followed by assault (5%). In 27% of hospitalizations, an external cause code, which is used to determine the intent and mechanism of an injury, was not reported.

Figure 12. Number of TBI-Related Emergency Department Visits by Quarter, Ohio, 2015 – 2017



*Due to the transition of ICD-9-CM to ICD-10-CM, data prior to the fourth quarter of 2015 are not presented.

TBI includes diagnoses codes S02.0, S02.1, S02.8, S02.91, S04.02, S04.3, S04.04, S06, S07.1 and T74.4.

TBI, Unspecified Injury of Head includes diagnosis code S09.90.

Figure 12 includes Ohio residents and excludes fatal and hospital admitted cases. The numbers represent all visits, not unique individuals.

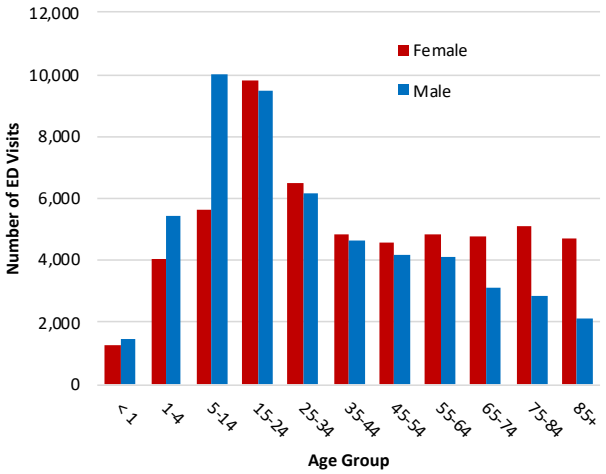
Source: Ohio Hospital Association, discharge diagnoses data. Analysis conducted by the Ohio Department of Health Violence & Injury Prevention Section.

Previously, the ICD-9-CM-based surveillance definition for TBI-related ED visits included the head injury unspecified code (959.01). National guidelines to define TBI-related ED visits following the transition are still being tested, but they currently propose to examine TBI and TBI, unspecified injury of the head, (S09.90) separately. Therefore, TBI and TBI, unspecified injury of the head, are presented separately in Figure 12 for comparison. They are combined for all other figures and tables for conciseness.

Figure 12 shows the number of TBI-related ED visits by quarter starting with the fourth quarter of 2015 when the transition to ICD-10-CM coding went into effect. These data include Ohio residents and exclude hospital-admitted and fatal cases. Overall, in 2016, there were 113,095 TBI-related ED visits (33,382 TBI visits and 79,713 TBI, unspecified injury of the head, visits). In 2017, there were 109,817 TBI-related ED visits (31,006 TBI visits and 78,811 TBI, unspecified injury of the head, visits). As more data are collected using ICD-10-CM coding, trends across time will be assessed.

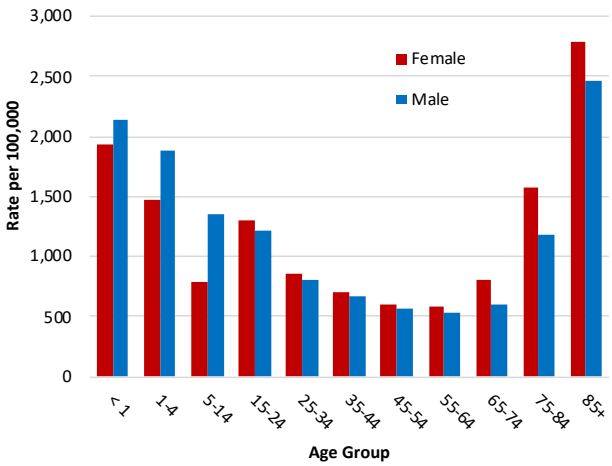
In both 2016 and 2017, the number of TBI-related ED visits increased by quarter, peaking in the third quarter (July – September) and then declining in the fourth quarter (October – December).

Figure 13. Number of TBI-Related Emergency Department Visits by Age and Sex, Ohio, 2017



Source: Ohio Hospital Association

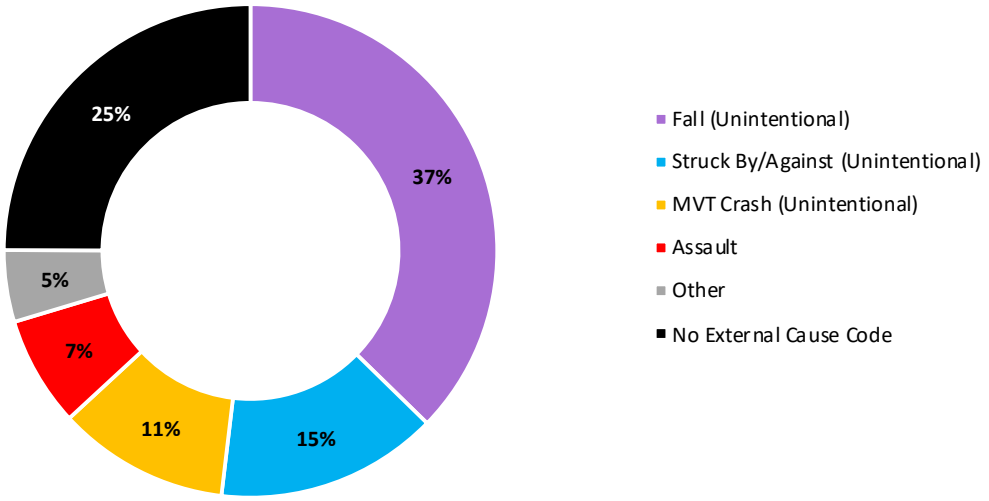
Figure 14. Rate of TBI-Related Emergency Department Visits by Age and Sex, Ohio, 2017



Source: Ohio Hospital Association

Figures 13 and 14 show the number and rate of TBI-related ED visits, respectively, by age and sex. For younger age groups (0 – 14 years old), males had a higher number and rate of TBI-related ED visits than their female counterparts. Among Ohioans 15 years old and older, females had a higher number and rate of ED visits. The rate of TBI-related ED visits was highest at either end of the age spectrum, peaking among adults 85 years of age and older followed by children less than 1 year old. The rate was lowest for both females and males between the ages of 55 – 64 years old (584.5 per 100,000 and 529 per 100,000, respectively).

Figure 15. Percentage of TBI-Related Emergency Department Visits by Intent/Mechanism, Ohio, 2017



Source: Ohio Hospital Association

In 2017, unintentional fall was the leading intent/mechanism of TBI-related ED visits, accounting for 37% of visits (Figure 15). Unintentional struck by/against accounted for 15% of visits followed by unintentional MVT crashes (11%). In 25% of TBI-related ED visits, an external cause code, which is used to determine the intent and mechanism of an injury, was not reported.

Table 1. Number and Rate of TBI-Related Emergency Department Visits, Hospitalizations and Deaths by Demographic Characteristics, Ohio, 2017

Demographic Characteristics	% of Ohio Population	Emergency Department Visits*		Hospitalizations*		Deaths†	
		N (% Distribution)	Rate§	N (% Distribution)	Rate§	N (% Distribution)	Rate§
Total		109,817 (100)	954.3	10,543 (100)	80.7	2,639 (100)	21.0
Sex							
Female	51.0	56,233 (51.2)	933.1	4,527 (42.9)	60.5	722 (27.4)	10.2
Male	49.0	53,581 (48.8)	968.0	6,015 (57.1)	101.8	1,917 (72.6)	33.0
Age							
<1 year	1.2	2,763 (2.5)	2,040.5	183 (1.7)	135.1	14 (0.5)	10.3
1 – 4 years	4.8	9,505 (8.7)	1,688.6	150 (1.4)	26.6	32 (1.2)	5.7
5 – 14 years	12.4	15,614 (14.2)	1,077.2	315 (3.0)	21.7	30 (1.1)	2.1
15 – 24 years	13.2	19,318 (17.6)	1,258.8	840 (8.0)	54.7	340 (12.9)	22.2
25 – 34 years	13.1	12,660 (11.5)	829.0	858 (8.1)	56.2	319 (12.1)	20.9
35 – 44 years	11.8	9,444 (8.6)	683.6	725 (6.9)	52.5	265 (10.0)	19.2
45 – 54 years	13.0	8,774 (8.0)	577.5	969 (9.2)	63.8	318 (12.1)	20.9
55 – 64 years	13.8	8,985 (8.2)	557.7	1,340 (12.7)	83.2	326 (12.4)	20.2
65 – 74 years	9.6	7,945 (7.2)	709.3	1,481 (14.0)	132.2	279 (10.6)	24.9
75 – 84 years	4.9	7,943 (7.2)	1,402.9	1,902 (18.0)	335.9	369 (14.0)	65.2
85+ years	2.2	6,865 (6.3)	2,679.5	1,780 (16.9)	694.8	347 (13.1)	135.4
Race/Ethnicity							
White, Non-Hispanic	80.0	82,229 (74.9)	899.7	8,589 (81.5)	77.5	2,150 (81.5)	20.3
Black, Non-Hispanic	13.4	18,129 (16.5)	1,137.9	1,336 (12.7)	88.3	402 (15.2)	26.6
Hispanic	3.8	3,594 (3.3)	836.3	243 (2.3)	80.8	48 (1.8)	14.9

* Source: Ohio Hospital Association

† Source: Ohio Department of Health Bureau of Vital Statistics

§ Rates presented for age groups are age-specific. Rates presented for total, sex and race/ethnicity are age-adjusted to the 2002 U.S. standard population. Rates are calculated per 100,000 population.

Race/ethnicity categories are mutually exclusive. Hispanic includes any race. Categories may not total 100% due to missing demographic data.

In 2017, the age-adjusted rate of TBI-related ED visits was 954.3 per 100,000, the age-adjusted rate of TBI-related hospitalizations was 80.7 per 100,000 and the age-adjusted rate of TBI-related deaths was 21 per 100,000. While TBI-related ED visits were more likely to be female (51.2%), males made up a larger proportion of TBI-related hospitalizations (57.1%) and deaths (72.6%). This suggests males had more severe TBIs when compared to females. Overall, males had a higher age-adjusted rate for TBI-related ED visits, hospitalizations and deaths—more than 1.6 times and three times the hospitalization and death rate, respectively, when compared to females. While the largest proportion of TBI-related ED visits was among young adults 15 – 24 years old (17.6%), older adults 75 – 84 years old made up the largest proportion of TBI-related hospitalizations (18%) and deaths (14%). Older adults 85 years and older had the highest rate of TBI-related ED visits, hospitalizations and deaths. Black, non-Hispanic Ohioans had the highest rate of TBI-related ED visits, hospitalizations and deaths.

Table 2. Number and Rate of TBI-Related Deaths by Geographic Region of Residence, Ohio, 2017

Graphic Region	% of Ohio Population	Deaths*	
		N (% Distribution)	Death Rate†
Region 1	6.2	142 (5.4)	18.2
Region 2	3.1	77 (2.9)	19.5
Region 3	4.1	93 (3.5)	17.1
Region 4	16.1	485 (18.4)	23.1
Region 5	11.2	292 (11.1)	21.1
Region 6	6.8	183 (6.9)	20.7
Region 7	3.6	64 (2.4)	15.4
Region 8	14.8	392 (14.9)	23.0
Region 9	10.0	269 (10.2)	20.9
Region 10	14.3	342 (13.0)	19.6
Region 11	2.8	80 (3.0)	21.7
Region 12	2.7	79 (3.0)	23.0
Region 13	2.2	72 (2.7)	25.9
Region 14	2.2	68 (2.6)	25.7

* Source: Ohio Department of Health Bureau of Vital Statistics

† Rates are age-adjusted to the 2000 U.S. standard population and calculated per 100,000 population.

Region 1 Defiance, Fulton, Henry, Lucas, Paulding, Williams, Wood

Region 2 Allen, Auglaize, Hancock, Hardin, Mercer, Putnam, Van Wert

Region 3 Crawford, Erie, Huron, Ottawa, Richland, Sandusky, Seneca, Wyandot

Region 4 Cuyahoga, Geauga, Lake, Lorain

Region 5 Ashland, Holmes, Medina, Stark, Summit, Wayne

Region 6 Ashtabula, Columbiana, Mahoning, Portage, Trumbull

Region 7 Delaware, Knox, Marion, Morrow, Union

Region 8 Fairfield, Franklin, Licking, Madison, Pickaway

Region 9 Champaign, Clark, Darke, Greene, Logan, Miami, Montgomery, Preble, Shelby

Region 10 Butler, Clermont, Clinton, Hamilton, Warren

Region 11 Adams, Brown, Fayette, Highland, Pike, Ross, Scioto

Region 12 Coshocton, Guernsey, Morgan, Muskingum, Noble, Perry, Tuscarawas

Region 13 Belmont, Carroll, Harrison, Jefferson, Monroe, Washington

Region 14 Athens, Gallia, Hocking, Jackson, Lawrence, Meigs, Vinton

Residents of Region 4, Ohio's most populous region, which encompasses Cuyahoga, Geauga, Lake and Lorain counties, accounted for the largest proportion of TBI-related deaths (18.4%) across the state. Regions 13 and 14 had the highest rate of TBI-related death (25.9 and 25.7, respectively, per 100,000). Notably, Regions 13 and 14 make up much of the state's Appalachian region.

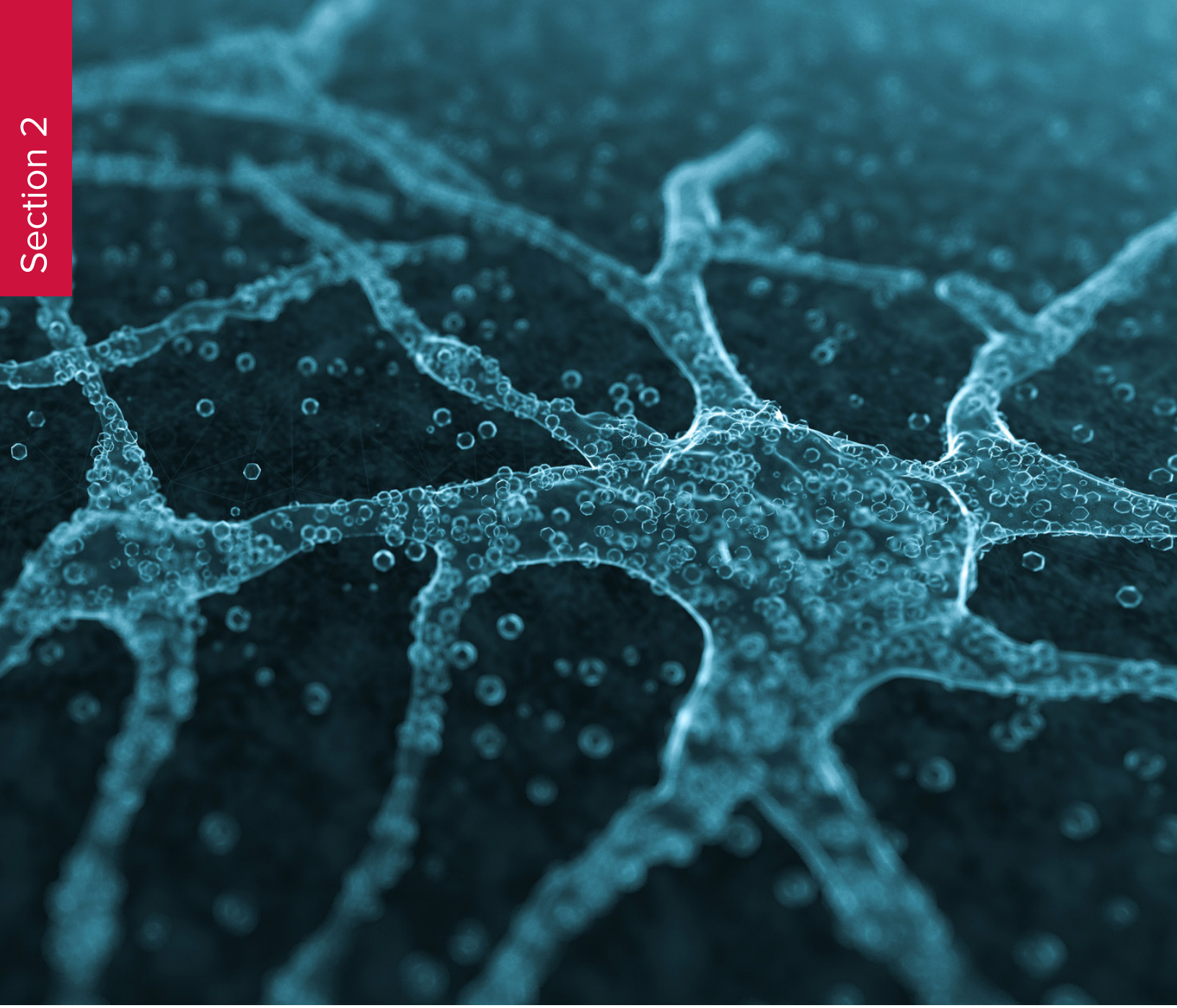
Summary

From 2007 – 2017, the number of TBI deaths increased 23.5% (from 2,136 to 2,639) and the rate of TBI deaths increased 17.3% (from 17.9 to 21.0 per 100,000).

In 2017:

- Suicide and unintentional falls were the leading intents/mechanisms of TBI deaths. Unintentional falls were the leading intent/mechanism of TBI-related hospitalizations and ED visits.
- Males had a higher age-adjusted rate for TBI-related ED visits, hospitalizations and deaths—more than 1.6 times and three times the hospitalization and death rate, respectively, when compared to females.
- While the largest proportion of TBI-related ED visits was among young adults 15 – 24 years old (17.6%), older adults 75 – 84 years old made up the largest proportion of TBI-related hospitalizations (18%) and deaths (14%). Older adults 85 years and older had the highest rate of TBI-related ED visits, hospitalizations and deaths.

Section 2



Ohio Trauma Registry Data From the Ohio Department of Public Safety Division of Emergency Medical Services

The Ohio Trauma Registry data supplied for this report represents that which is current as of October 2019. It includes Ohio Trauma Registry data from 2015 through 2017.

The Ohio Trauma Acute Care Registry

The Ohio Trauma Acute Care Registry (TACR) is Ohio's data system for sustained traumatic injuries that arrive at an Ohio facility. The system collects injury, care, hospital status and discharge status data on patients with traumatic injuries. Data are reported by trauma hospitals, acute care hospitals and freestanding emergency departments that receive patients with traumatic injuries. The Ohio TACR is maintained by the Division of Emergency Medical Services (EMS) at the Ohio Department of Public Safety. Trauma brain injury data for this report were extracted and analyzed from this data system.

Trauma Inclusion Criteria

TRAUMA PATIENT DEFINITION

In order to ensure consistent data collection across the state of Ohio and to follow the National Trauma Data Standard, a trauma patient is defined as a patient sustaining a traumatic injury and meeting the patient inclusion criteria described below.

Patient Inclusion Criteria

To be included in the Ohio TACR:

- The patient must have incurred at least one of the injury diagnostic codes defined in the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) no more than 30 days prior to presentation for initial treatment:
  - **J70.5 with character modifier of A ONLY** (Respiratory conditions due to smoke inhalation – initial encounter)
  - **S00-S99 with seventh character modifier of A, B or C ONLY** (Injuries to specific body parts – initial encounter)
  - **T07** (Unspecified multiple injuries)
  - **T14** (Injury of unspecified body region)
  - **T20-T28** with seventh character modifier of A ONLY (Burns by specified body parts – initial encounter)
  - **T30-T32** (Burn by total body surface area percentage)
  - **T33 with character modifier of A ONLY** (Superficial frostbite – initial encounter)
  - **T34 with character modifier of A ONLY** (Frostbite with tissue necrosis – initial encounter)
  - **T67 with character modifier of A ONLY** (Effects of heat and light – initial encounter)
  - **T68 with character modifier of A ONLY** (Hypothermia – initial encounter)
  - **T69 with character modifier of A ONLY** (Other effects of reduced temperature – initial encounter)
  - **T70.4 with character modifier of A ONLY** (Effects of high-pressure fluids – initial encounter)
  - **T70.8 with character modifier of A ONLY** (Other effects of air pressure and water pressure – initial encounter)
  - **T70.9 with character modifier of A ONLY** (Effect of air pressure and water pressure, unspecified – initial encounter)
  - **T71 with character modifier of A ONLY** (Asphyxiation – initial encounter)
  - **T74.1 with character modifier of A ONLY** (Physical abuse, confirmed – initial encounter)

  - **T74.4 with character modifier of A ONL**Y (Shaken infant syndrome – initial encounter)
  - **T75.0 with character modifier of A ONLY** (Effects of lightning – initial encounter)
  - **T75.1 with character modifier of A ONLY** (Unspecified effects of drowning and nonfatal submersion – initial encounter)
  - **T75.4 with character modifier of A ONLY** (Electrocution – initial encounter)
  - **T79.A1-T79.A9 with seventh character modifier of A ONLY** (Traumatic compartment syndrome – initial encounter)
- The patient MUST ALSO:
  - On initial presentation for treatment of an injury, be admitted to a hospital or hospital observation unit as defined by a physician order regardless of the length of stay; **AND/OR**
  - Be transferred via EMS transport (including air ambulance) from one hospital (or freestanding emergency department) to another hospital regardless of the patient's length of stay or admission status; **AND/OR**
  - Have an outcome of death resulting from the traumatic injury (independent of hospital admission or hospital transfer status)

Patient Exclusion Criteria

Patients with the following isolated ICD-10-CM codes are excluded from the Ohio TACR:

- **S72.00-S72.14** (Fracture of head/neck of femur *ONLY IF* age > 70 *AND* it resulted from slipping, tripping, stumbling or a same-level fall, which are codes W01.0, W18.30, W18.31 and W18.39)
- **S00, S10, S20, S30, S40, S50, S60, S70, S80, S90** (Abrasion or contusion injuries – patients with abrasion or contusion injuries who were transferred in/out for treatment of injuries or died because of injuries would be included in the registry)
- **Seventh character modifiers of D through S** (Late effects)

Traumatic Brain Injury Selection Criteria

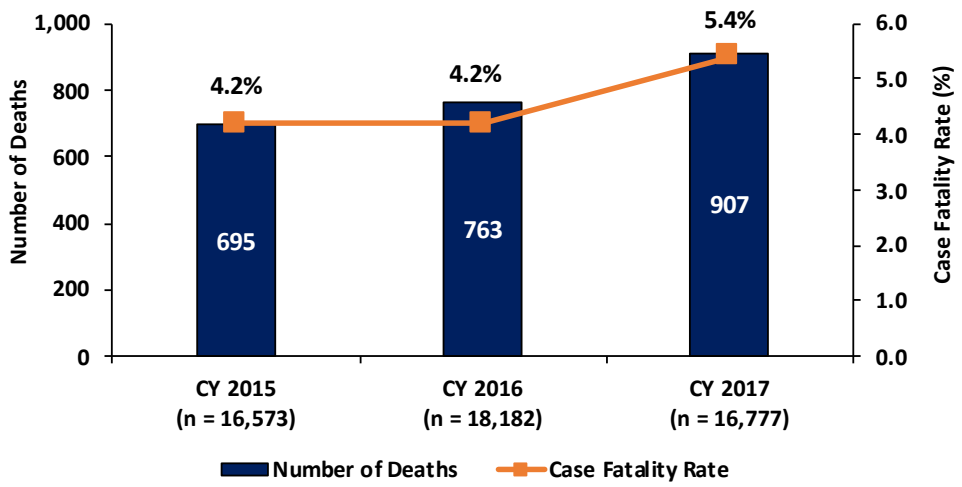
Injuries were identified as traumatic brain injuries (TBIs) based on their reported Abbreviated Injury Scale (AIS) pre-dot codes. The AIS is a trauma injury classification system that describes the injury and its severity. The pre-dot code consists of the six digits that occur before a decimal point that indicate body region, anatomical structure and level of injury.[1] The post-dot code (also known as the severity score[2]) consists of the digit after the decimal that indicates the injury's severity. TBIs were defined as injuries that had an AIS pre-dot code that was one of the following:

- Equal to **113000**
- Between 1**20199** and **123099**
- Between **130202** and **132699**
- Between **140202** and **140299**
- Between **140402** and **140499**
- Between **140602** and **140699**
- Equal to **140799**
- Between **161000** and **161013**

[1] Association for the Advancement of Automotive Medicine. (2016). *Abbreviated Injury Scale (c) 2005 Update 2008.* (T. Gennarelli, & E. Woodzin, Eds.) Chicago, Illinois.

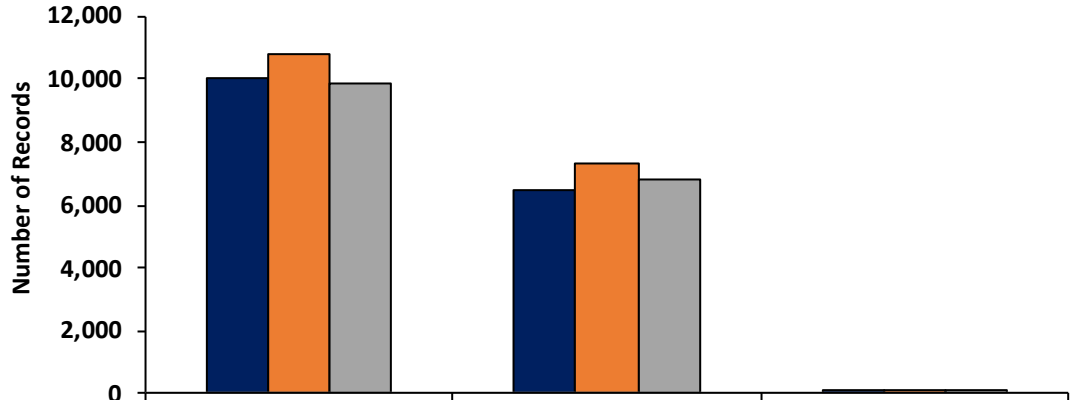
[2] Centers for Disease Control and Prevention. (n.d.). *Discussion document on injury severity measurement in administrative datasets* [PDF File]. Retrieved from https://www.cdc.gov/nchs/data/injury/DiscussionDocu.pdf.

Figure 1. Number of Deaths and Case Fatality Rates Among TBIs by Year, Ohio Trauma Registry, CY 2015 – CY 2017



There were 695 deaths among TBIs in CY 2015, 763 in CY 2016 and 907 in CY 2017. The case fatality rate among TBIs increased from CY 2015 to CY 2017 from 4.2% to 5.4%.

Figure 2. Number of TBIs by Gender and Year, Ohio Trauma Registry, CY 2015 – CY 2017

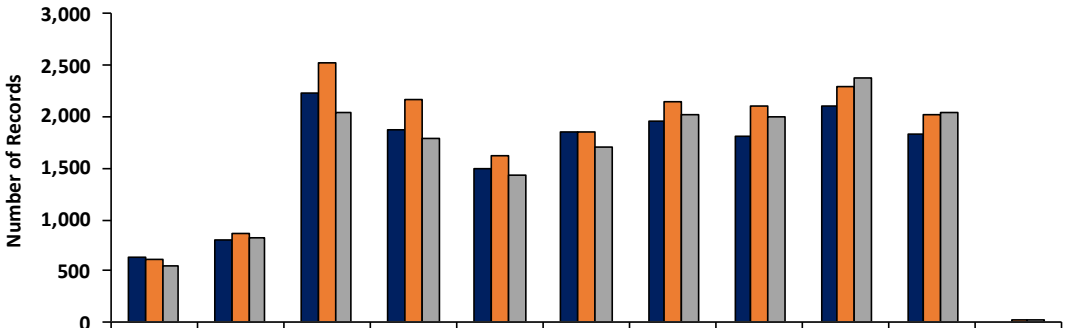


	Male	Female	Not Valued
CY 2015 (n = 16,573)	10,063	6,496	14
CY 2016 (n = 18,182)	10,834	7,346	2
CY 2017 (n = 16,777)	9,880	6,800	97

Gender

Within each calendar year, the majority of TBIs were male (CY 2015: 10,063; CY 2016: 10,834; CY 2017: 9,880).

Figure 3. Number of TBIs by Age Group and Year, Ohio Trauma Registry, CY 2015 – CY 2017

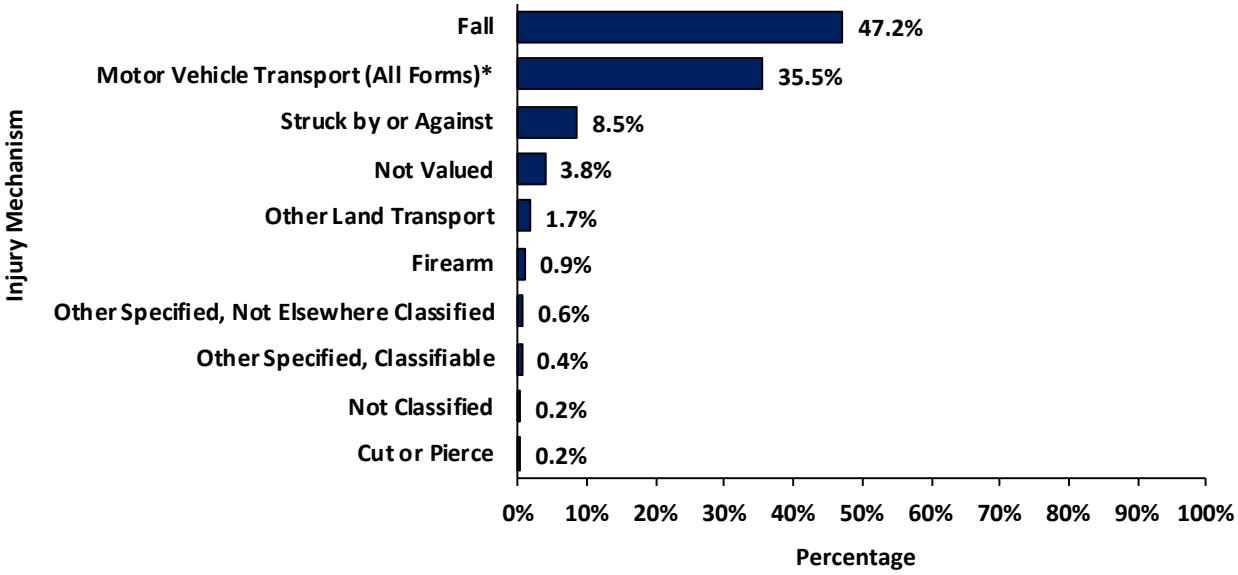


	0 – 4	5 – 14	15 – 24	25 – 34	35 – 44	45 – 54	55 – 64	65 – 74	75 – 84	85+	Not Valued
CY 2015 (n = 16,573)	632	806	2,223	1,870	1,488	1,848	1,958	1,810	2,101	1,837	0
CY 2016 (n = 18,182)	605	874	2,518	2,156	1,622	1,847	2,137	2,104	2,297	2,021	1
CY 2017 (n = 16,777)	560	817	2,044	1,787	1,431	1,701	2,020	2,002	2,378	2,036	1

Age Group

In both CY 2015 and CY 2016, TBIs occurred most frequently within the 15 – 24 age group (CY 2015: 2,223; CY 2016: 2,518). However, in CY 2017, the most frequent age category was 75 – 84 (2,378).

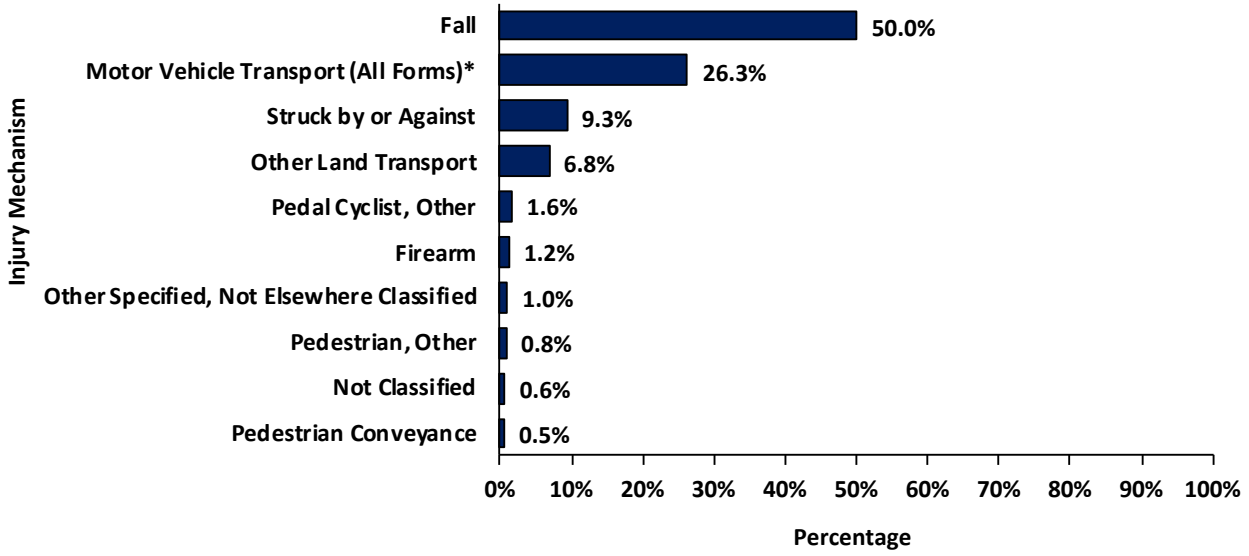
Figure 4. Top 10 Mechanisms of Injury for TBIs, Ohio Trauma Registry, CY 2015 (n = 16,573)



*TBIs involving motor vehicle transport include forms where the injury occurred to an occupant of the motor vehicle, a pedestrian, a motorcyclist, a pedal cyclist, other or unspecified.

In CY 2015, the most frequent injury mechanism among TBIs was falls (47.2%) followed by injuries sustained by motor vehicle transport (MVT) incidents (35.5%).

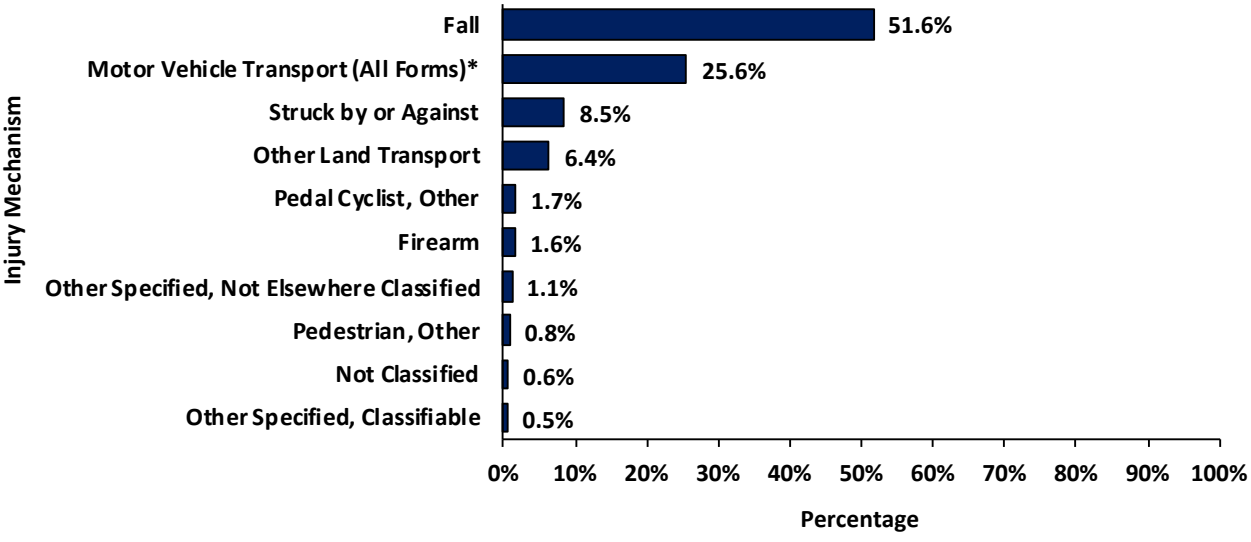
Figure 5. Top 10 Mechanisms of Injury for TBIs, Ohio Trauma Registry, CY 2016 (n = 18,182)



*TBIs involving MVT include forms where the injury occurred to an occupant of the motor vehicle, a pedestrian, a motorcyclist, a pedal cyclist, other or unspecified.

In CY 2016, the most frequent injury mechanism among TBIs was falls (50%) followed by injuries sustained by MVT incidents (26.3%).

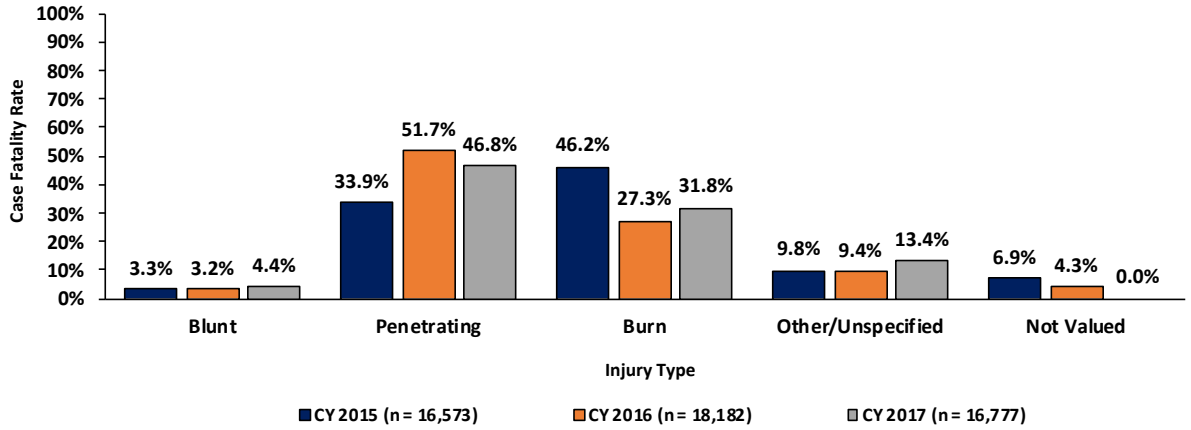
Figure 6. Top 10 Mechanisms of Injury for TBIs, Ohio Trauma Registry, CY 2017 (n = 16,777)



*TBIs involving MVT include forms where the injury occurred to an occupant of the motor vehicle, a pedestrian, a motorcyclist, a pedal cyclist, other or unspecified.

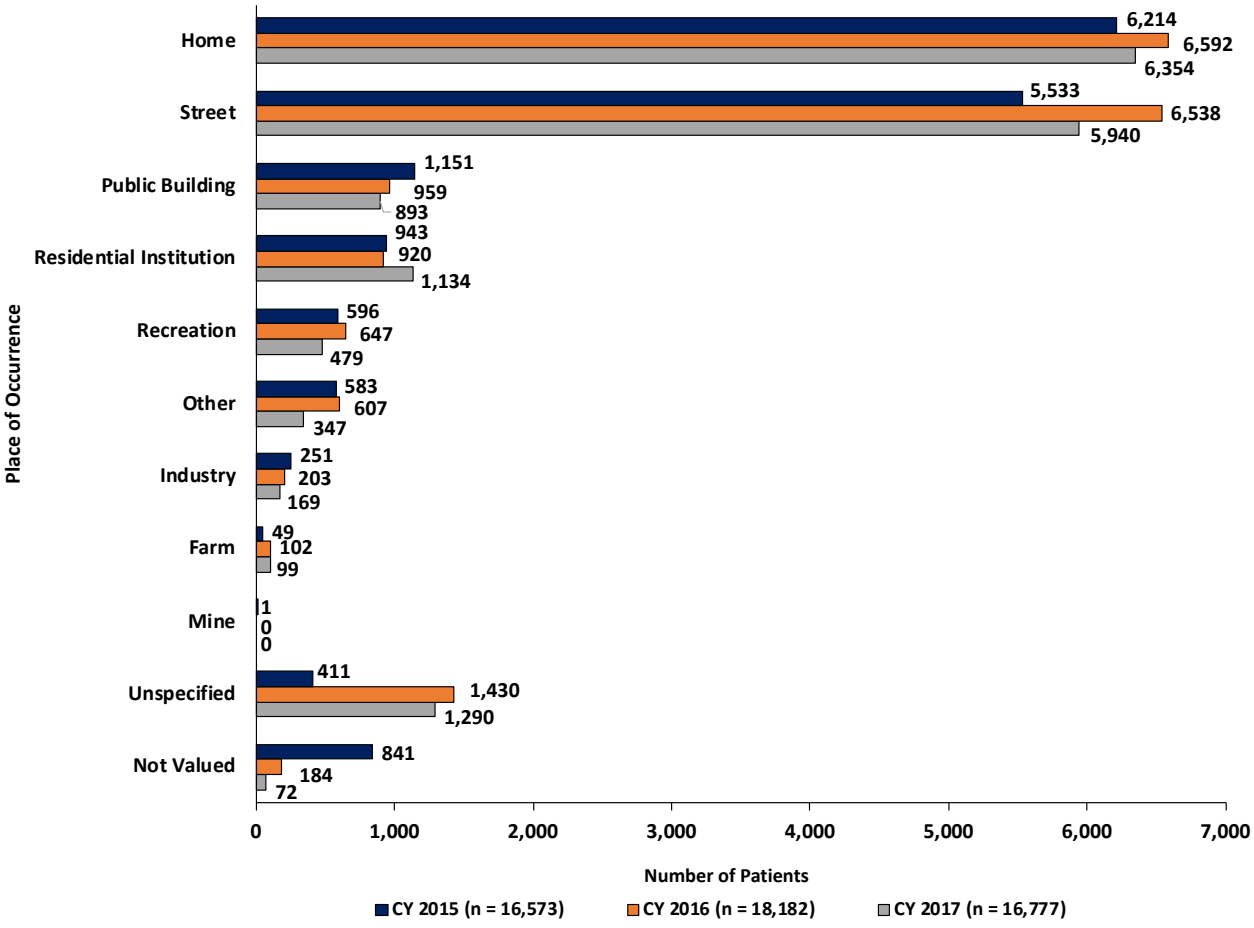
In CY 2017, the most frequent injury mechanism among TBIs was falls (51.6%) followed by injuries sustained by MVT incidents (25.6%).

Figure 7. Case Fatality Rates Among TBIs by Year and Injury Type, Ohio Trauma Registry, CY 2015 – CY 2017



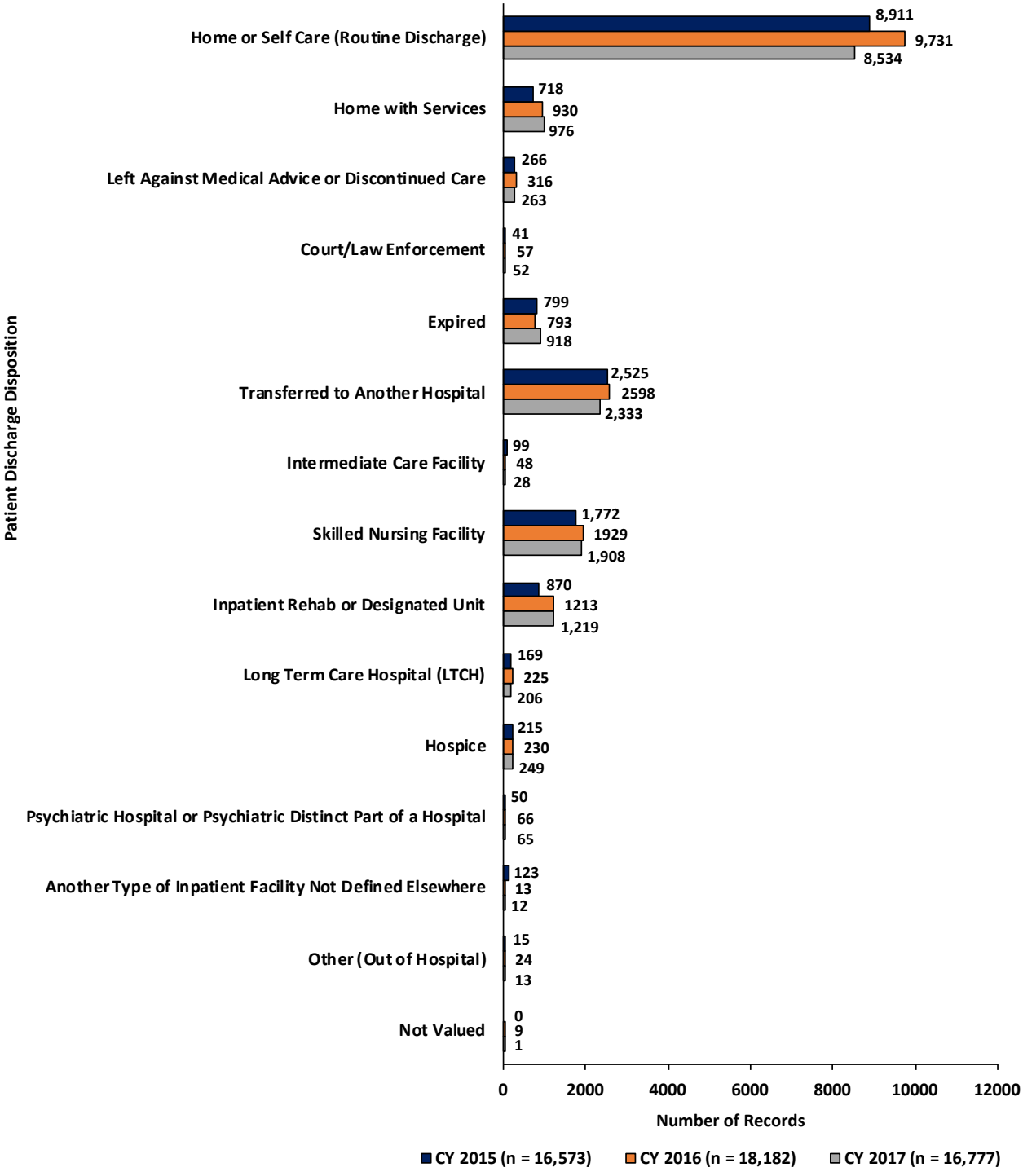
In CY 2015, the highest case fatality rate occurred among TBIs caused by burns (46.2%). However, in CY 2016 and CY 2017, the highest case fatality rate occurred among TBIs caused by penetrating wounds (CY 2016: 51.7%; CY 2017: 46.8%).

Figure 8: Number of TBIs by Place of Occurrence and Year, Ohio Trauma Registry, CY 2015 – CY 2017



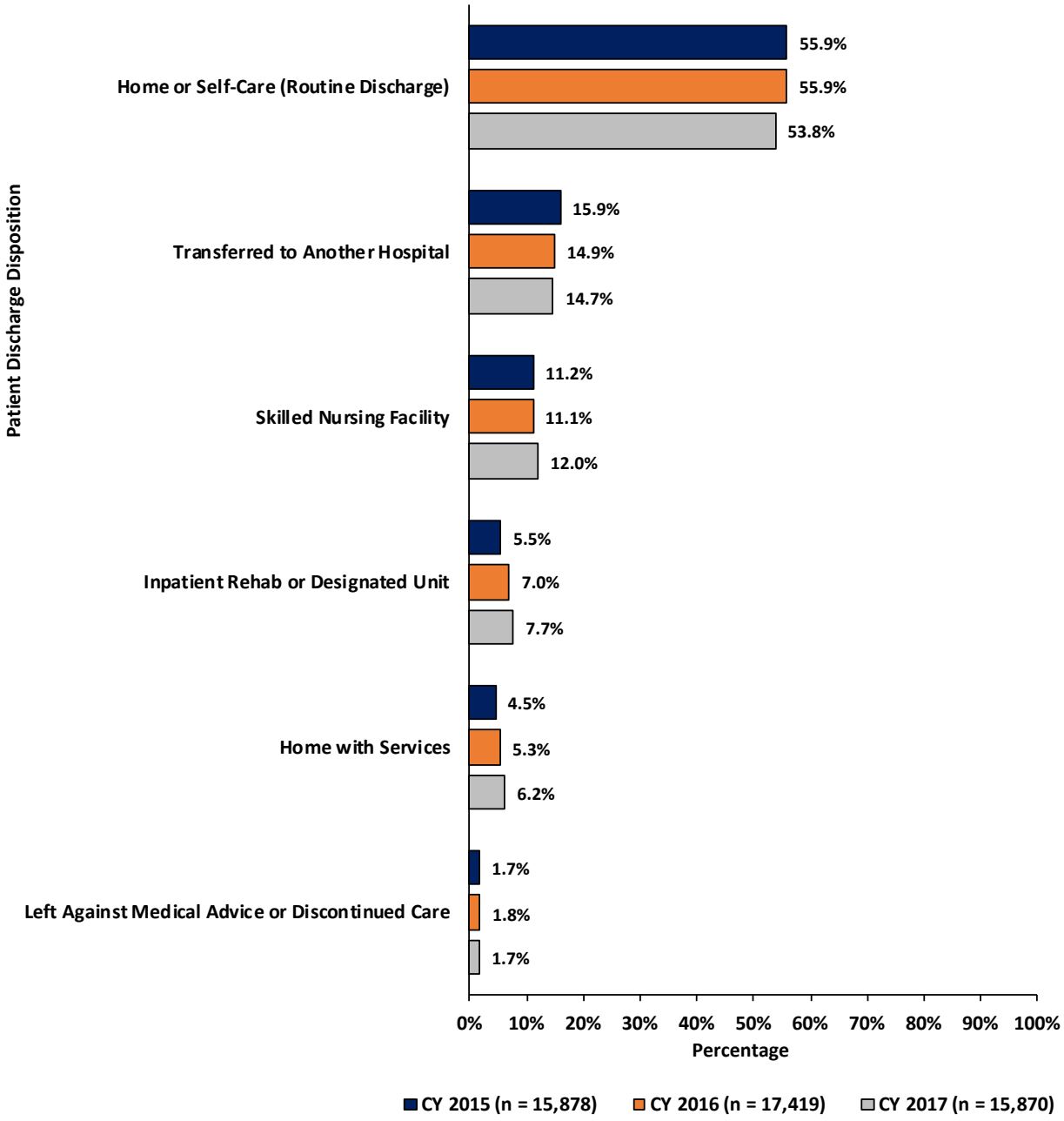
Across all calendar years, the most common place of occurrence for TBIs was home (CY 2015: 6,214; CY 2016: 6,592; CY 2017: 6,354) followed by street (CY 2015: 5,533; CY 2016: 6,538; CY 2017: 5,940).

Figure 9. Number of TBIs by Patient Discharge Status, All Patients, Ohio Trauma Registry, CY 2015 – CY 2017



Across all calendar years, the most common patient discharge status was home or self-care (CY 2015: 8,911; CY 2016: 9,731; CY 2017: 8,534). This means patients were sent home without any additional services as a routine discharge.

Figure 10. Top 6 Patient Discharge Status for TBIs, Alive Patients at Time of Discharge, Ohio Trauma Registry, CY 2015 – CY 2017



Across all calendar years, the majority of patients who were discharged alive were sent home without any additional services as a routine discharge (CY 2015: 55.9%; CY 2016: 55.9%; CY 2017: 53.8%).

The Injury Severity Score (ISS) is an assessment of a patient's injury severity. The score is based on the Abbreviated Injury Scale (AIS), another scoring system for injury severity. When a patient is injured, each area of the body is assigned an AIS score depending on the injury severity. An ISS is calculated by squaring the AIS score from the three most severely injured body areas and adding them together. An ISS can range from 1 to 75.[3] The higher the ISS, the more severe the injury.

Table 1. ISS and Length of Hospital Stay Among TBIs by Year, Ohio Trauma Registry, CY 2015

ISS Group	1 Day	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days	8+ Days	Not Recorded	Total Number of Records
1 – 8	4,442	983	473	290	170	114	52	191	0	6,715
9 – 15	2,110	698	554	365	259	159	142	448	0	4,735
16 – 24	623	290	263	202	191	150	108	528	1	2,356
25+	490	110	110	97	102	74	65	668	2	1,718
Not Calculable	505	162	95	69	38	29	33	117	1	1,049
Total	**8,170**	**2,243**	**1,495**	**1,023**	**760**	**526**	**400**	**1,952**	**4**	**16,573**

Table 2. ISS and Length of Hospital Stay Among TBIs by Year, Ohio Trauma Registry, CY 2016

ISS Group	1 Day	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days	8+ Days	Not Recorded	Total Number of Records
1 – 8	4,758	1,111	532	291	177	121	70	224	307	7,591
9 – 15	2,438	931	684	456	314	200	157	496	124	5,800
16 – 24	660	323	300	272	205	163	134	625	60	2,742
25+	531	111	133	100	98	90	78	760	51	1,952
Not Calculable	34	0	0	0	0	0	0	1	62	97
Total	**8,421**	**2,476**	**1,649**	**1,119**	**794**	**574**	**439**	**2,106**	**604**	**18,182**

Table 3. ISS and Length of Hospital Stay Among TBIs by Year, Ohio Trauma Registry, CY 2017

ISS Group	1 Day	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days	8+ Days	Not Recorded	Total Number of Records
1 – 8	4,072	989	484	278	120	96	76	170	69	6,354
9 – 15	2,277	881	623	419	302	217	160	512	77	5,468
16 – 24	678	349	306	253	234	164	134	659	51	2,828
25+	571	154	141	119	91	90	105	816	39	2,126
Not Calculable	1	0	0	0	0	0	0	0	0	1
Total	**7,599**	**2,373**	**1,554**	**1,069**	**747**	**567**	**475**	**2,157**	**236**	**16,777**

Across all calendar years, TBIs with an ISS of 25+ had a higher frequency of hospital stays lasting eight days or longer compared to other scores. The majority of TBIs with an ISS between 1 and 8 only stayed one day at the hospital.

[3] Injury Severity Score (n.d.). Retrieved from https://www.aci.health.nsw.gov.au/get-involved/institute-of-trauma-and-injury-management/Data/injury-scoring/injury_severity_score.

Section 3

Ohio Traumatic Brain Injury Prevalence Data From the Behavioral Risk Factor Surveillance Survey, Ohio Valley Center for Brain Injury Prevention and Rehabilitation at The Ohio State University Wexner Medical Center

Ohio Behavioral Risk Factor Surveillance System Data

The Behavioral Risk Factor Surveillance System (BRFSS) is an annual cross-sectional telephone survey developed by the CDC that collects information regarding health risk behaviors among non-institutionalized adults 18 years and older at the state level. The BRFSS uses complex weighting processes (design weight and iterative proportional fitting) to make generalizations from the sample to the state population. The Ohio BRFSS is conducted by the Ohio Department of Health.

In 2014, the Ohio BRFSS included a Traumatic Brain Injury (TBI) Module, adapted from the Traumatic Brain Injury Identification Method that was developed by the Ohio Valley Center for Brain Injury Prevention and Rehabilitation at The Ohio State University Wexner Medical Center. This module was included to provide vital information on lifetime prevalence of TBI in the Ohio adult population. The TBI Module was subsequently included in the 2016 (Split 1) and 2017 (Split 2) BRFSS surveys.

- This report's analysis includes data from the 2016 – 2017 Ohio BRFSS.
- The data were reweighted based on the proportion of the sample size from each year.
    - (2016, Split 1 = 8,206 respondents; 2017, Split 2 = 3,799 respondents)
- Our analysis accounts for the complex survey design and excludes "missing," "don't know/not sure" and "refused" responses.

Data from the lifetime history of the TBI Module of the BRFSS has produced significant insight into the prevalence of TBI in the Ohio population and the impact of injuries over time in terms of long-term disability, behavioral problems, employment and quality of life.

Table 1. Lifetime Prevalence of TBI Among Adults 18+ Years by Demographic Characteristics, Ohio, 2016 – 2017

Demographic Characteristics	Overall Sample Population	TBI With Loss of Consciousness (LOC)		Total TBI*	
	Ohio Estimate (% Distribution)	Ohio Estimate	Estimated %	Ohio Estimate	Estimated %
Total	**7,758,864**	**1,317,534**	**17.0**	**1,864,615**	**24.0**
Sex					
Female	4,056,061 (52.3)	577,569	14.2	791,301	19.5
Male	3,702,803 (47.7)	739,965	20.0	1,073,314	29.0
Age					
18 – 24	916,772 (11.8)	101,474	11.1	172,188	18.8
25 – 34	1,231,144 (15.9)	240,184	19.5	354,877	28.8
35 – 44	1,164,185 (15.0)	263,852	22.7	337,115	29.0
45 – 54	1,336,546 (17.2)	279,123	20.9	383,774	28.7
55 – 64	1,408,549 (18.2)	230,325	16.4	336,220	23.9
65+	1,701,668 (21.9)	202,576	11.9	280,440	16.5
Race/Ethnicity					
White, Non-Hispanic	6,284,674 (82.4)	1,093,902	17.4	1,526,645	24.3
Black, Non-Hispanic	858,887 (11.3)	92,226	10.7	150,101	17.5
Other	481,035 (6.3)	90,439	18.8	144,577	30.1
Marital Status					
Married	3,947,449 (50.9)	628,823	15.9	870,766	22.1
Never Married	2,101,276 (27.1)	346,261	16.5	539,831	25.7
All Else	1,710,138 (22.0)	342,450	20.0	454,017	26.5
# Children Living in Household					
0	5,153,159 (66.6)	827,426	16.1	1,191,878	23.1
1	1,057,347 (13.7)	191,806	18.1	275,006	26.0
2	915,991 (11.8)	180,954	19.8	232,107	25.3
3+	608,100 (7.9)	114,238	18.8	162,198	26.7
Highest Level of Education Completed					
<High School (HS)	824,302 (10.6)	168,848	20.5	236,212	28.7
HS Degree or GED	2,573,152 (33.2)	426,285	16.6	600,998	23.4
Some College	2,453,392 (31.7)	447,930	18.3	639,549	26.1
College Degree or More	1,898,176 (24.5)	274,236	14.4	387,110	20.4
Employment Status					
Employed/Self-Employed	4,440,232 (57.5)	746,827	16.8	1,045,292	23.5
Unemployed	389,258 (5.0)	90,847	23.3	126,877	32.6
Retired	1,602,559 (20.8)	196,597	12.3	279,328	17.4
Unable to Work	589,600 (7.6)	190,404	32.3	272,788	46.3
Homemaker	382,419 (5.0)	53,677	14.0	66,605	17.4
Student	315,129 (4.1)	32,795	10.4	65,973	20.9
Annual Household Income					
<$15,000	627,594 (9.4)	147,381	23.5	226,797	36.1
$15,000 - $24,999	1,173,727 (17.5)	222,483	19.0	294,838	25.1
$25,000 - $34,999	743,730 (11.1)	129,131	17.4	194,675	26.2
$35,000 - $49,999	1,075,759 (16.0)	190,196	17.7	260,037	24.2
$50,000+	3,088,058 (46.0)	488,504	15.8	691,870	22.4

* Combines TBI without LOC and TBI with LOC.
Analysis excludes respondents that had missing, don't know/not sure and refused responses.
Source: Ohio BRFSS, including module on lifetime history of TBI (2016 Split 1, 2017 Split 2).

Table 2. Lifetime Prevalence of TBI Among Adults 18+ Years by Geographic Region of Residence, Ohio, 2016 – 2017

Region	Ohio Sample	Severity of TBI				All TBI With LOC	Age at First TBI With LOC	
		No LOC	<5 Min LOC	5-30 Min LOC	>30 Min LOC		<20 Years	≥20 Years
	Ohio Estimate (% Distribution)	%	%	%	%	%	%	%
Total	**7,758,864**	**8.5**	**8.7**	**3.1**	**3.2**	**17.0**	**10.5**	**6.2**
Region 1	499,033 (6.4)	10.1	6.1	4.3	2.8	15.6	8.5	6.5
Region 2	243,766 (3.1)	5.6	7.3	--	1.2	13.4	8.8	4.4
Region 3	342,941 (4.4)	9.5	9.8	4.8	6.1	22.8	14.9	7.7
Region 4	1,193,781 (15.4)	10.6	6.7	--	--	13.7	8.4	5.1
Region 5	800,573 (10.3)	8.5	8.8	--	3.3	17.1	9.8	6.8
Region 6	560,107 (7.2)	8.2	8.6	5.2	--	19.5	10.3	8.8
Region 7	241,524 (3.1)	7.2	6.5	--	5.7	17.8	11.8	6.0
Region 8	1,163,787 (15.0)	6.8	11.3	3.2	2.7	18.6	12.9	5.4
Region 9	751,122 (9.7)	9.6	10.2	--	2.7	16.0	11.1	4.9
Region 10	1,065,062 (13.7)	7.1	8.3	2.5	3.7	15.8	10.3	5.5
Region 11	261,723 (3.4)	9.0	8.3	--	--	16.8	8.7	7.0
Region 12	242,334 (3.1)	7.9	9.5	3.8	3.9	19.7	11.8	7.7
Region 13	198,901 (2.6)	7.6	8.8	2.9	4.3	17.9	10.2	7.5
Region 14	194,208 (2.5)	9.4	10.7	4.5	4.5	21.8	11.3	9.9

Analysis excludes respondents that had missing, don't know/not sure and refused responses.
—data suppressed when denominator <50 or when the RSE >30
Source: Ohio BRFSS, including module on lifetime history of TBI (2016 Split 1, 2017 Split 2).

Region 1 Defiance, Fulton, Henry, Lucas, Paulding, Williams, Wood
Region 2 Allen, Auglaize, Hancock, Hardin, Mercer, Putnam, Van Wert
Region 3 Crawford, Erie, Huron, Ottawa, Richland, Sandusky, Seneca, Wyandot
Region 4 Cuyahoga, Geauga, Lake, Lorain
Region 5 Ashland, Holmes, Medina, Stark, Summit, Wayne
Region 6 Ashtabula, Columbiana, Mahoning, Portage, Trumbull
Region 7 Delaware, Knox, Marion, Morrow, Union
Region 8 Fairfield, Franklin, Licking, Madison, Pickaway
Region 9 Champaign, Clark, Darke, Greene, Logan, Miami, Montgomery, Preble, Shelby
Region 10 Butler, Clermont, Clinton, Hamilton, Warren
Region 11 Adams, Brown, Fayette, Highland, Pike, Ross, Scioto
Region 12 Coshocton, Guernsey, Morgan, Muskingum, Noble, Perry, Tuscarawas
Region 13 Belmont, Carroll, Harrison, Jefferson, Monroe, Washington
Region 14 Athens, Gallia, Hocking, Jackson, Lawrence, Meigs, Vinton

Table 3. Prevalence of Current Health Conditions and Behaviors Among All Adults and Adults With a Lifetime History of TBI by Severity of TBI and Age at First TBI With Loss of Consciousness (LOC), Ohio, 2016–2017

Current Health Condition/ Behavior	Overall Adult Population	Lifetime History of TBI						
		Severity of TBI				All TBI With LOC	Age at First TBI With LOC	
		No LOC	<5 Min LOC	5-30 Min LOC	>30 Min LOC		<20 Years	≥20 Years
	%	%	%	%	%	%	%	%
Any Disability	28.0	41.9	32.8	48.3	54.5	42.2	36.5	50.5
Hearing	6.8	10.0	7.0	14.9	12.5	9.8	7.6	13.2
Vision	4.3	7.0	4.7	9.9	7.7	6.4	5.3	8.0
Cognition	12.0	24.4	18.8	28.1	28.9	23.8	22.6	24.8
Mobility	15.0	23.7	16.7	27.5	31.1	22.3	18.0	29.5
Self-Care	3.5	4.4	5.9	--	8.9	7.6	6.0	9.9
Independent Living	7.0	13.2	10.2	19.2	21.7	15.2	14.2	16.1
Fair or Poor Health vs (Great/ Good Health)	18.4	30.0	23.1	30.2	35.5	27.8	24.0	34.0
1 – 7 Days of Physical Health Not Good	20.4	26.6	21.8	25.0	16.9	20.6	22.7	17.0
8 – 30 Days of Physical Health Not Good	15.8	22.9	22.0	31.7	37.5	27.8	24.2	33.3
1 – 7 Days of Poor Health Keeping From Activities	21.3	24.2	21.7	25.7	18.8	21.8	25.9	15.1
8 – 30 Days of Poor Health Keeping From Activities	22.3	33.1	31.7	38.1	45.1	36.0	31.2	43.9
Chronic Health Problem*	57.4	71.6	64.4	69.9	75.4	68.7	62.8	78.0
Binge Drinking†	17.7	18.4	26.2	24.3	21.2	24.8	27.8	20.1
Heavy Drinking§	6.4	5.3	9.6	13.3	11.2	10.5	10.4	10.6
Smoke (Cigarettes)	22.3	32.2	31.9	40.8	40.3	34.9	33.7	36.4
Smoke (E-cigarettes)	5.1	6.0	9.7	--	--	8.8	10.2	7.0
Depressive Disorder	19.9	36.1	32.9	30.2	35.5	34.1	32.5	36.2
Mental Health Not Good¶	23.8	36.6	36.5	40.9	40.0	38.1	39.1	36.7

* Chronic Health Problem includes heart attack; angina or coronary heart disease; stroke; asthma; skin cancer; other types of cancer; chronic obstructive pulmonary disease, emphysema or chronic bronchitis; some form of arthritis, rheumatoid arthritis, gout, lupus or fibromyalgia; depressive disorder, including depression, major depression, dysthymia or minor depression; and kidney disease and diabetes (not pregnancy-related).

† Binge drinking is defined as males having five or more drinks on one occasion and females having four or more drinks on one occasion, in the past 30 days.

§ Heavy drinking is defined as males having more than 14 drinks per week and females having more than 7 drinks per week, in the past 30 days.

¶ Mental Health Not Good reflects mental health reported as not good on more than five days in the past 30 days.

Analysis excludes respondents that had missing, don't know/not sure and refused responses.

—data suppressed when denominator <50 or when the RSE >30

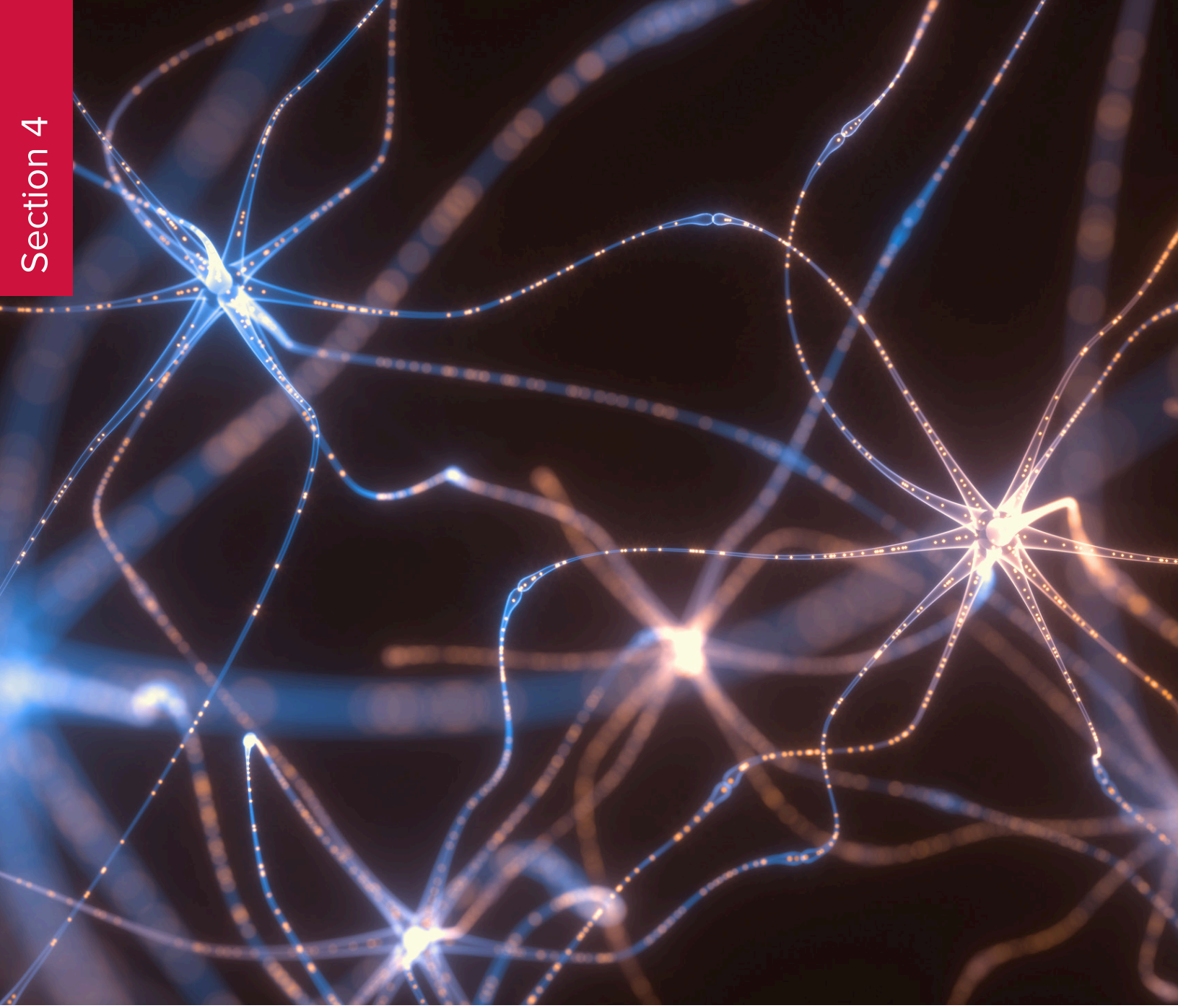
Source: Ohio BRFSS, including module on lifetime history of TBI (2016 Split 1, 2017 Split 2).

Summary of Findings From the 2016 – 2017 Ohio BRFSS

- The estimated number of adults in Ohio who have had at least one TBI in their lifetime is almost 1.9 million—more than 800,000 of these adults had their first TBI before age 20.
- Twenty-four percent of adults have had a TBI; 17% have had a TBI resulting in loss of consciousness (LOC).
- TBI is less prevalent among adults who are female, Black non-Hispanic and 18 – 24 years of age or 65 years or older.
- A history of TBI is associated with lower education, less income and being unemployed or unable to work.
- More than 550,000 Ohio adults reported having both a disability and a history of TBI with LOC.
- Among the nearly 250,000 (3.2%) Ohio adults who have a history of moderate to severe TBI (>30 min LOC), 135,000 (54.4%) also reported having a current disability.
- Disability due to cognitive problems, limited mobility and an inability to get around the community independently are more associated with a history of TBI than other causes of disability.
- Adults with a history of TBI reported higher prevalence rates of poor health, smoking, alcohol misuse, chronic illness and mental health problems when compared to all adults who reported the respective health condition.
- Binge drinking and e-cigarette use were more prevalent among those who sustained their first TBI with LOC before the age of 20, while other health conditions examined were more prevalent among those adults who sustained their first TBI with LOC at ≥20 years old.

These findings demonstrate that a history of TBI is associated with poorer living situations, health and disability. These data do not allow us to conclude that TBI causes these problems, but the prevalence of TBI in the Ohio population suggests that the cost to society from these injuries extends beyond just the medical cost of treating the initial injury.

Section 4



The Costs of Traumatic Brain Injury: Can They Be Reduced?

Previous sections of this report have documented the alarming incidence and prevalence of traumatic brain injury (TBI) in the Ohio population over the time period from 2015 – 2017. The figures clearly establish TBI as a major cause of death and disability in the state, with brutal effects on the well-being of the population. Beyond the personal loss, however, an estimate of the financial costs of the injury remains difficult to calculate but can be appreciated by a consideration of the breadth of factors that make a brain injury one of the costliest injuries that any individual can sustain. The financial costs include:

- Medical treatment
- Rehabilitation
- Lost wages
- Home modifications
- Personal caregiver needs
- Loss of future earning capacity
- Loss of caregiver earning capacity

Comprehensive studies to quantify the sum total of these costs are difficult to complete, but the data continues to grow, which underscores the financial and social burden of TBI on a personal and societal level. Table 1 below shows the lifetime financial impact of TBI-related deaths, hospitalizations and emergency department (ED) visits in Ohio in 2017 as estimated by a CDC algorithm.

Table 1. Estimated Lifetime Costs of TBI – Deaths, Hospitalizations and Emergency Department Visits

	Number of Injuries, 2017	Medical Cost*	Work Loss Cost*	Combined Cost*
Deaths	2,639 †	$ 32,172,000	$ 1,755,533,000	**$ 1,787,705,000**
Hospitalizations	10,543 ‡	$ 931,383,000	$ 2,188,950,000	**$ 3,120,333,000**
ED Visits	109,817 ‡	$ 561,306,000	$ 506,455,000	**$ 1,067,761,000**
Total	**122,999**	**$ 1,524,861,000**	**$ 4,450,938,000**	**$ 5,975,799,000**

*__Source:__ CDC Web-based Injury Statistics Query and Reporting System (WISQARS).
†__Source:__ Ohio Department of Health Bureau of Vital Statistics.
‡__Source:__ Ohio Hospital Association, discharge diagnoses data.

A similar estimate derived from the same source shown in our last report—*2017 Biennial Report on the Incidence of Traumatic Brain Injury in Ohio*—projected the total lifetime cost to be $4,393,926,000 for TBIs that occurred in 2014. If the additional cost elements listed above in Table 1 were added to this total, the sum would be even more staggering.

The Cost Management Imperative

Identifying and mitigating the cost drivers of TBI medical management, rehabilitation and long-term care present multiple challenges, which are inherent in the complexity of TBI. Factors, such as age at time of injury, gender, severity and access to services, are just a few variables that combine to challenge the research. However, studies do continue to accumulate that not only confirm the efficacy of cost containment strategies published in our previous report, but reinforce the application of chronic disease management techniques to provide the right treatment at the right time according to the right method and carefully watching for signs of progression or deterioration.

Such strategies are based on efficiencies of resource use and effectiveness of interventions, which improve outcomes:

Strategy 1: Adhere to the treatment guideline developed by the Brain Trauma Foundation

Our prior report documented the findings of a 2007 CDC study that defined the cost and outcome improvements achieved through the application of the Brain Trauma Foundation guidelines.[1] That study reported that the improved outcomes attained through compliance with those guidelines reduced medical costs by $11,280 per person and direct medical costs by a total of $262 million. Annual rehabilitation costs were reduced by $43 million, and lifetime societal costs were reduced by $3.84 billion.

The cost-saving potential of this strategy was supported in the work of a research team from the Sunnybrook Health Sciences Centre in Toronto, which was published in the journal *Value in Health*. The team undertook the systematic review of 3,539 published studies of contemporary economic evaluations in the diagnosis and management of TBI.[2]

Study findings confirmed the significance of the cost-utility of compliance with the Brain Trauma Foundation in achieving an incremental cost-effectiveness ratio for the management of severe TBI. A cost-utility analysis of compliance with the Brain Trauma Foundation's guidelines at a compliance rate of >50% for the management of severe TBI proved less costly and more effective than compliance rates of <50% for patients 40 – 60 years of age. For age 80 years, the incremental cost-effectiveness ratio was $88,507.

Although research concerning the societal costs of TBI needs to be expanded, the work done thus far shows immense opportunities to substantially reduce societal costs by recognizing the value of established best practices as an operative means of promoting the cost-effectiveness of medical care and treatment as well as forestalling future costs that result from inadequate treatment regimens in the earlier phases of care. Implementation, of course, presumes training of professionals in the content and application of the guidelines.

[1] 2017 Biennial Report on the Incidence of Traumatic Brain Injury in Ohio, Jan. 1, 2018, Brain Injury Advisory Committee.
[2] Aziz SA, et al, "Economic Evaluations in the Diagnosis and Management of Traumatic Brain Injury: A Systematic Review and Analysis of Quality," *Value in Health*, Volume 18, Issue 5, July 2015, Pages 721 – 734.

Strategy 2: Utilize post-acute TBI rehabilitation

The singular importance of rehabilitation in reducing the lifetime costs of TBI has been further validated by a study of researchers at the Centre for Neuro Skills and the UCLA Department of Neurosurgery.[3] Their study found that rehabilitation, particularly that which was initiated within the first year after a TBI, produced both rehabilitation dollars saved as well as improved outcome scores in functional improvement. In addition, rehabilitation savings were observed in all age groups. Projected dollars saved were a calculation of life care planners who based their assessment on such factors as decreased lifetime costs due to reduction in projected medical expenses, hospitalizations and nursing care.

Furthermore, the findings indicated that higher function was observed in those patients who had the benefit of previous rehabilitation, showing the importance of the continuous and proper sequencing of the therapeutic program from acute through post-acute stages. The study showed that recovery at this later period is possible, in that rehabilitation itself facilitates neuroplasticity and, therefore, maximizes the possibility for the individual to return to pre-injury social and vocational activities.

A review of empirical literature done by the Department of Physical Medicine and Rehabilitation, Wayne State University School of Medicine and the rehabilitation psychology and neuropsychology team at the Rehabilitation Institute of Michigan[3] concludes that the appropriate use of rehabilitation can reduce future expenditures by improving and sustaining functional outcomes of brain injury survivors in the following dimensions:

- Patients who were referred for rehabilitation earlier in the course of care demonstrated reduced lengths of stay for inpatient rehabilitation.
  Decreased Length of Stay = Decreased Costs

- Rehabilitation resulted in decreased general disability and improvement in psychosocial factors both at discharge and at one year post-injury, thus reducing the need for ongoing specialty interventions and the associated costs.
  Improved Functionality and Independence = Cost Avoidance of Ongoing Need for Treatment/Care

- Timely rehabilitation improves outcomes, which results in improved vocational reintegration.
  Improved Vocational Reintegration = Reduced Wage Loss for Survivor and Caregiver

These findings repeated across the body of research concluded that the sooner rehabilitation services are implemented, the better the expected outcome and the lower the future costs in present value terms. The obvious corollary is the additional psychosocial benefit of improvements in functionality and quality of life for both the TBI survivor and the family.

[3] Ricker JH, "Traumatic Brain Injury Rehabilitation: Is it Worth the Cost?" *Applied Neuropsychology,* 1998, Vol. 5, No. 4, 184 – 193.

Strategy 3: Deliver specific and individualized community supports and service coordination

The importance of community supports and individualized coordination of services to the success of return-to-work (RTW) and social reentry following a TBI was discussed previously in our 2017 biennial report.[4] The contribution to lifetime cost savings for the ongoing care and rehabilitation of the survivor demonstrated compelling evidence of the value proposition.

- Survivors who received specific services and supports achieved a 64% RTW rate compared to only a 40% to 50% RTW rate for those who did not receive them.

- That RTW rate generated an estimated cost avoidance of $31 million in annual lost wages.

A Minnesota study, which evaluated employment outcomes of a medical/vocational case coordination system, produced similarly impressive results in a group of 114 participants between the ages of 18 – 65.[5]

This chart shows the return-to-work outcomes achieved through the case coordination system:

	RTW at Initial Placement	RTW at One-Year Follow-Up
Independent Work	46%	53%
Transitional Placement	25%	19%
Long-Term Supported Work	9%	9%
Sheltered Work	10%	6%
Unemployed	13%	13%

This study adds to the body of information that supports the contention that the special circumstances that surround the aftermath of a brain injury require solutions that are designed to address such variables of age, severity of injury, type of injury, rehabilitation history and degree of disability. Recognition of this fact has led a number of states to introduce programs to meet the needs of individuals affected by brain injury to pursue full reentry into community life, including that of employment and independence. The “cost savings” that result extend far beyond the financial to the broader societal impacts that comprise the spectrum of human costs resulting from brain injury.

[4] 2017 Biennial Report on the Incidence of Traumatic Brain Injury in Ohio, Jan. 1, 2018, Brain Injury Advisory Committee.
[5] Malec JF, et al, “A medical/vocational case coordination system for persons with brain injury: An evaluation of employment outcomes,” *Archives of Physical Medicine and Rehabilitation*, Vol. 81, Issue 8, August 2000, 1007-1015.

TBI is well recognized as one of the costliest injuries, having life-changing implications that include ongoing disability, the need for long-term care and treatment, negative social effects and human suffering. Although those costs can be highly variable, the fundamental principles of providing aggressive and appropriate chronic disease management in the acute state, rehabilitation for maximum recovery at post-acute stages and continued supports to prevent deterioration and complications remain the best strategies to reduce both the financial and human costs of TBI.

THE OHIO BRAIN INJURY PROGRAM AND
THE BRAIN INJURY ADVISORY COMMITTEE

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER