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CHAPTER 1

Epidemiology of Traumatic Brain Injury

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A traumatic brain injury (TBI) is a disruption of brain function and/or structure due to the application of an external physical force that produces signs and symptoms of brain dysfunction in the acute injury period. In this chapter, we offer further detail on the incidence of TBI and explain the methodology for examining the burden of TBI. Several methodologies and data sets are presented in this chapter to provide a picture of the epidemiology of TBI. Data from emergency department (ED) visits, hospitalizations, and deaths offer a picture of the incidence of TBI in the United States. Using the Traumatic Brain Injury Model Systems National Database (TBIMS NDB), weighted to represent the population of adults who receive inpatient rehabilitation for a primary diagnosis of TBI in the United States, provides insights into long-term outcomes and mortality for individuals with TBIs that require acute inpatient rehabilitation. Population studies examining the lifetime history of TBI contribute to the knowledge of the full public health burden of TBI. In this chapter, we also explore limitations of existing methodologies in order to provide a greater understanding of the complexity of estimating the number of individuals affected by this condition and how they fare over time. Understanding the epidemiology of TBI and its associated consequences is necessary for improving quality of life for individuals and families and essential for reducing the costs to society arising from TBI.

Disclaimer: The views expressed in this chapter are those of the authors and do not reflect the official policy or position of the Centers for Disease Control and Prevention or the U.S. government.

Incidence of Traumatic Brain Injury

TBI is a major cause of death and disability in the United States, contributing to about 2.2% of all deaths (Taylor et al. 2017). Since 1995, the Centers for Disease Control and Prevention (CDC) has defined TBI for surveillance case definitions as an injury to the head arising from blunt or penetrating trauma or from acceleration/deceleration forces that is associated with one or more of the following: decreased level of consciousness, amnesia, objective neurological or neuropsychological abnormality, skull fracture(s), diagnosed intracranial lesion(s), or head injury listed as a cause of death on the death certificate (Centers for Disease Control and Prevention 1999; Coronado et al. 2012; Marr and Coronado 2004). Other agencies and organizations have developed definitions that are largely consistent with the CDC case definition, although nuances in operationalization do exist (Carroll et al. 2004; Menon et al. 2010; Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine 1993). In all definitions, not all bumps, blows, or jolts to the head result in TBI. Additionally, not all persons who experience a TBI will have behavioral effects or a TBI-related disability (Corrigan et al. 2010).

Incidence and Burden of Medically Treated Traumatic Brain Injury

Figure 1–1 illustrates the estimated number of TBI-related ED visits, hospitalizations, and deaths in the United States, comparing 2007 with 2013 (Menon et al. 2010; Taylor et al. 2017). The CDC estimated that in 2013 TBIs were diagnosed in 1.9% (2.8 million) of the 149 million injury and noninjury-related ED visits, hospitalizations, and deaths in the United States. Of these persons, approximately 89.3% (2.5 million) were treated in and released from the ED, another 10% (282,000) were hospitalized and discharged, and approximately 2% (56,000) died. The number of TBI-related ED visits increased from approximately 1.6 million in 2007 to approximately 2.5 million in 2013, an increase of more than 50% (850,000 ED visits). Heightened public awareness about sports-related concussions and increased awareness of TBI among health care professionals are possible contributors to the increase in medically treated TBI. In addition, the number and rate of fall-related TBI in the older adult age group substantially increased (Taylor et al. 2017).

In 2013, rates of TBI-related ED visits, hospitalizations, and deaths were higher in males (959.0 per 100,000) compared with females (810.8 per 100,000). Rates also varied by age, with the highest rates observed among persons ages ≥75 years (2,232.2 per 100,000 population), 0–4 years (1,591.5 per 100,000), and 15–24 years (1,080.7 per 100,000). The principal injury mechanisms for all age groups included falls (413.2 per 100,000, age adjusted), being struck by or against an object (142.1 per 100,000, age adjusted), and motor vehicle crashes (121.7 per 100,000, age adjusted). Fall-related TBIs among persons ages ≥75 years accounted for 17.9% of the increase in these medically attended TBIs. The number and rate of TBI-related hospitalizations also increased in the oldest age group, primarily because of falls (from 356.9 per 100,000 in 2007 to 454.4 per 100,000 in 2013) (Taylor et al. 2017).

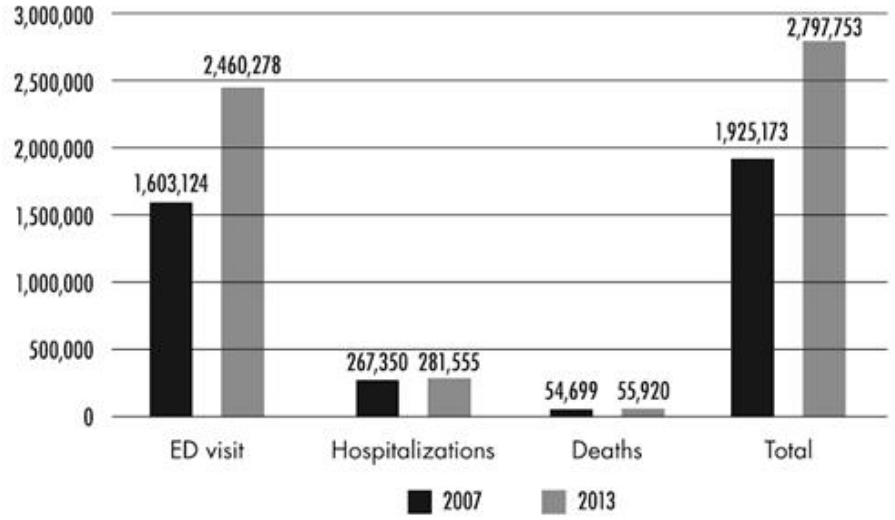

FIGURE 1–1. Estimated number of traumatic brain injury–related emergency department (ED) visits, hospitalizations, and deaths—United States, 2007 and 2013.
Source. Taylor et al. 2017.

In 2013, falls were the leading cause of TBI, accounting for 47.2% of all TBIs in the United States, followed by being struck by or against an object (15.4%) and motor vehicle crashes (13.7%). Falls accounted for 57.3% of the increase in TBI-related ED visits, being struck by or against an object accounted for 18.2% of the increase, and motor vehicle crashes accounted for 7%. The number and rate of TBI-related ED visits for falls in older adults has increased substantially, with additional increases in rates of hospitalization and deaths in this age group. Persons ages ≥75 years had the highest rate of fall-related TBI ED visits (1,859 per 100,000), followed by 0–4 years (1,119.3 per 100,000) and 65–74 years (539.8 per 100,000). Although self-harm and assault account for a lower proportion of TBI-related ED visits, a substantial increase was noted for both TBIs related to self-harm (75% increase) and assault-related TBIs (20% increase) (Taylor et al. 2017).

In the most recent report from the CDC (Taylor et al. 2017), broad mechanisms of injury based on external-cause-of-injury codes (i.e., E codes, which classify injury incidents by mechanism, such as falls and being struck by or against an object) are described that do not account for specific sports or recreational activities. It is possible that persons seeking treatment for these injury mechanisms were involved in sports and recreational activities. More detailed information about sports- and recreation-related TBI can be informed by a recent report using the National Electronic Injury Surveillance System All Injury Program, which includes narratives describing the injury event. In 2012, approximately 430,000 ED visits resulted from sports- and recreation-related mild TBI (mTBI; Coronado et al. 2015). Nearly 70% of those ED visits (325,000) occurred among individuals ages 0–19 years (Coronado et al. 2015). From 2001 to 2012 the rate of sports- and recreation-related ED visits increased significantly among males, particularly for those ages 10–14 years (139.9% increase) and those ages 15–19 years

(119.3% increase). Increased attention to TBI in sports, as well as the enactment of sports concussion legislation in all 50 states, may have contributed to this increase. Among male youth, the largest number of ED visits for sports- and recreation-related mTBI occurred as a result of injuries while bicycling or playing football or basketball. A similar increase was found for females, particularly among those ages 15–19 years (211.5% increase) and those ages 10–14 years (145.2% increase). Among females ages 0–19 years, the largest number of ED visits for sports- and recreation-related mTBIs occurred as a result of injuries while bicycling, engaging in playground activities, or horseback riding (Coronado et al. 2015). In addition to sports-related injuries, the rate of ED visits for playground-related TBIs significantly increased from 2005 to 2013 (Cheng et al. 2016). During 2001–2013, an annual average of 21,201 children ages 14 years and younger were seen in the ED for playground-related TBIs, with the highest rates found among males and children ages 5–9 years.

Abusive head trauma (AHT) is an injury to the skull or intracranial contents of a child age 5 years or younger due to blunt impact and/or violent shaking (Parks et al. 2012). It is a mechanism of injury most frequently experienced by young children and generally results in moderate or severe injury. Annual estimates of AHT ED visits and hospital admissions in 2001–2006 were 3,227 nationally; nearly two-thirds of those visits resulted in hospital admission, a reflection of the typical severity of AHT (Peterson et al. 2015).

In 2015, the Department of Defense estimated the incidence of medically diagnosed TBI since 2000 among U.S. forces stationed throughout the world as 22,681 for all areas of service. Of this total, 82.3% (18,666) were mild, 12.2% (2,763) were moderate, 0.08% (174) were severe, 0.06% (140) were penetrating, and 4.1% (938) were not classifiable (Defense and Veterans Brain Injury Center 2015).

Current national estimates based only on ED visits, hospitalizations, and deaths underestimate the occurrence of TBIs because they do not account for individuals who had outpatient or office-based visits (e.g., urgent care facilities, physicians' offices, or specialized clinics), those who received care at a federal facility (e.g., persons serving in the U.S. military or seeking care at a Veterans Affairs hospital), or persons who did not receive any medical attention (Faul et al. 2010). For example, a recent study examining the point of entry in a large pediatric health care system found that among children with mTBI, 82% visited primary care, 5% visited specialty care, and 12% visited the ED for care at the time of the injury (Arbogast et al. 2016). National survey methodologies rely on individual self-report, which would not exclude events treated in other health care settings or that were untreated, and in so doing could provide a more complete estimate of incidence.

Injury Severity Classification of Traumatic Brain Injury

Although several injury indicators exist for the classification of TBI, the Glasgow Coma Scale (GCS), developed in 1974, has been the most utilized measure (Malec et al. 2007; Teasdale and Jennett 1974). The GCS was originally developed to assess coma and other impaired levels of consciousness on the basis of observed clinical signs and symptoms (Teasdale and Jennett 1974). The scale incorporates three components of neurological function: eye opening, verbal response, and motor response. The component scores are added to create an overall score to determine a patient's level of consciousness. As defined by the GCS, an mTBI is assigned a score of 13–15,