What is a “Brain Injury”? 

An acquired brain injury is damage to the brain caused by anything that would be acquired – such as tumors, strokes, or a traumatic injury. Traumatic brain injury (TBI) is more specific as it implies trauma to the brain caused by an external force impinging upon the head and brain. It does not define the force or the severity of the force, but just an external force. 

Even more specific is closed versus open head injury. Closed simply means the cranial contents have not been penetrated and there is no air inside the protective layers of the skull. Open means the skull is penetrated and exposed to air. A classic example of an open head injury is a gunshot wound to the head. A classic closed head injury is one that occurs as the result of a motor vehicle crash. The abbreviations used are CHI (closed head injury) and TBI (traumatic brain injury).

TBI Model System Definition of TBI

The TBI Model Systems (TBIMS) is a group of 17 national Centers funded by the National Institute on Disability and Rehabilitation Research (NIDRR). The TBIMS works to maintain and improve a cost-effective, comprehensive service delivery system for people who incur a traumatic brain injury (TBI), from the moment of their injury and throughout their life span.

The criteria established by the TBIMS states that for someone to have a TBI, one of the following has occurred.

- There was a documented loss of consciousness. The length of time is not indicated. It can be very brief or it could be very long.
- The person has amnesia for the event. This means they cannot recall the actual traumatic event.
- A Glasgow Coma Scale (GCS) score of less than 15 during the first 24 hours.
  - The GCS is how the medical staff measures the depth of coma when a person comes into the emergency room. The scores can range from 3 to 15, with 3 being the poorest score and 15 being the best score. Three is extremely critical and fifteen means the person is talking, alert, and oriented. Anything less than that perfect score can be construed as evidence of a traumatic brain injury when someone is admitted to the ER.
- The presence of a skull fracture, post-traumatic seizure, or a CT scan (computerized tomography) or MRI (magnetic resonance imaging) associated with trauma.

A common question is, “Can someone have TBI but never lose consciousness?” If you look at the Model System’s definition, the answer is yes. An individual can have amnesia for the event or an abnormal CT scan, but not lose consciousness. Someone with an open brain injury, like a penetrating gunshot wound, may not even lose consciousness. The person comes into the ER and can ask for help even though they are significantly brain injured. So it is possible to have a TBI without loss of consciousness.
Measuring the Severity of TBI

Glasgow Coma Scale Score
A common method used to measure the severity of a traumatic brain injury is the Glasgow Coma Scale (GCS) score. The ICRC Data show a proportion of people who come into the Neuro Intensive Care Unit (NICU) have a GCS score in the mild (13-15) or moderate (9-12) range.

There are many reasons for an individual to be in the NICU besides the Glasgow Coma Scale Score. These individuals showed other signs of a brain injury, such as positive CT scan. They may have experienced a set-back after they were initially assessed. The national data are very similar, showing individuals admitted to rehabilitation with significant problems even though the GCS suggested a mild to moderate injury.

CT Scan Results
The ICRC Data show only 9% of these individuals had a normal CT Scan. Not everything that happens in a head injury shows up on a CT scan. It is possible to have a normal CT Scan with a head injury.

Duration of Post-Traumatic Amnesia
One of the better estimates for severity of a brain injury is post-traumatic amnesia. Anytime a person has a significant blow to the head they will have amnesia for the event. They do not remember the event itself and possibly events for sometime afterwards (post-traumatic amnesia).

The longer the duration of amnesia, the more severe the brain dysfunction. If the duration of amnesia is up to an hour, it is considered a mild trauma; up to a day of amnesia signifies a moderate injury; up to a week of amnesia after the injury is considered a severe injury. Beyond a week of amnesia, the injury is considered very severe.

This is also one of the better estimates for long-term outcome. It can be estimated and used by anyone. By interviewing the person, one can determine the period of time for which the person has no recall of ongoing events. In the ICRC study, 45% of the cases had a post-traumatic amnesia of 4 weeks or greater indicating the population was very severely injured for the most part. Very few individuals (2.6%) experienced no post-traumatic amnesia.

Associated Injuries
When dealing with traumatic brain injury, there are often other injuries as well. The Model Systems National Database shows that 72% of the TBI admissions had fractures. There were cranial nerve deficits in 17% of cases and 4% of the individuals had a spinal cord injury. Often it is necessary to deal with other injuries in addition to the head injury.

On the other hand, it is possible for someone to have only a TBI with no external markers of severe trauma. In this situation, families may have a difficult time understanding the seriousness of the brain injury when they see their family member in the NICU. The injured person may not have a mark on their body to show any injury.
Pathology

What happens to the brain as a result of a traumatic brain injury? The brain is about 3 to 4 pounds of soft tissue that is extremely delicate. Nature views the brain as a very important organ, providing it with several protective layers. The brain is composed of about 15 to 20 billion neurons plus other support cells.

Hematoma forms if the blood clot is below one of the protective layers that surround and envelop the brain. This is a venous bleed. An epidural hematoma means the blood clot forms between one protective layer of the brain (the dura) and the skull. This is usually an arterial bleed. An intracerebral hematoma or hemorrhage is when there is bleeding within the brain tissue itself. One of the major problems caused by hematomas is that they press the soft tissue compressing the brain out of the way and eventually, if the pressure is sufficient and treatment (usually surgery) is not forthcoming, the person dies.

Diffuse Axonal Injury

Axons extend from each neuron cell body in the brain. The axons allow communication from one neuron to another neuron. There are 15 to 20 billion neurons in the brain; each is very delicate and very tiny. When the brain moves, such as occurs in acceleration/deceleration, those axons can pull, stretch, tear, etc. If there is sufficient injury to the axon, the cell will die, immediately or within a few days. That happens all over the brain, not just in one area, which is why it is called diffuse axonal injury. This kind of injury does not show up on a CT scan.

Secondary Brain Injury

Localized and diffuse axonal injuries occur at the time of impact and there is not a lot that the hospital or rehabilitation center can do to reverse those injuries. Instead, their goal is to prevent secondary injury to the brain. One example of secondary injury is hypoxia, or not getting sufficient oxygen to the brain. This can occur when the person is not breathing or their blood pressure is too low. The end result is further brain injury.

Another secondary problem can be increased intracranial pressure, which can result in significant swelling, often referred to as edema. The physicians try to bring the pressure down because if the edema is great enough, it prevents blood flow into the tissue. There can also be pressure effects from a hematoma that prevent blood from getting into the tissue. The important step is to stop the oxygen deprivation and increase the blood flow. One of the main goals is to maintain the cerebral perfusion pressure. This ensures there is enough pressure to get blood to the brain tissue.
Incidence of Traumatic Brain Injury

The incidence of traumatic brain injury is about 100 hospitalized cases per 100,000 population. (Kraus & McArthur, 1999). It is helpful to understand how TBI compares to the occurrence of other disorders. With spinal cord injury, the incidence rate is about 4 per 100,000 and for cerebral palsy it is about 10 per 100,000. While the incidence of stoke approaches that of TBI, it usually occurs in an older population.

TBI is an injury that affects a younger population. The occurrence peaks with age groups below 5 years, between 15-24 years, and over 70 years. The maximum peaks are 133 per 100,000 in the 15-24 year age range and 165 per 100,000 in the over 65 age group.

The mortality (death) rate for TBI is 30 per 100,000. Of those who die, 50% do so within the first 2 hours of their injury. This is one reason that there is increased emphasis on treatment at the scene of the injury. The treatment given by paramedics and in the emergency room can make a big difference in terms of an individual’s survival. However, even with all of our progress in treating people with severe injuries, tens of thousands still die.

Severe blunt trauma has a mortality rate of 30% if TBI is involved, whereas without TBI, the death rate for blunt trauma is 1%. That gives you an idea of the seriousness of a head injury. Trauma is still the leading cause of death from people ages 1 to 44.

There are an estimated 50,000 individuals per year who die of traumatic brain injury in the U.S. Consider that to the fact that about 50,000-60,000 servicemen died in Vietnam. We are outraged by death in war but have become acclimated to the decimation of our population by trauma.

Another estimated 70,000 people experience impairment due to their TBI, causing lasting problems for these people. Ninety-three percent of persons diagnosed with a moderate head injury and 42% of those with severe head injury survive their injury and are discharged from acute care.

There is some good news. The incidence of hospitalization for traumatic brain injury has been diminishing over time. In the early 80’s, there were 200 per 100,000 hospitalized cases of head injury based on population estimates. In 1995, that has fallen to about 100 per 100,000. That sounds good, but remember this is the hospitalization rate. When broken down in terms of mild, moderate, and severe head injuries, more recently we find that milder head injuries are not being hospitalized, even for an overnight stay. This is why the incidence of hospitalization for TBI is diminishing. The numbers of those with more severe head injuries are actually increasing slightly, possibly because they are surviving those first 2 hours so they are getting to the hospital. So the news isn’t quite as good as it first sounded.

Demographics
Who experiences TBI and how does it happen?

Gender
Gender is no surprise! Three quarters of those injured are males. Only 21.2% of the TBI injuries were to females while 78.8% involved males.

Race
For the Birmingham area, where these data were collected, almost 36% of those injured were African American. This represents the actual breakdown of our racial distribution in the metropolitan area.

Marital status at time of Injury
Considering that TBI is a young person’s disorder, many of these individuals, 47%, were single at the time of their injury, although 32.5% were married. Most of them have not made it to the age where they would be divorced or widowed.

Residence at time of Injury
Because of the young age when these individuals were injured, many, 37%, still lived with their parents. The other large group, 32%, lived with their spouse. Many had not made it out on their own yet.

Age at the time of Injury
The data on age comes from the ICRC study of 240 cases. We enlisted adult individuals, age 15 and above, so there are no young children included.
This graph shows the percentage of all ICU admissions due to TBI for that age range. The graph shows the peak age group is 15-25 years, with 31.7% of the hospitalizations for TBI occurring in that age range. We do not see a peak for older individuals (above 65), although this has been reported elsewhere.

![Percent of TBI injuries per Age Group]

### Employment at onset

At the time of injury, 57% were employed in some capacity, part-time or full-time. Another 10% were students. The information collected was usually reported by family members. They reported in 24% of the cases that the injured individual was unemployed. This high number may be because only 1% indicated a family member as a homemaker. They may have reported a person as unemployed rather than as a homemaker.

### Alcohol and Drug Abuse History

We ask about an individual’s use of alcohol prior to his/her injury using the CAGE. The CAGE consists of four questions relating to things like: Did the injured person feel the need to cut down on his/her drinking in the past year?” or “Did the injured person get annoyed by people criticizing his/her drinking in the past year?” If a family member answers “yes” on two of those four questions, the injured person is considered to have had an alcohol abuse history. Approximately 31% of those injured had an alcohol abuse history.

Another four questions relate to the individual’s drug use in the past. In the ICRC sample, 27% had a drug abuse history. Drug abuse and alcohol abuse are significant factors that need to be considered in recovery from TBI.

### Social Dysfunction History

Social dysfunction looks at things like being arrested, being incarcerated, or being expelled from school. Relatively few (6%) of the individuals have two or more of these types of problems.

### History of TBI

For this measure, we looked at data from the National Model TBI Database. We see that 10% of the individuals that receive rehabilitation for severe traumatic brain injury have a history of a previous brain injury. Another study out of Virginia in the early 1980’s looked at mildly injured individuals and found that 30% of their population had been to the ER before with a head injury.

### Education

Keep in mind that in looking at the ICRC data, many of these individuals were injured before they had a chance to complete high school. This may skew some of this data. Generally this is not a population group with many years of education.
**Etiology of Injury**

What is the cause of TBI? Most individuals are injured in motor vehicle crashes. The national statistics cite between 50% and 70% of traumatic brain injuries are the result of a motor vehicle crash (MVC).

The ICRC data found that MVC’s are the cause of 64% of TBI’s and in over half of these, 53%, the driver was under the influence of alcohol. Other causes were gunshot wounds to the brain (13%) and assaults (8%). Sports-related TBI’s ranked last with about 1% of cases. Sports-related head injuries receive a lot of attention by the news media. However, when you look at the really severe injuries, sports are not a significant factor. This is because there are not the same forces involved in sports as in a motor vehicle crash. Severe head injury resulting from playing sports is rare.

The cause of the injury varies based on where the data are collected. The Model Systems National Database lists TBI’s that result from assaults as 28% of cases. The ICRC data combined assaults and gunshot wounds and reported about 21% of cases. This difference probably is because a large amount of data for the National Database comes from downtown Detroit.

**Intentionality**

Some head injuries are intentional. It is presumed that a motor vehicle crash is unintentional. ICRC data shows 15% of injuries during the 5-year period of data collection were intentional. The cause could be assault with a blunt instrument or a gun. Four percent of the intentional injuries were suicide attempts. There has not been sufficient study of those with intentional vs. unintentional injury. A research project at UAB recently studied the differences in how individuals in these two groups recover and the services they need.

**Supplemental Facts**

Other data show that most accidents occur primarily on weekends (51%) and most occur in the night time hours.

**Cost of TBI**

When considering costs there are two types of costs: financial and the cost of life. For a good summary of such costs you might wish to read the chapter in Kraus & McArthur (1999). With every death that results from a TBI, on the average, there are 38 years of living lost. The care for people with new-onset TBI costs an estimated $6.5 billion in 1993 dollars. Ongoing care for people with an existing head injury costs $13.5 billion in 1993 dollars. For a person in a persistent nonresponsive state, which used to be called a vegetative state, the lifetime costs is over 3 million dollars. Keep in mind that in most cases these individuals do not live for a full life span.

The life expectancy of most head-injured persons is, as best we know, similar to that of the average individual. For a severe head injury, the lifetime costs are over $3 million; for moderate injury, $941,000; and for mild trauma $85,000.

**Prevention of TBI**

How can you prevent a traumatic brain injury?  
1. **Wear a seatbelt!**  
   A person not wearing a seatbelt is 8.4 times more likely to sustain a traumatic brain injury with loss of consciousness in a car wreck.

   The average hospital bill for an unbelted person in an auto accident is $2,400; for the individual wearing a seatbelt, it is $753. Hospital stays following an auto accident are 2.6 times longer for unbeltsed people. (Peterson, 1989)

2. **Don’t mix alcohol and driving.**  
   50% of motor vehicle crash fatalities involve alcohol. 37% of fatally injured drivers were intoxicated at the time of their crash. (Polen, 1988)

3. **Wear a helmet when you are bicycling.**  
   A properly fitted helmet reduces the risk by 85% of having a head injury if you happen to fall off of your bike. (Thompson, 1989)
TBI Resources

Web Publications

Brain Injury - A Guide for Families and Friends
www.vh.org/adult/patient/neurosurgery/braininjury/index.html
By: The Univ of Iowa Hospitals and Clinics Rev. July, 2000
A booklet with basic information about brain injury and its treatment, including: How the brain works; What happens with brain injury; Types of brain injury; What increases intracranial pressure; and How brain injuries evaluated?

Catalogue of Education Resources
www.braininjurybooks.com/
The Brain Injury Association of America has many publications offering up-to-date information
This web site has links to specific publications to learn more about them. For a Free Print Copy call: HDI Publishers 800-321-7037

What is a Brain Injury?
www.biausa.org/Pages/What%20is%20Brain%20Injury.html
Select topics on causes, types, consequences, definitions, facts & stats or brain maps.

Listing of State Brain Injury Associations
www.biausa.org/Pages/state%20contacts.html

Print Materials

by D. M.A. Gronwall, Philip Wrightson, Peter Waddel
A readable, informative book that uses real life examples to provide solutions and strategies to dealing with head injury.

Daño cerebral: Guía para familiares y cuidadores
By: José León-Carrión 1994
A Spanish guide for people with brain injury, their families and caregivers. Covers: Intensive care; Mechanics of Brain Injury; Coma; Consequences of Brain Injury; Mental and Emotional Symptoms; Sexuality; Social life; and Return to Work/Studies. 158 pages, $15.00 Item# IDANO
Phone: 703-236-6000 Fax: 703-236-6001

Statistical Information

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Injury Control Research Center
www.uab.edu/icrc

References


81% of people admitted to the NICU with head injuries following an automobile crash were not using seatbelts.
Use your seat belt!

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