A framework for describing physical and psychological trauma and stress as a cause of disease

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Accelerated Cure Project, Inc.

Multiple sclerosis is a chronic inflammatory demyelinating disease of the central nervous system that is most commonly diagnosed in early adulthood, although earlier or later onset is also possible. The causes/triggers of MS are unknown, but it is believed that both genetic and environmental factors are involved in the disease.

The goal of the Accelerated Cure Project is to determine the causes of MS as the most direct route to developing a cure for this disease. One of our major efforts is the systematic analysis of medical literature into the five root causes of disease – genetics, pathogens, toxic agents, nutrition, and trauma – as they pertain to MS. This effort is called the Cure Map.

The purpose of this document, which constitutes Phase 1 of the Trauma track of our Cure Map, is to organize the characteristics of physical and psychological trauma and their adverse effects on health into a logical framework. This framework is used in Phase 2 of the Trauma track in which we analyze past studies exploring whether trauma can increase the risk of MS, and identify areas that require further study.

For the sake of clarity, we have treated physical and psychological trauma separately in this document. However, it should be noted that events that are physically traumatic are often psychologically traumatic as well, and that any association between trauma and MS may have both physical and psychological components.

I. Physical Trauma

Physical trauma refers to harm inflicted on the body by an injury, which is defined by the World Health Organization as "a suspected bodily lesion resulting from acute overexposure to energy (mechanical, thermal, electrical, chemical, radiant) interacting with the body in amounts or rates that exceed the threshold of physiological tolerance."

A number of characteristics influence the chance that someone will experience physical injury and the nature and severity of the resulting adverse effects. The following sections discuss five key characteristics of physical trauma and its effects:

- Mechanism of injury
- Activity and intent
- Location at time of injury
- Severity
- Location and extent of damage

Mechanism of injury

There are several ways by which trauma can be inflicted on a living being. These can be grouped into two categories:

- Transfer of energy
- Physical interference with normal bodily functions

Trauma can also allow secondary damage mechanisms to take place. For example, an animal bite (penetrating trauma) can lead to infection (e.g., rabies) or toxicity (e.g., snake venom). These are not dealt with in this document but are addressed in other Cure Map tracks.

TRANSFER OF ENERGY

Energy is the ability to do work. According to the principle of conservation of energy, energy can neither be created or destroyed – it can only be changed from one form to another. Injury can be caused when energy is transferred from another entity to a human being in a manner that exceeds the threshold of human tolerance.

Kinetic energy

Kinetic energy involves the transfer of energy from one moving object to another with which it comes into physical contact. Three kinds of trauma are caused by kinetic energy: penetrating trauma, blunt trauma, and mechanical stress. These may occur together in a single incident – for instance, someone may sustain both penetrating and blunt trauma in a motor vehicle accident.

Penetrating trauma: When objects such as bullets, projectiles, and knives collide with tissues and organs, the amount of kinetic energy they once possessed is absorbed by the body. In penetrating trauma, a large amount of force and energy is applied to a relatively small area, inflicting much damage upon one particular part of the human

body. In this type of trauma, the penetrating object inflicts an open wound as it passes through the skin and causes direct injury to underlying structures. Types of penetrating trauma include gunshots, stabbing, piercing, cutting, surgery, and animal bites.

Various types of damage can result from a penetrating wound, including:

- Hemorrhage, including arterial/venous bleeding
- Damage to the skin and subdermal tissues, including abrasions, contusions, hematomas, and lacerations
- Bone fractures, which may also involve blood vessels and surrounding tissues and which may be open or closed; fractures typically account for more than half of all hospitalizations for trauma
- Injuries to vital internal organs

In addition to the injury initially inflicted on the body, penetrating trauma also carries the risk of subsequent infection due to penetration of the skin and other tissues within the body.

Blunt trauma: In contrast to penetrating trauma, blunt trauma is characterized by the dispersal of energy over a larger surface area. Energy is exchanged between an outside object and the human body without intrusion through the skin, injuring the underlying structures through crushing, shearing, and stretching.

Common causes of blunt trauma include falls (which frequently cause head injuries in children and fractures in adults) and collisions, including motor vehicle accidents, pedestrian vs. automobile accidents, and collisions with animals, other human beings, or inanimate objects. Blunt trauma can also involve compression of tissues and organs, such as through improper seatbelt positioning.

Although impact with a physical object is often responsible for blunt trauma injuries, blunt trauma can also be caused by overpressurization waves, such as those produced by the explosion of a bomb. These waves can affect gas-filled organs such as the lung, ear, and abdomen.

The types of damage caused by blunt trauma include contusions, hematomas, ruptures, abrasions, hemorrhages, fractures, and dislocations of long bones or other structures from their normal anatomical location.

Mechanical stress: Some injuries are caused when certain parts of the body are used beyond their capacity, or are twisted, rolled, or otherwise stretched beyond the physical limits of the human body. Such injuries include physical overexertion, sprains (stretching and tearing of ligaments), dislocations of joints, and strains (pulling or spasm of muscles).

Thermal energy

Humans are homeothermic. Our physiology functions optimally within a narrow range of core temperatures. Any deviation from this range of temperatures could lead to organ and tissue failure.

The thermal energy of a substance is produced by the movement of its molecules, and this energy can be transferred from one entity to another via conduction (transfer of heat via direct contact), convection (transfer of heat via flow of liquids or gases), or radiation (transfer of heat in the form of electromagnetic waves).

Heat: Heat-related injuries occur when thermal energy is transferred from a hot substance to a person. These injuries may involve direct contact with fire or a hot object, including contact with hot liquid, steam, or grease resulting in scalding. They may also involve heat stress, which is internal overheating due to failure of the body's thermal regulation systems. Heat stress is often associated with exertion and is brought on by exposure to high temperatures and/or the sun, coupled with inadequate access to water leading to dehydration.

Cold: Just as the human body is intolerant of extreme heat, it is intolerant of extreme cold as well. In cold environments, heat transfers from the body to its surroundings. If too much heat is transferred, tissues and organs can be damaged, in some cases permanently. Damage due to cold can involve freezing of tissue, as in frostbite which refers to local freezing of tissues resulting in ice crystal formation within extracellular space. However, nonfreezing cold injury due to repeated long-term exposure is also possible, as in the case of trenchfoot which is caused by prolonged exposure to cold water at near-freezing temperatures. While skin generally bears the initial brunt of cold exposure, other tissues can be damaged by exposure to cold, including muscles, blood vessels (damage to which may result in gangrene) and peripheral nerves (peripheral myelin sheaths are particularly cold-sensitive).

Chemical energy

Chemical energy is the energy stored in molecular bonds. When bonds are broken or created, a chemical reaction takes place, and heat is either released or absorbed. Thus chemical energy may cause injury through mechanisms very similar to those found in heat-related trauma. However, chemical energy can also cause damage to the victim's skin via chemical reactions with components of skin cells. Consequently, when skin is exposed to certain chemicals, its keratinous covering can be destroyed and its underlying dermal tissues exposed to a continual necrotizing action. Examples of chemical agents that can cause direct damage to skin and other tissues through contact include alkalis (particularly harmful to eyes), acids, and hydrocarbons.

For more information on the toxic effects of chemical agents, please see the Cure Map documents on toxic agents.

Electrical energy

Electrical energy is produced by the movement of electrically charged particles. When electrons flow from one atom to another, a current of electricity is created. Electrical current can cause damage to the human body by employing the body as a conductor, thereby transferring electrical energy to and through cells and tissues. This transfer of electrical energy can have several harmful effects, including the depolarization of cells such as muscle cells and neurons, creation of thermal energy via resistance causing electrical burns, and formation of pores in cellular membranes. These effects can result in the destruction of tissue as well as the disruption of electrical signals and rhythms in the heart and nervous system. Electrocution can result in loss of consciousness,

seizures, and cardiac arrest. It can also result in secondary mechanical injury with trauma resulting from falls or violent muscle contraction.

The effect that an electrical shock will have upon a person depends on many factors, including characteristics of the shock itself. For example, contact with direct current often causes a strong muscle spasm that throws the victim away from the source, whereas contact with alternating current may cause the victim to hold on to the source, prolonging the exposure. Voltage and current also influence the type and degree of damage inflicted, and the path that the current takes through the body determines the tissues and organs that are directly affected.

Electrical injuries can result from direct contact with a source of electricity, such as contact with exposed electrical wiring. Indirect contact can also occur when an electrical arc is formed between a person and a high-voltage source. The temperatures of such an arc are extremely high, and can cause very deep thermal burns.

Radiation

Radiation is any form of energy that is propagated through a medium. Radiation is transmitted in the form of rays, waves, or particles, such as alpha and beta particles and neutrons. Some forms of radiation have enough energy to ionize (remove an electron from) an atom or molecule and can therefore cause a great deal of damage to molecules such as DNA. Non-ionizing radiation has only enough energy to excite electrons to a higher energetic state, but this can still cause considerable damage to biological tissues.

Traumatic effects of radiation may be localized, affecting only a small part of the human body, or whole-body, affecting multiple organs and systems. Localized injuries result from local exposure to low-energy radiation, and symptoms include erythema (redness) of the skin and depilation (loss of hair). On the other hand, whole-body exposures involve the absorption of a much larger amount of energy. While effects depend on the type and dose of radiation absorbed by the tissues, general symptoms include nausea and vomiting. Whole-body exposure to radiation has its greatest impacts on the hematopoietic, gastrointestinal, cardiovascular, and central nervous systems.

The two sub-categories of radiation are electromagnetic energy and particle (nuclear) energy.

Electromagnetic energy: Electromagnetic waves consist of oscillating electric and magnetic fields that can propagate through space from one region to the next. The energy possessed by an electromagnetic wave is directly proportional to the wave's frequency, defined as the number of oscillations per unit of time.

The electromagnetic spectrum ranges from extremely low frequency radiowaves and visible light to high-frequency x-rays and gamma rays. Low-frequency electromagnetic waves cause non-ionizing damage, i.e., they have enough energy to cause atoms in a molecule to vibrate, but not enough to ionize an electron. When these waves strike the human body, energy is expended as heat, potentially resulting in thermal damage to the cells and tissues. On the other hand, high-frequency electromagnetic waves can cause ionizing damage. Atoms struck by ionizing radiation will lose electrons, resulting in the creation of highly unstable ions called free radicals. Free radicals are highly toxic and will

react with various biologic molecules, causing widespread damage at the cellular level (including damage to the phospholipid membrane and DNA). (For more information on toxicity effects of radiation, please see the Cure Map documents in the Toxic Agents track.)

Examples of electromagnetic rays that can have physiological effects include:

- Ultraviolet rays: UV rays are electromagnetic waves with wavelengths of 10-380nm that lie between visible light and x-rays in the electromagnetic spectrum. UV rays are emitted by the sun, and can cause cellular damage. They can accelerate the aging of the skin by disrupting collagen fibers and, if they have enough energy, can also ionize DNA molecules, resulting in a greater susceptibility to cancer. UV rays can also cause damage to eyes, as can even visible spectrum rays (e.g., blue light with 400-500 nm wavelengths).

- X-rays: X-rays are high-frequency electromagnetic waves with wavelengths of approximately 0.01–10nm. They are produced by energy transitions of accelerating and decelerating electrons. X-rays are frequently used in medical diagnostic tools, but are a form of ionizing radiation and therefore are particularly hazardous to human health. X-rays may cause burns, genetic mutations, and cancer.

- Gamma rays: Gamma rays are extremely high-frequency electromagnetic waves that are very similar to x-rays. However, they are produced not by electron transitions, but by nuclear ones. Gamma rays can be produced by radioactive decay and by such dramatic events as supernova explosions and the destruction of atoms. Gamma rays possess large amounts of energy and can penetrate very deeply into human tissue. Like x-rays, gamma rays can also cause burns, genetic mutations, and cancer.

Particle energy: The protons and neutrons (collectively called nucleons) of an atom's nucleus are bound together by a type of energy called *binding energy*. Unstable atoms will decay to form other, more stable atoms by emitting particles, such as alpha particles, beta particles, and neutrons. When these particles hit the human body, their energy is transferred to biological molecules. Molecular bonds are broken, ions are created, chemical compositions are changed, and widespread damage can ensue.

- Alpha particles consist of two protons and two neutrons bound together and are emitted in a process called alpha decay. When an atom undergoes alpha decay, an alpha particle is ejected from the nucleus creating a new atom with new atomic and mass numbers. Alpha particles are not high-energy particles and can travel only a few tenths or hundredths of a millimeter through solids before being brought to rest by the collision. Consequently, they cause minimal penetration and damage to the human body, unless ingested or inhaled. If they do enter the human body, alpha particles are the most ionizing of all radiation types, and therefore are particularly hazardous to human health. This type of harm is posed by radon, for example, a gaseous radioactive element that emits alpha particles.

- Beta particles are high-energy electrons emitted by radioactive nuclei in a process known as beta decay. The energy possessed by a beta particle, while larger than that of an alpha particle, is still not enough to cause deep penetration into human tissue. Like alpha particles, beta particles penetrate minimally into human skin and cause major damage only when ingested or inhaled.

- Neutrons can be released as a result of various nuclear reactions, including nuclear fission and fusion. Although neutrons do not possess a charge, they can still ionize atoms that absorb them. In addition, their lack of a charge allows them to penetrate more deeply into tissue than alpha or beta particles.

Acoustic waves and ultrasound

Exposure to sound pressure waves can also cause trauma. Hearing loss and related symptoms such as tinnitus (ringing in the ears) can result from exposure to loud noises – either sudden loud blasts/explosions, which cause acoustic trauma, or repeated or prolonged exposure to elevated noise levels, which causes noise-induced hearing loss. Loud noises (85 decibels and over) impair hearing by damaging sensory receptors in the inner ear called hair cells. The excessive shearing forces that loud noises inflict on hair cells can disrupt the cells' metabolism and even lead to cell death. Noise-induced hearing loss and acoustic trauma are occupational hazards of certain jobs, but they can also result from listening to loud music, using power tools, and other activities.

Ultrasound pressures (those with a frequency of over 20 kilohertz, higher than the range of human hearing) can heat and/or create pockets of gas in soft tissues. Ultrasound is used in a variety of diagnostic and therapeutic applications. These uses are considered to be generally safe when conducted properly, although research demonstrating developmental abnormalities in fetal mice exposed to ultrasound has led to cautions against non-medically necessary use of ultrasound during pregnancy[1].

PHYSICAL INTERFERENCE WITH VITAL BODILY FUNCTIONS

Vital functions necessary for life, including breathing and blood circulation, may be restricted via various mechanisms of injury.

Asphyxiation/suffocation

Interference with breathing and inadequate intake of oxygen (asphyxiation) can lead to loss of consciousness, and can cause brain damage or even death if prolonged. Traumatic mechanisms associated with asphyxiation include:

- Choking on food or other foreign objects
- Drowning due to inhalation of water that interferes with breathing and results in oxygen deficit
- Smothering (physical interference with access to air by the mouth or nostrils)
- Strangulation, or constriction of the airway
- Compressive asphyxia, or compression of the chest in a way that limits lung expansion

Asphyxiation can also result from being in situations where environmental oxygen is inadequate (e.g., in coal mines) or from seizures, drug overdoses, and other events.

Restriction of blood flow

Cutting off the blood flow to a body part, such as through the use of a tourniquet, will result in local hypoxia (lack of oxygen) and may eventually lead to necrosis or tissue death.

Insertion of foreign body
Traumatic injury can also be caused by the insertion of foreign objects in the ear, nose, mouth, rectum, or other orifice, thereby interfering with breathing, swallowing, urination, hearing, etc. Examples of foreign objects used in this manner include food, toys, insects, and buttons. This type of injury is usually prevalent in children, who stick things into their ears, noses, and mouths out of curiosity, boredom, or imitation of their peers. However, adults also are subject to this type of injury, such as through the insertion of foreign objects into the rectum for sexual pleasure.

Activity and intent

Certain activities carry a higher risk of trauma than others, and are sometimes associated with specific types of injury. The intent toward causing injury can vary among activities – in some, traumatic injury is an unintentional outcome of the activity whereas in others, it is intentional. Several activities that are associated with risk of trauma are described below along with the types of injuries that may occur during these activities and whether these are likely to be intentional or unintentional.

SPORTS/LEISURE ACTIVITIES – usually unintentional
Injuries are often sustained by people when participating in athletic activities, including both organized and unorganized sports. Recreational activities such as camping, fishing, hiking, and swimming can also lead to accidents and physical trauma such as:

- Heat stress: sports and outdoor activities are a common cause of heat exhaustion or other heat illness due to dehydration
- Blunt trauma: collisions can occur with another athlete or with goalposts, volleyball nets, the ground, etc.
- Penetrating trauma: risks include being poked in the eye with a stick, wild animal bites, etc.
- Mechanical stress: tearing of ligaments/tendons, stress fractures, sprains, and strains are often seen as a result of overuse
- Drowning: swimmers and boaters can drown as a result of inexperience, accidents, or hazardous swimming conditions

OCCUPATION – generally unintentional except in the case of workplace violence
Occupational injury is defined by the US Department of Labor as “any injury such as a cut, fracture, sprain, amputation, etc. which results from a work-related event or from a single instantaneous exposure in the work environment.” Although all jobs have at least a small potential for injury, some jobs are quite risky (see Appendix A for charts of occupational injury and fatality risk by industry and occupation). Common mechanisms of work-related fatalities are highway accidents (motor vehicle crashes), falls, and homicides.

Mechanical/kinetic energy injuries
This category includes transportation-related incidents, assaults and violent acts, contact with objects and equipment, and falls. Transportation jobs (e.g., truck driving), construction work, farming, and other forms of manual labor are often associated with these types of injuries.

Noise-related hearing loss
Certain occupations are associated with exposures to higher noise levels, including firefighters, factory workers, construction workers, musicians, and farmers.

Thermal injuries
Firefighters and chefs are at an increased risk of burns while foundry workers, construction workers, professional athletes, and others who work, play or practice in hot conditions may experience heat stress.

Chemical injuries
Certain occupations such as laboratory workers, industrial workers, and farmers are associated with an increased risk of injury due to contact with chemical toxins.

Electrical injuries
Electrocution is a leading cause of occupational traumatic death in the US, and is a particular risk for electricians, utility workers, and construction workers, although other occupations such as farming also present a risk for this type of injury. Contact with power lines is the most common cause of electrocution, followed by accidents involving electrical tools and machines.

Radiation injuries
Radiation injuries/illnesses can come about through exposure to or contamination by radiation as a result of medical, industrial, and laboratory accidents. Categories of workers that may face increased exposure to radiation include nuclear industry workers, airline employees (higher exposure to cosmic radiation), medical/dental professionals, and uranium miners (increased radon exposure). However, increasing recognition of the dangers of radiation have led to strict regulations being put in place to help protect workers so that they experience only low levels of radiation exposure. Increased exposure to ultraviolet rays is another occupational risk factor and is common among workers who spend their time outdoors (e.g., gardeners and postal carriers).

EDUCATION – unintentional or intentional
Accidents, particularly on playgrounds (e.g., falling off monkey bars) are a common source of traumatic injury in school settings. School violence is another source of injury and encompasses fighting, bullying, shootings, etc. Victims of school violence are most often students, but can include teachers and other staff as well as visitors. According to the National Center for Chronic Disease Prevention and Health Promotion, boys are over 50% more likely than girls to be threatened or injured with a weapon at school[2].

TRANSPORTATION/TRAVELING - unintentional
Transportation is an important cause of injury requiring hospitalization and treatment in the emergency department.

Motor vehicle accidents
Motor vehicle collisions often result in blunt trauma as well as chemical injuries due to contact with gasoline. According to the National Highway Traffic Safety Administration's (NHTSA) Traffic Safety Annual Assessment[a], in 2005 close to 2.5 million passenger vehicle occupants were injured in traffic accidents, and 31,549 were killed.

Factors that contribute to the risk of motor vehicle accidents include the age, gender and experience level of the driver, use of alcohol, and travel conditions. Other factors such as the use or nonuse of seatbelts can influence the severity of the resulting injuries. For instance, the NHTSA's Traffic Safety Annual Assessment for 2001[b] reported that in crashes involving injuries, 70% of unrestrained occupants were injured compared with 52% of restrained occupants, and in crashes involving fatalities, 56% of unrestrained occupants compared with 27% of restrained occupants were killed.

Bicycle accidents
Data from the Consumer Product Safety Commission's National Electronic Injury Surveillance System[c] indicates that in 2005, bicycle use resulted in nearly 500,000 injuries requiring a hospital visit. Also in that year, according to the NHTSA's Traffic Safety Annual Assessment, 784 cyclists died in accidents involving motor vehicle collisions. The most common cause of long-term disability and death in bicycle accidents is head injury.

Aviation accidents
According to the Bureau of Transportation Statistics[3], 636 fatalities and 304 serious injuries resulted from commercial or general aviation accidents in 2004, most occurring in general aviation. Pilot error and mechanical failure/maintenance issues are commonly cited as causes of aircraft accidents.

Boating/water accidents
In 2005, 697 boating-related fatalities and 3,451 injuries requiring medical attention were reported to the US Coast Guard[d]. Most of the fatalities (70%) were due to drowning, and in most of these cases, the victims were not wearing flotation devices. Broken bones, contusions and lacerations were frequently reported types of injuries. Operator error, alcohol use, and hazardous waters are common contributing factors to boating accidents.

WARFARE/TERRORISM – intentional
Involvement in war, terrorism, or similar forms of conflict, either as a combatant or a civilian/noncombatant, puts a person at risk of serious bodily injury or death by a number of different means. These include, but are not limited to:

- Penetrating wounds (gunshot wounds and stab wounds)
- Blunt trauma, e.g., through bomb explosions
- Rape, often used as a strategy of war; examples include Korea in WWII, Bangladesh, Algeria, Rwanda

[a] http://www-nrd.nhtsa.dot.gov/pubs/810639.pdf
[b] http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/Rpts/2002/Assess01.pdf
[c] http://www.cpsc.gov/library/neiss.html
[d] http://www.uscgboating.org/statistics/Boating_Statistics_2005.pdf

- Exposure to radiation, e.g., through detonation of nuclear weapons (as in Hiroshima and Nagasaki in World War II)
- Exposure to chemical agents like blistering agents (mustard gas), white phosphorus, choking and nerve agents, and cyanide

ACTS OF VIOLENCE – intentional
This category includes victims of violent actions, such as homicides, assault, and gang shootings.

Homicides/suicides
Suicide: According to the National Center for Health Statistics, in 2004 over 31,000 Americans took their own lives[4]. There are three levels of severity of suicide. Fatal suicidal behavior results in death, while attempted suicide is non-fatal, but may cause long-term physical and emotional disability and impairment. Finally, suicide ideation encompasses thoughts of killing oneself. Common mechanisms of suicide include firearms, suffocation, and strangulation.

Homicide: FBI statistics reveal that 16,692 murders and nonnegligent homicides were committed in the US in the year 2005[e]. 79% of murder victims were male, and 73% of homicides involved the use of handguns. Most homicides were committed by someone known to the victim; in only 25% of the cases where identities were known was the perpetrator a stranger.

Sexual assault
Sexual assault has a profound impact on the physical and mental well-being of millions of women and men around the world. While sexual assault may lead to physical injury to some extent, and even death, the predominant trauma suffered by the victim is emotional and psychological in nature. Physical injuries to the genitalia are minor for the most part, and include vaginal bleeding and infection, genital irritation, urinary tract infection, and chronic pelvis pain. Non-genital injuries include abrasions and contusions to the head, neck, and upper extremities. Pregnancy and the transmission of life-threatening sexually-transmitted diseases such as HIV are two further consequences of sexual assault.

Domestic violence
Child abuse: Child abuse is the mistreatment of a child by his or her parents, guardians, or other caretakers, compromising his or her health, survival, development, and/or dignity. It encompasses both physical and emotional abuse, as well as sexual assault, neglect, and exploitation.
- Physical abuse involves the infliction of physical pain or injury to the child by a responsible adult.
- Emotional abuse encompasses the failure on the part of the child's caretakers to provide a supportive and nurturing environment (this is discussed further in the Psychological Trauma section below).
- Sexual assault is the involvement of a child in sexual activity that he or she does not fully comprehend, and therefore, is unable to give informed consent to.

[e] http://www.fbi.gov/ucr/05cius/data/table_01.html

- Neglect occurs when the child's caretaker fails to meet his or her needs for medical care, nutrition, supervision, cognitive stimulation, emotional nurture, and physical care-taking when the resources are readily available. A common manifestation of neglect is the inadequate supervision of the child by a parent, leading to drowning, contact burns, or other household accidents.
- Exploitation involves the coercion of a child to work or take part in other activities for the benefit of others, such as child labor.

The US National Child Abuse and Neglect Data System (NCANDS) estimated that in 2004, 1,490 children died due to abuse and neglect, and reported that 872,000 children were determined to be victims of child abuse or neglect[5]. (These numbers are likely to be underestimates since many cases of abuse are not reported and not all fatalities are appropriately attributed to abuse.) There are risk factors for child abuse at both the individual and societal levels. Individual-level factors include the sex and age of the victim, as well as the family structure and personal characteristics of the perpetrator. On the societal level, the risk of being abused as a child is dependent upon socio-economic inequalities, the social welfare system, and larger social conflicts, such as war.

Elder abuse: According to the World Health Organization, elder abuse is "a single or repeated act, or lack of appropriate action, occurring within any relationship where there is an expectation of trusts which causes harm or distress to an older person." There are three main categories of elder abuse—domestic abuse, institutional abuse, and self-neglect or self-abuse. Domestic abuse occurs at the home of the elder or the caregiver, and is perpetrated by a family member or caregiver. Institutional abuse, on the other hand, occurs at a residential facility for the elderly, and those who are responsible are people with a legal or contractual obligation to provide care for the elders. Finally, self-neglect and self-abuse are the result of behaviors conducted by the elderly person, threatening his or her own health and safety.

A number of risk factors are associated with elder abuse. Elder abuse is most prevalent in familial conditions in which the perpetrator lives with the abused elder, as well as in families that are socially isolated from the rest of the community. People who suffer from high levels of stress, who have grown up in households with a high prevalence of domestic violence, or who are financially or otherwise dependent on the victim are more likely to inflict abuse upon the elderly.

Intimate partner violence and abuse: Intimate partner violence and abuse is defined as a pattern of assaultive and coercive behaviors, including physical, sexual, psychological, and economic abuse. The US Bureau of Justice has reported that 84% of spouse abuse victims and 86% of victims of violence between boyfriends and girlfriends between 1998 and 2002 were female[6]. However, other studies report that the prevalence of violence to males and females is similar. Differences among survey methodologies are thought to underlie discrepancies among gender prevalence findings.

Physical injury, emotional injury, and sexual coercion are all possible types of intimate partner violence and abuse, and usually coexist with each other. Acts of physical aggression include slapping, kicking, and beating. The most common sites of physical injury are the head, face, neck, and areas that are usually covered by clothing. If sexual

coercion is involved, common physical injuries may include vaginal infections, pelvic inflammatory disease, chronic pelvic pain, and urinary tract infections.

In general, victims of intimate partner violence and abuse endure long-term ill-health effects, including an increased tendency to use alcohol and drugs and a decreased tendency to exercise. They are also at increased risk of depression, suicide attempts, chronic pain syndromes, gastrointestinal disorders, irritable bowel syndrome, and various reproductive health consequences.

Gangs and youth violence
In response to the stresses of society, inner-city adolescents from similar socioeconomic backgrounds often band together in gangs, providing for each other a sense of belonging, protection, status, and adventure. Members of a gang are willing to die, to kill rival gang members, to risk imprisonment, and to harm innocent bystanders in defending their turf and proving their supremacy over other gangs. Violence is a common characteristic of street gangs, involving anything from fistfights and stabbings with knives, to the use of blunt force weapons and drive-by shootings.

OTHER ACTIVITY – unintentional or intentional
This includes trauma that could occur to any given person in any given location. Some are the result of accidents that happen during normal day-to-day tasks (such as bathing or eating). Others result from being in the wrong place at the wrong time, such as being at the scene of a natural disaster.

Location at time of injury

Just as some activities are associated with risks of certain types of trauma, so too can specific locations present an elevated risk of injury of various types. Following are a few examples of locations where injuries often occur.

HOME – includes building and surrounding property
Typical injuries sustained in a home setting include mechanical injuries (falls, abuse/assault); thermal injuries (from cooking accidents, scalding with hot water, and fire); electrical injuries (particularly in the case of children); and drowning in a swimming pool or bathtub (a particular risk for very young children).

RESIDENTIAL INSTITUTION
Other types of residential settings present certain types of hazards. Residents of nursing homes are at high risk of falls due to age and infirmity. Prison inmates may become involved in fights or may be abused by staff.

MEDICAL SERVICE CENTER (hospital, medical center, etc.)
Causes/types of injuries that may occur in a medical setting include surgical accidents, problems with anesthesia delivery, improper care, or even rape (especially of female patients by male health care workers).

SCHOOL

As described above under Education, a variety of injuries may be experienced at school. Playground injuries are commonly experienced. School violence is another source of injury/death at school.

ATHLETIC/SPORTS AREA
Sports-related injuries such as sprains, strains, fractures, scrapes, and concussions are frequent occurrences at athletic facilities or related locations such as ski slopes. Drowning is a risk wherever a swimming pool is located. Heat trauma can also occur where people are exercising in hot locations.

STREET/HIGHWAY
Transportation-related accidents (motor vehicle accidents, auto vs. pedestrian accidents, bicycle accidents) generally occur on streets, highways, driveways, parking lots, etc. These typically involve blunt trauma.

INDUSTRIAL/CONSTRUCTION AREA
Types of trauma that may be encountered at industrial or work sites include electrical trauma, such as from contact with power lines; blunt trauma; chemical injuries where the work involves the use of harmful chemicals; radiation injuries; and others.

FARM
Agricultural workers face a variety of risks stemming from the use of power equipment (electrocution, blunt trauma), working with animals (blunt and penetrating trauma), being exposed to the elements (UV radiation, thermal trauma), and working in potentially hazardous situations such as in grain storage areas (suffocation, etc.).

WILDERNESS (nature, woods, water, mountains, countryside, etc.)
Wilderness sites present the opportunity for a number of different types of trauma to occur. These include, among others, penetrating or blunt trauma from animal encounters and falls, drowning from swimming or boating in open waters, and thermal trauma from exposure to extreme cold or heat.

BATTLEFIELDS/WAR ZONES
People who find themselves in battlefields or war zones, either intentionally or unintentionally, are at high risk for a number of injuries including penetrating trauma, blunt trauma, trauma resulting from blasts and explosions, etc.

Severity

The severity of an injury is an important determinant of resulting mortality and morbidity, and is partly determined by the amount of energy that is concentrated outside the band of human tolerance. Severity classification systems have been developed for several different forms of injury.

SEVERITY OF BURNS
Burns are classified into three severity levels based on the surface area involved and the depth of the damage:

Minor burn:

- No critical area or respiratory involvement
- Second degree burn affecting less than 15% of body surface
- Third degree burn affecting less than 2% of body surface

Moderate burn:

- First degree burn affecting 50-75% of body surface
- Second degree burn affecting 15-30% of body surface
- Third degree burn affecting 2-10% of body surface

Critical burn:

- Respiratory involvement
- Associated injuries or fractures
- Critical area involvement
- Second degree burn affecting more than 30% of body surface
- Third degree burn affecting more than 10% of body surface
- All electrical burns

First degree burns only affect the outer layer (epidermis) of skin; they cause redness, tenderness, and pain, but no blistering. Second degree burns affect the epidermis and, to some extent, the layer beneath the epidermis (dermis). They cause red and blanched white skin and blisters. Third degree burns cause damage to the full depth of the skin, with the capillary network of dermis completely destroyed. They result in white, black, or cherry red and leathery skin, and numbness. Finally, fourth degree burns result in full thickness destruction of skin and subcutaneous tissue, and involvement of underlying fascia, muscle, and bone. They are a result of prolonged exposure to third degree burns.

Factors affecting severity of burns:

The severity of a burn depends on the rate and manner in which heat is transferred from the external object to a person's skin and is influenced by:

- Heat capacity of agent: amount of heat necessary to change temperature of material by 1 degree Celsius
- Temperature of agent: initial temperature of material at instant of contact
- Duration of contact: varies depending on properties of the heat source and manner in which heat is applied to skin
- Transfer coefficient: ability to transfer heat between two different materials – burn injuries will only occur if a hot substance has the ability to transfer its heat to the skin
- Tissue conductivity: different tissues have different levels of conductivity; conductivity is influenced by water content, natural oils, and the presence of insulating material within the tissue

SEVERITY OF CHEMICAL INJURIES

The severity of injuries that result from the transfer of chemical energy is dependent on the specific chemical agent that comes into contact with the skin. Substances with different chemical compositions will cause different types and varying extents of damage. For example, alkalis cause a more serious degree of injury to ocular tissue

than do acids, because our eyes have a significant acid-buffering capability, but nothing of the sort for alkalis. Furthermore, the severity of damage is also determined in part by the concentration of the agent and the duration of its contact with the skin.

SEVERITY OF ELECTRICAL INJURIES

The degree of injury caused by the transfer of electrical energy is dependent on the voltage of the electricity source and the resistance of the tissues through which the current flows (which together determine the current strength). A more highly resistant tissue will transform more of the electrical energy to thermal energy, thus sustaining more thermal damage locally but limiting the effects on internal tissues. Resistance of skin to electrical current is greatly affected by whether it is wet or dry as well as other factors such as degree of callusing. Resistance to current flow inside the body depends on tissue type (the least resistant body tissues include nerves, blood, mucous membranes, and muscle, while the most resistant include tendon, fat, and bone).

Other factors affecting the severity of electrical injuries include duration of current flow, type of current (alternating vs. direct), and the particular path taken by the current through the body.

SEVERITY OF RADIATION INJURIES

The potential for biologic injury in encounters with radiation depends on the amount of energy transmitted by the particle/photon when it interacts with the target (called *linear energy transfer*). Severity also depends on the cell type, extent of cellular mass exposed, duration of exposure, and homogeneity of the radiation field.

Radiation dosimetry

Radiation dosimetry is the quantitative description of the effect of radiation on living tissue. Energy delivered to tissue per unit mass is called the *absorbed dose*, and has units of J/Kg, also called a Gray (Gy). A more commonly used unit is the rad, which is the equivalent of 0.01 Gy. The Gy is not an accurate description of the biological effect of radiation, however, because different kinds of radiation will cause different extents of biological damage even when they possess they same amount of energy. Hence, scientists have taken this variation into account by introducing the Relative Biological Effectiveness, or RBE. The RBE is a numerical factor unique to each specific type of radiation, and is multiplied by the absorbed dose to produce the biologically equivalent dose. The biologically equivalent dose has units of rem ("röntgen equivalent for man").

Exposure (rems)	Health Effect
5-10	Changes in blood chemistry
50	Nausea
55	Fatigue
70	Vomiting
75	Hair loss
90	Diarrhea
100	Hemorrhage
400	Death from fatal doses
1000	Destruction of intestinal lining
	Internal bleeding
	Death

2000	Damage to central nervous system Loss of consciousness Death

(Source: U.S. Environmental Protection Agency)

GENERAL SEVERITY SCORING

The goal of severity scoring systems is to accurately and quantitatively summarize the extent and severity of an injury. These systems are useful in predicting outcome (e.g., mortality) from trauma and can provide objective information for decision-making and resource allocation.

Physiologic scores

These scores are based on the physiological characteristics of the victim:

Glasgow Coma Score (GCS)

The GCS is often used to assess the severity of brain injury – mild, moderate, or severe. Scores range from 3 to 15, with 3 indicating the most severe damage and 15 indicating the least severe damage. The parameters employed to determine severity include eye response, verbal response, and motor response.

Trauma Score (TS)/Revised Trauma Score (RTS)

The TS combines the GCS score with data on systolic blood pressure, respiratory efforts and capillary refill. The RTS is derived from the TS, and takes into consideration the GCS score, systolic blood pressure, and respiratory rate.

Acute Physiology and Chronic Health Evaluation (APACHE)

The APACHE system encompasses two broad aspects when considering the severity of a traumatic injury. The “chronic health” portion incorporates major pre-existing illnesses and comorbidity, while the “physiology” section addresses weighted variables derived from the body’s principal systems (neurologic, cardiovascular, respiratory, renal, gastrointestinal, metabolic, hematologic) and measurements of laboratory values (pH, serum creatinine, hematocrit).

Systemic Inflammatory Response Syndrome Scores (SIRS)

The SIRS is a simple additive function of patient’s temperature, heart rate, respiratory rate, and white blood cell count. Despite its simplicity of calculation, it reliably predicts mortality and hospital length of stay in traumatic patients.

Anatomical scores

These scores are based on anatomic sites of injury.

Abbreviated Injury Scale (AIS)

The AIS is a scale of 1-6 that characterizes the injury to a single body region: 1 = minor; 2 = moderate; 3 = serious; 4 = severe; 5 = critical; 6 = unsurvivable.

Injury Severity Scale (ISS)

The ISS provides an overall score for patients with multiple injuries. It takes the three highest AIS scores from among six body regions (head and neck; face; chest; abdominal and pelvic contents; extremities and pelvic girdle; and external), squares them, and then

adds the squares together. Possible values in the ISS are between 0 and 75. A 6 on the AIS for any injury correlates with an automatic 75 on the ISS. The ISS correlates linearly with mortality, morbidity, hospital stay, and other measures of severity. Recently a revised version of the ISS (new ISS, or NISS) was introduced that takes into account the three most severe injuries independent of body region. This version may be even predictive of outcome than the ISS.

Combined scoring systems
These systems attempt to improve upon accuracy by taking into account both physiological and anatomical characteristics of the injury.

Trauma and Injury Severity Score (TRISS)
TRISS determines the probability of survival of a patient from his/her combined ISS and RTS scores using a certain algorithm that also takes into consideration the patient's age and the mechanism of injury (blunt vs. penetrating). Over the years, however, the TRISS has not demonstrated reliable accuracy.

A Severity Characterization of Trauma (ASCOT)
The ASCOT was originally introduced to overcome the criticisms of the TRISS methodology and calculates the probability of survival of a trauma patient by looking at the mechanism of injury, the victim's age, and his or her AIS and RTS scores. It combines all of these parameters into a logistic regression. Patients with extreme RTS and AIS scores are excluded from regression analysis.

Location and extent of damage

Related to the severity of a traumatic injury are the location and extent of the damage sustained in that injury. Certain body parts and systems, when injured, need special types of care, are more urgent to treat than others, and may present more significant short- and long-term implications. An injury may affect only a single body part or multiple ones; in general, the fewer affected the better, although some organs are so critical that injuries can be immediately fatal (for example, severe head trauma or penetrating trauma to the heart).

INITIAL INJURY SITES
Any part of the body can be affected by a traumatic injury. Listed below are some body parts that are more commonly injured along with frequent causes of these injuries and typical outcomes and complications.

Head
The Centers for Disease Control and Prevention (CDC) estimates that 1.4 million Americans experience a traumatic brain injury each year[7], with the most common causes being falls, motor vehicle accidents, and being struck on the head. Although most head injuries needing medical treatment are considered mild, the CDC estimates that 50,000 Americans die from traumatic brain injury each year. Specific injuries resulting from blows to the head include hematomas, hemorrhage, axonal injury, and

ischemia. Penetrating trauma to the brain not only destroys brain tissue but also subsequently leads to swelling of brain tissue and infection.

Face (eyes, ears, nose, mouth) – maxillofacial trauma
Facial trauma in itself is seldom life threatening, but it is often associated with injuries or medical problems that require immediate attention, such as airway obstruction, head and cervical spine injury, and hemorrhage. Blunt trauma causes are common (fists/clubs, motor vehicle accidents), and the face is also particularly vulnerable to both burns and frostbite. Facial trauma can cause severe ocular, nasal, and jaw dysfunction, and may lead to significant cosmetic deformities if not adequately repaired.

Traumatic injuries to the eye can come from a number of sources, including exposure to chemicals, "pokes" to the eye, foreign bodies in the eye, blows to the face around the eye, and direct exposure to harmful UV rays. Consequences of these injuries may include irritation of eye membranes, abrasions and lacerations, ruptures, and bone fractures. Pain and visual disturbances are common symptoms of eye trauma. In severe cases, loss of vision can occur.

Injuries to the lips and tongue (lacerations, e.g., through self-inflicted bites) and teeth (e.g., broken, loosened or dislocated teeth) are frequently the result of athletic and recreational activities. Tissues inside the mouth can also sustain burns if excessively hot food or drink is ingested.

The nose is both centrally located and protruding from the face, and therefore is a common site of soft tissue and bone injuries. Ears can be damaged on the outside (e.g., with cuts and scrapes) as well as on the inside (e.g., through acoustic trauma or damage to the inner ear through insertion of foreign objects).

Neck
Because it contains vital airways, the spinal cord, and major blood vessels, and does not have a rigid protective layer, the neck is a prime site for critical injuries. The patterns of organ damage vary depending on the mechanism of damage. Penetrating trauma (e.g., knife wounds) can involve severe loss of blood and damage to the aerodigestive tract. Blunt trauma to the neck (e.g., through motor vehicle accidents) can injure vital air and circulatory pathways as well as damage the cervical spine. Strangulation is also a common cause of neck trauma.

Spinal cord and vertebrae
Spinal cord injuries are often life-threatening, and when non-fatal can result in significant physical and psychological deficits. They are most often caused by motor vehicle accidents, falls, violence, and sports (especially football, gymnastics, skiing, hang gliding, equestrian sports, and diving). The risk of spinal injury varies depending on age and anatomic region injured. Spinal injuries are particularly prevalent among the young, due to their level of activity, and the elderly, due to their increased risk of osteoporosis. The risk of spinal injuries in males compared with females is approximately 4:1.

Chest and lungs
Trauma to the thorax can cause a variety of injuries, some of them life-threatening because of their impact on the lungs. Broken ribs are often seen in blunt trauma to the

chest and can impair breathing ability. Injuries to blood vessels in the chest wall can result in hemorrhage, either inside or outside the pleura. Blood inside the pleural space not only has hemodynamic effects due to loss of blood, but also can have respiratory effects through limiting the lung's ability to expand. Pneumothorax, or entry of air into the pleural space, can result from punctures in the lung or open chest wounds, and can cause the lung to collapse. Secondary effects from chest trauma, such as pulmonary contusion and infections, can also contribute to pulmonary dysfunction.

Heart and great vessels
Penetrating wounds from weapons such as guns and knives are the most common means of traumatic injury to the heart and great vessels. These structures may also be inadvertently injured during medical procedures such as catheterization. In small wounds to the heart, the pericardial laceration may clot and seal, allowing blood to pool within the pericardium (tamponade) and impairing cardiac function. Larger wounds may lead to heavy blood loss and shock. Blunt trauma (e.g., from falls or car accidents) may affect the heart, with effects ranging from mild to fatal (as in the case of cardiac rupture). Great vessels can also be injured in blunt trauma situations, again with potentially fatal consequences.

Abdomen (includes liver, gallbladder, spleen, stomach, large/small intestine, kidneys)
Abdominal trauma often goes unrecognized, and when this happens, it is one of the major causes of death in trauma patients. However, if abdominal trauma is recognized early on in the treatment process, it rarely leads to mortality. Injuries to the abdomen are the second leading cause of preventable trauma deaths. They are usually caused by blunt trauma (compression, shearing, deceleration, motor vehicle accidents, seat belt injuries, pedestrian vs. auto injuries) or penetrating trauma (gunshot wounds, stab wounds).

- The **liver** is very prone to injury in blunt and penetrating trauma due to its size and location; contusions, lacerations, hematomas, vascular damage, and bile duct injuries are types of liver injuries that can be sustained.
- The **spleen** is another abdominal organ that is highly susceptible to traumatic injury; injury to the spleen can lead to uncontrolled internal bleeding, potentially fatal.
- The **stomach and small bowel** are more susceptible to penetrating wounds, particularly gunshot wounds, but can also be injured in blunt trauma. These organs can be contused or even perforated. In addition to damage to these organs themselves, additional harm can result from the release of gastric contents into the peritoneum.
- Injuries to the **duodenum and pancreas** are not as common as to the previously listed organs, but can have severe consequences, particularly if not detected during initial examinations.
- Most injuries to the **kidneys** are due to blunt trauma, but kidneys can also be damaged by penetrating trauma. Contusions from being forced against a rib or an object such as a seatbelt are fairly common, but lacerations and vascular injuries are also possible.

Rectum and colon
Injuries to the rectum and colon are most often caused by forms of penetrating trauma such as gunshot and stab wounds; blunt trauma (e.g., car accidents) and insertion of

foreign objects through the anus are other causes of injury. Blood loss and fecal contamination leading to infection and peritonitis are of particular concern in these injuries.

Pelvis and genitourinary organs
Pelvic fractures are a common outcome of motor vehicle accidents, falls, and other incidents involving blunt trauma. These fractures may be accompanied by injuries to nearby genitourinary organs (lacerations, hematomas, ruptured bladder) as well as blood loss. Other injuries to genitourinary organs include “straddle” injuries to the urethra, penile fracture, and penile amputation.

Reproductive organs
Trauma during pregnancy is fairly common and can involve injury to the uterus via gunshots, stabbing, falls, and so on. Trauma of this nature may affect not only the pregnant woman but also her fetus. For example, shearing forces inflicted by blunt trauma can separate the placenta from the uterus (placental abruption) with potentially fatal consequences for the fetus. In addition, childbirth itself is an inherently traumatic process; complications of childbirth include umbilical cord compression, genital tract tearing, or uterine rupture. In nonpregnant women, reproductive organ injury is less common because these organs are well-protected by the pelvis, but straddle injuries, perineal tearing, and penetrating trauma are all possible.

Extremities (upper/lower extremities, including orthopedic injuries)
Extremity injuries are rarely life threatening, but may threaten a limb or its function. They often occur in isolation but may also occur in conjunction with other injuries. Trauma to the extremities is usually a result of accidents (industrial, sports, etc.) and often affects young, otherwise healthy, individuals. Common types of injuries to the extremities include fractures, dislocations, sprains and muscle strains, burns, and frostbite.

SYSTEMIC EFFECTS AND COMPLICATIONS
Physically traumatic events frequently affect only a single body part (e.g., a broken finger, a concussion, or a sprained ankle). However, more serious injuries can involve multiple organs and systems. While some may resolve with treatment, others can lead to widespread effects throughout the body. Described here are some of the systemic effects and subsequent complications that can stem from traumatic incidents that are severe and/or involve multiple injuries.

Infection and sepsis
Infection is a common complication of traumatic injuries and can result from the disruption of external membranes (e.g., skin) or tearing of internal tissues (e.g., the colon). Whether a wound from a traumatic injury will become infected depends on a number of factors including the type of bacteria or other pathogen present and the nature of the injury. Particularly serious consequences of infection include gangrene and necrotizing fasciitis. The body's own response to infection may also be harmful. Activation of an inflammatory cascade, called systemic inflammatory response syndrome (SIRS), can lead to a form of shock termed septic shock (see below).

Shock
Shock occurs when the circulatory system is unable to provide adequate circulation to body tissues. The subsequent shortage of the delivery of oxygen and nutrients to tissues and cells results in systemic failure. Shock is a total body circulatory disturbance and induces a systemic response, as compared to other injuries, such as ischemia and reperfusion, which elicit a more localized response. Shock is characterized by profound changes to cardiovascular, neuroendocrine, and immunologic function, and if severe and untreated, will lead to multiple organ failure and death.

There are several forms of shock:

- In **hypovolemic shock**, the cardiovascular system loses large amounts of fluid, in the form of blood (internal or external hemorrhage), plasma (a result of severe burns), or interstitial fluid (due to dehydration from diarrhea, vomiting, or excessive sweating).
- **Cardiogenic shock** is characterized by a decreased cardiac output and an inability of the heart to pump blood effectively. Cardiogenic shock may result from a heart attack or other type of heart injury.
- **Vasogenic shock** is a result of decreased resistance within capacitance vessels. Muscular vessel walls relax and blood pools form in the veins. As a result of these physiological changes, blood returns to the heart at inadequate levels, leading to a loss of sympathetic tone, a pooling of blood in venous and capillary beds, and an increased vascular permeability. Such dilations of blood vessels may be caused by injury to the nervous system (e.g., spinal cord injury), pain, emotional stress, or body-wide infections.
- **Septic shock** is a state of shock resulting from the body's aggressive inflammatory response to a pathogen (discussed above).
- **Neurogenic shock** results when head trauma/spinal cord injury, spinal anesthesia, or vasomotor center depression causes vasodilation It leads to an impairment of nerve impulse transmission, a decrease in sympathetic rate, hypotension, bradycardia (slow heart rate), hypothermia, dry skin, and a decrease in vasomotor (relating to nerves and muscles that deal with blood vessel constriction) tone.
- **Anaphylactic shock** is a hypersensitivity reaction resulting from exposure to various offending substances, including, but not limited to food, bee venom, and drugs. It may also be triggered by severe allergic reactions. Anaphylactic shock causes the release of large amounts of histamine and other vasoactive amines, which are distributed throughout the circulatory system and cause vasodilation, increased capillary permeability, hypovolemia, and vascular collapse.
- **Traumatic shock** results from multiple soft tissue injuries and long-bone fractures and subsequent hypoperfusion, with effects amplified by activation of the immune system.

Acute respiratory distress syndrome (ARDS)
ARDS is an acute (sudden onset) life-threatening condition involving swelling and fluid build-up in the lungs. It can occur within hours of the initial trauma or up to several days later. Damage to the alveolar tissue is a prominent feature of the condition. The exact mechanism of damage is not well understood, but factors that appear to be involved

include neutrophils, complement, cytokines, and reactive oxygen radicals. ARDS is often associated with sepsis and can be the first event in multiple organ failure (see next paragraph).

Multiple organ failure (MOF)
MOF, or multiple organ dysfunction syndrome (MODS), is a progressive dysfunction of more than one organ system following sepsis and/or SIRS. Failure of a greater number of organs is associated with a higher risk of death. As mentioned above, respiratory failure is often the first symptom in MOF; heart failure, hepatic failure, renal failure, and other events may follow. Again, the sequence(s) of events that lead to MOF are not understood.

Epidemiology

Characteristics of the trauma victim affect his or her susceptibility to trauma and ability to recover from injuries. These factors include physical characteristics (age, gender, size, motor skills) and mental/behavioral characteristics (intelligence, fatigue, intoxication, risk-taking behavior, disposition, social morals, lifestyle).

AGE

Pediatrics
Injury is the leading cause of death among children, adolescents, and young adults. It is important to note that children are not simply small adults – significant differences in physiology, epidemiology, mechanisms of injury, patterns of organ involvement, and potential long-term effect on growth and development differentiate the consequences and effects of trauma in adults compared with children. A child's body is more compliant and may absorb considerable kinetic energy before internal damage is noticeable. Multiple injuries are also common in children. Head injuries are the leading cause of death from trauma, with chest and abdominal trauma ranked second. Special considerations that must be taken into account include:

- Size: Children are smaller than adults, and consequently are more prone to a wider range of injuries. For example, children are more likely to suffer from multiple-organ injuries due to the close proximity of their organs and tissues. They also have a raised center of gravity and a large head-to-body ratio, which accounts for the higher incidence of head injury among children.
- Connective tissue and skeletal structure: The connective tissue in children is more elastic, thereby allowing for more stretching and tearing. Similarly, a child's bones are less rigid and not fully calcified. As a result, children are able to withstand severe forces without breaking bones.
- Body fat and weight: Children are particularly susceptible to heat and cold-related traumas because their decreased percentage of body fat and larger surface area-to-body weight ratio predispose them to heat loss.
- Blood volume: The total circulating blood volume per unit of body weight in children is greater than an adult's by 25%; however, the total blood volume is

smaller. Consequently, while a given volume of blood loss may not result in a particularly severe injury in adults, it can have dire consequences for children.

- Chest wall: A child's chest wall is very resilient, thereby lowering the occurrence of rib fractures, sternal fractures, and flail chests among children. However, children are still at risk for the transmission of energy and damage to the lungs and heart.
- Abdomen: Children are more susceptible to intra-abdominal injuries. They have more elastic thoracic cavities and smaller muscle/adipose tissue mass. Furthermore, their diaphragms lie in a horizontal plane, exposing their livers and spleens and making them more prone to injury.

Geriatrics

Just as children are not simply "small adults," the elderly are not merely "old adults." Fundamental physiological and anatomical changes that arise as a result of old age set the elderly apart from their younger counterparts when the extent and severity of injuries are concerned. The physiological changes that occur as people age result in an increased vulnerability to serious physical injury. Older members of the community have a lower level of antibodies, and, consequently, a higher risk of infection. They also have a predisposition towards the reactivation of latent diseases, an increased risk of hypertension, and a decreased ability to respond to physiologic stressors. Furthermore, pre-existing medical conditions, such as muscle atrophy, difficulty with gait and coordination, degenerative joint disease, neuromuscular disorders, medication use, decreased cardiovascular reserve, and osteoporosis make it more likely for members of the elderly community to suffer from serious injury when trauma does occur.

The most common mechanisms for injury amongst the elderly are falls, being struck/colliding into another object, motor vehicle accidents, cuts or piercings, and over-exertion. Factors that may contribute to an increased risk of falling include sedative use, visual and cognitive impairment, a history of stroke, and arthritis. Cognitive impairment, decreased hearing and vision, and an increased reaction time are common risk factors for motor vehicle accidents, while alcohol use, excessive speeds, and reckless driving are not. While elderly women are more likely to suffer from falls, elderly men are at a greater risk for nearly every other mechanism of injury. The overwhelmingly most common location for injury among the elderly is the home.

GENDER

According to the CDC, in 2004 69% of injury deaths and 55% of nonfatal injuries (all causes) occurred within the male population[f]. Fatalities occurring in the occupational sector are also overwhelmingly more prevalent among males. In 2005, 46% of all workers in the United States were women, and yet only 7% of all occupational fatalities involved females[g]. These differences in injury risks likely reflect both biological differences as well as differing societal and cultural expectations for males and females.

PREGNANCY

Trauma is the leading cause of death among women of childbearing age, and is the causative factor in 20% of maternal deaths during pregnancy. Furthermore, the

[f] http://www.cdc.gov/ncipc/wisqars/

[g] http://www.bls.gov/iif/oshwc/cfoi/cfch0004.pdf

incidence of trauma during pregnancy increases with gestation, with more than half of all traumas sustained during pregnancy occurring during the third trimester. While the types of injuries that pregnant women incur are similar to those sustained by the rest of the population, pregnancy adds additional complications because of certain physiological changes and because of the existence of a second life that is hidden from view.

Leading causes of blunt trauma in pregnancy include falls and motor vehicle accidents. The pregnant woman's growing uterus disrupts her sense of balance and walk, increasing her risk of falling. Furthermore, the increase in abdominal size often makes wearing seatbelts uncomfortable, increasing the risk of serious injury during automobile accidents. Violent assault may also take place during pregnancy, with the attacker usually being the biological father or another male associate. Penetrating trauma, such as stabbing or gunshot wounds, is common in cases of assault.

Trauma also increases fetal loss rate, with poor fetal outcome strongly correlated with an increasing severity of maternal injury. The most serious injuries to the fetus include uterine rupture or placental separation from the uterus, both of which are almost always fatal. Premature labor may also result from trauma, and future complications, such as appendicitis in the mother and periventricular leukomalacia or cerebral palsy in the fetus, may ensue.

ALCOHOL AND DRUGS

Alcohol abuse is a leading risk factor for injury, particularly in motor vehicle accidents but also in falls, domestic violence, suicide, and assaults. Alcohol abuse increases the risk of death from serious injury and the likelihood of serious complications following non-fatal trauma. Excessive, chronic use of alcohol produces physiological changes that make the body far more susceptible to serious injury and death. Alcohol is a peripheral vasodilator (limits the ability to compensate for blood loss) and osmotic diuretic (inhibits the release of anti-diuretic hormone and results in inappropriate urine output). It impairs clot formation and leads to respiratory depression as well as a compromise of airways. Alcohol abuse may also exacerbate brain, spinal cord, and heart injuries, and may increase the likelihood of excessive hemorrhage and shock. Substance abuse also increases the incidence of infection, the reduction of bone mass, the propensity for fractures, and the occurrence of impaired bone healing.

OCCUPATION

As discussed above in "Activity and Intent," occupation plays a significant role in determining a person's risk for certain injuries because of the risks inherent in certain jobs.

PHYSICAL FITNESS AND HEALTH

Obesity has been shown to increase the risk of certain types of trauma, such as falls and overexertion, although findings on the effect of obesity on mortality are mixed. On the other side of the spectrum, people who regularly partake in physical activity are also at high risk for trauma. Injury is more common in athletes and in those who exercise at least once a week. People with pre-existing health conditions and co-morbidities may also be at higher risks for sustaining injuries and, once injured, tend to experience more frequent and serious complications and require longer hospitalizations.

GEOGRAPHY, CULTURE, AND RACE

The incidence and mechanism of injury differ widely across varying geographical regions, cultures, and societies. For instance, unintentional trauma is prevalent in rural areas, while homicides are frequent occurrences in urban environments and central cities.

The patterns of injury differ between cultures and races as well. For example, in the US, fatal injuries in children are more common in African-Americans and Native Americans than in Caucasians, Hispanics, and Asian-Americans[8]. Differences in living styles, values, and traditions predispose various groups of people to certain mechanisms and extents of injury.

II. Psychological Trauma and Stress

Psychological trauma refers to psychological damage resulting from an event such as a violent attack, natural disaster, or act of warfare, that overwhelms a person's ability to emotionally cope with the experience and/or causes the person to believe that his/her life is in danger. Psychological damage can also be caused by chronic exposure to a persistently stressful situation that threatens to cause harm to a person.

The effects of psychologically harmful events and situations depend on the event/situation itself as well as the individual who experiences it. Outcomes of exposure to traumatic events and stress can range from temporary and mild (e.g., short-term anxiety) to chronic and severe (e.g., chronic post-traumatic stress disorder). Psychological symptoms can also be accompanied by physiological changes, and thus can have far-reaching effects on a person's overall health.

In the following sections we discuss the following aspects of psychological trauma and stress:

- Nature of psychological stressor
- Risk factors for psychological trauma/stress
- Response to trauma/stressor
- Factors that influence response to stressor

Nature of psychological stressor

The characteristics of a particular stressful event or situation play a major role in determining the effect on a person who experiences it. Stressors that can cause significant psychological consequences can be classified in several different ways.

TYPE OF INCIDENT

Events or situations that can produce psychological symptoms and/or trauma include but are not limited to:

- Violence: rape/sexual assault, combat, being mugged/threatened with a weapon, being shot or stabbed, other forms of physical attack
- Accidents: car accidents, natural disasters, other accidents
- Sudden unexpected death of a loved one
- Serious illness
- Abandonment or neglect by others, particularly in vulnerable individuals such as the very young or very old
- Emotional abuse, which can involve name-calling, belittling, threatening, ridiculing, humiliation, and denigrating by a parent or other family member, an intimate partner, or a caregiver
- Chronic social stress from family tensions, difficulties in the work place, or financial strain.
- Daily hassles, which include the many of the minor stressors that are part of modern living, such as traffic jams, waiting in line, etc.

- Positive stress – stress arising from events that are generally viewed as positive, such as getting married, a job promotion, etc.

DIRECT VS. INDIRECT
The event that provokes a psychological effect in a person can either be one that directly affects that person (e.g., by physical harming him/her) or one in which that person learns about or witnesses harm to another person. Although direct experience may at first glance seem more harmful, witnessing harm can be particularly stressful to someone dependent on the victim for care, because it disrupts his/her sense of security. It is also generally more distressing when a person can identify with the victim or situation – e.g., the stress of viewing serious injury to children is more significant for people who have children than those who do not.

ACTUAL VS. THREATENED
Although psychological trauma can be triggered by a situation involving actual harm or loss, even threatened harm or loss can be enough to cause trauma.

ONE-TIME OR REPEATED
While one-time events such as natural disasters or single violent crimes can have significant impacts on those involved, repetitive trauma such as child abuse, domestic violence, and wartime experiences can have even more profound effects. For example, repetitive abuse in childhood can lead to dissociation (see below) as a coping mechanism.

SEVERITY OF EVENT/SITUATION
Any event that threatens a person's sense of well-being in a way that challenges or overwhelms his/her coping mechanisms can have a resulting psychological effect. Two factors that have been shown to be critical in a person's appraisal of a stressful life event are the level of perceived threat to the individual or to a valued goal, and the level of he person's perceived control over the event. Less severe events may not result in a diagnosis of psychological trauma, but may still cause such psychological problems as depression, anxiety, and somatic pain that persist until the event and its aftermath have been resolved. More severe events are more likely to have more harmful and lasting effects that cause greater ongoing disruption in the victim's life. For example, certain types of trauma (e.g., rape, severe battery, and trauma to a person in a dependent relationship) are associated with a higher risk of developing a severe, lasting type of response such as post-traumatic stress disorder (PTSD). Some studies have correlated an event's potential to threaten the victim's life or well-being and provoke a strong fear response with a greater risk of PTSD.

Risk factors for psychological trauma/stress

While nobody can be fully protected against traumatic events, and everyone experiences at least some degree of stress or anxiety in their lives from time to time, certain groups

are at higher risk than others for chronically stressful situations or psychologically traumatic incidents that have significant emotional consequences.

Chronic stress can afflict anyone but appears to be particularly prevalent in groups such as those living in poverty who are faced with persistent difficulties and frustrations. Common sources of chronic stress include financial hardships, unemployment, lack of control at work, and living in areas affected by war. Children can also be at risk for the effects of chronic stress, for instance if they live with violence in their community or strife among family members within their home.

Certain types of emotionally traumatic events are similarly more likely to occur to certain types of people. Note that the increased risk of trauma exposure faced by these individuals applies to particular types of trauma such as assaultive violence or abuse. Other traumatic events such as learning about harm befalling another person tend to be experienced more equally across epidemiological groups.

Socioeconomic factors play a major role in determining risk of exposure to emotional trauma. For example, racial minorities (particularly those who reside in inner-city environments), people with lower levels of education or intelligence, and people in lower economic brackets often face a greater likelihood of exposure to assaultive violence.

As with physical trauma, gender differences have also been identified for exposure to psychologically traumatic events. Males are more likely than females to have personally experienced assaultive trauma (being shot, stabbed, or beaten up, being involved in military combat, etc.). However, women are more likely than men to have been sexually assaulted. Nonassaultive stressors (e.g., sudden death of a loved one) appear to be distributed more equally between males and females.

Certain age groups, by nature of their greater vulnerability, are at higher risk for psychological trauma resulting from various types of abuse. Both children and elders are at risk of neglect and abuse due to their greater dependence on others. Elders are also at increased risk of abandonment (being deserted in a public facility) and financial exploitation. Adolescents and young adults are more likely than people in other age groups to be exposed to assaultive violence.

Finally, personal characteristics such as a background of psychiatric conditions (e.g., depression), personal or family history of substance abuse, and a history of early conduct problems have also been found to increase the chance of exposure to trauma.

Response to trauma/stressor

Response to a traumatic incident reflects the person's attempt to adapt to the situation. Reactions include not only emotional responses but also physiological ones that affect brain chemistry and anatomical structures. Responses may change over time – for instance, someone may be diagnosed with PTSD at three months after the triggering

event and depression at twelve months. Likewise, certain responses may not be evident at first but only emerge after a period of time past the event.

PSYCHOLOGICAL RESPONSES TO TRAUMA/STRESS

Following are some typical responses to traumatic situations. They may occur individually in a given person although co-morbidities are often seen (e.g., post traumatic stress disorder may be seen in conjunction with substance abuse and depression). Additionally, some conditions are considered risk factors for others. For example, a history of depression increases the risk of PTSD following a traumatic incident.

Acute stress disorder (ASD)

Acute stress disorder may be diagnosed within the first four weeks following a traumatic incident. It is characterized by (1) intrusive symptoms (reliving the event in memories, dreams and images); (2) avoidance symptoms (avoiding things that remind the victim of the trauma and having difficulty remembering the event); (3) arousal symptoms (hypervigilance, sleep disturbances, irritability, etc.); and (4) dissociation symptoms (a sense of detachment or numbness, decrease in awareness of surroundings, depersonalization, etc.). If these symptoms persist past four weeks, post traumatic stress disorder is diagnosed.

Post traumatic stress disorder (PTSD)

According to the National Institute for Mental Health, approximately 7.7 million Americans 18 years and older have PTSD, an anxiety disorder[h]. Types of symptoms exhibited in PTSD include those listed above for ASD (although dissociation symptoms are emphasized more in diagnosing ASD compared with PTSD). PTSD is considered chronic if symptoms last for three months or more, but may last for years or even decades, especially if untreated. Certain physiological abnormalities have been observed in PTSD, such as abnormalities in cortisol levels, amygdala activation, and cerebral blood flow, and atrophy of the hippocampus. Post traumatic stress symptoms (similar to but not as severe as those seen in full-blown PTSD) have been observed in conjunction with certain stressful experiences – for instance, they have been found to be common in parents of children diagnosed with cancer.

Depression

Depression is characterized by feelings of hopelessness, helplessness or despair, lethargy, lack of interest in former interests, difficulty concentrating, and other symptoms. It often occurs as a comorbid symptom with PTSD, but can occur on its own following a traumatic experience. Victims who are diagnosed with depression (without PTSD) following a traumatic event are less likely than those diagnosed with PTSD to have chronic mental health effects.

Panic disorder

It is very common for trauma victims to experience panic attacks during the traumatic experience, and traumatic experiences appear to increase the risk of later development of panic disorders. Panic attacks occur suddenly, with symptoms that include rapid heartbeat, feelings of fear or terror, dizziness, and difficulty breathing.

[h] http://www.nimh.nih.gov/publicat/numbers.cfm

Borderline personality disorder (BPD)
Borderline personality disorder is a condition characterized by severe instability in moods and behavior, with disruptive impacts on relationships and self-image. Self-mutilation and suicide attempts are common in this disorder. People with BPD frequently report having been abused or neglected as children. In turn, BPD sufferers are also more likely to become victims of crime, possibly because of their environments or because of poor judgment associated with the disorder.

Substance abuse
Stressful events have been found to increase the risk of a person developing a substance abuse disorder, or relapsing after a period of abstinence. The abuse can begin soon after the traumatic experience or some time later; indeed, even children who experience abuse have been shown to be at higher risk of substance abuse later in life.

Dissociative identity disorder (DID)
Previously called Multiple Personality Disorder, DID can be a result of severe trauma (physical, sexual or emotional abuse) in early childhood. Comorbidity with PTSD is common in people with DID. Children who are abused may dissociate the memory of their trauma as a defense and coping mechanism that allows them to function. However, those who turn to this strategy frequently may continue to use this escape mechanism even in only mildly distressing situations, a pattern that can impair everyday functioning. People with DID may experience a variety of psychological symptoms including depression, sleep disorders, and panic attacks, and may even develop alternate personalities.

PHYSIOLOGICAL EFFECTS OF PSYCHOLOGICAL TRAUMA/STRESS

Response to stress or trauma elicits a series of physiological responses in the body, some of which can be directly felt such as elevated heart rate and perspiration. In turn, exposure to significant trauma or prolonged stress can alter a person's physiological stress response patterns. This section describes the normal physiological response to stress and ways in which it can be altered.

Exposure to psychological or physical stressors (such as infections) in a healthy human activates the complex neuroendocrine system known as the hypothalamo-pituitary-adrenal (HPA) axis. Upon receiving signals from other parts of the brain indicating that a stress response is required, the hypothalamus releases the hormones corticotropin-releasing factor (CRF) and vasopressin. These hormones stimulate cells in the pituitary gland that release adrenocorticotropic hormone (ACTH). ACTH in turn travels through the bloodstream to the adrenal glands which release glucocorticoids such as cortisol. These hormones have wide-ranging stimulatory effects in the body but also work to suppress the stress response. When cortisol binds to receptors on the pituitary gland, paraventricular nucleus, and hippocampus, the HPA axis is suppressed. This negative feedback mechanism shuts down the stress response and prevents overproduction of cortisol which can be toxic to cells.

Activation of the HPA axis by stressors produces effects on peripheral systems that are mediated by glucocorticoids and the sympathetic nervous system. Stress induces

sympathetic neurons to release catecholamines such as noradrenaline and adrenaline that bind to receptors on peripheral tissues, resulting in effects such as increased blood pressure and heart rate that send energy to muscles and vital organs. The immune system is also affected by the stress response. Not only does cortisol bind directly to immune cells such as macrophages and T cells, but catecholamines released by sympathetic nerve endings in lymphoid organs also contact receptors on immune cells. The binding of stress hormones to immune cells typically has the effect of shifting the immune system away from an inflammatory profile, thereby preventing the immune system from "overshooting" in its response. However, in certain conditions stress hormones can stimulate an inflammatory response.

In general, the amount of cortisol released in response to a stressor correlates with the stressor's level of severity. However, in certain conditions where the HPA axis is altered, this relationship does not hold. For example, in people with PTSD, cortisol release in response to stress is lower – in fact, low cortisol levels immediately after an acute event are predictive of later PTSD development – and glucocorticoid receptors on lymphocytes are higher and more sensitive. Conversely, chronic depression is characterized by higher levels of cortisol and decreased glucocorticoid receptor sensitivity. Chronic stress is associated with higher levels of cortisol output during the presence of the stressor but below-normal levels several months past onset. A flattened diurnal profile of cortisol secretion is also associated with certain stressor characteristics (physical threat, exposure to trauma, and uncontrollability).

Another factor that can alter the HPA axis and thereby affect a person's response to stress is smoking: habitual smokers may have a dampened stress response. In addition, alterations in the stress response have also been detected in some chronic inflammatory human diseases and disease models.

Structural changes in the brain may contribute to or result from the biochemical effects associated with HPA function and dysfunction. For example, atrophy of the hippocampus has been observed in people with PTSD and major depression, abnormalities in various gray matter structures such as the prefrontal cortex have been seen in bipolar disorder, and dendritic remodeling in the hippocampus, amygdala, and other regions can result from exposure to chronic, severe stress.

Personal factors that influence response to stressor

Whether an event proves psychologically traumatic to a person depends on whether it overwhelms that person's ability to emotionally cope with the experience. This is determined partially by the event itself, as discussed above, but is also influenced by individual characteristics of the person involved. These factors can also influence the type and severity of any psychological disorder manifested by the person after the event.

Gender

Although males are at greater risk for experiencing trauma directly, females appear to be at greater risk than males for developing psychological disorders following a trauma. For

instance, females appear to be at higher risk than males for PTSD. The increased conditional risk for PTSD in women is especially significant for assaultive violence stressors. This disparity may be due to women being more at risk for certain types of trauma (such as intimate partner violence) or to differences in response patterns or biological characteristics between the genders. Depression and panic disorder also appear to affect women more than men at about a 2:1 ratio.

Intelligence
Some studies have associated lower intelligence (lower IQ) with an increased conditional risk for PTSD. For example, lower precombat intelligence scores in combat veterans have been associated with a higher risk of developing PTSD. Similarly, a prospective study of children showed that subjects with higher intelligence at age 6 were less likely than those of lower intelligence to later develop PTSD after exposure to trauma[9]. It has been suggested that cognitive factors affect coping ability during a traumatic incident and therefore influence psychological outcomes following the trauma.

Prior traumatization
A history of previous trauma, abuse or adversity, particularly in childhood, increases the risk of emotional disorders following traumatic incidents later in life.

Social support structure
A supportive family and community can help minimize the severity and duration of trauma symptoms. Conversely, being surrounded by people who blame the victim or are in other ways unsupportive may increase the risk of developing PTSD or other outcomes.

Other personal/personality characteristics
Pre-existing personality traits (such as negativism, hostility, and low self-efficacy) as well as personal or family history of certain psychiatric disorders such as major depression have been associated with an increased risk of PTSD. It is unclear whether the association between psychiatric disorders and subsequent PTSD exists because these disorders themselves predispose a person to PTSD or because factors that influence vulnerability to depression, etc. also influence vulnerability to PTSD.

Genetics
Genetic factors appear to contribute to the likelihood of PTSD as well as PTSD symptoms such as hyperarousal and avoidance. Other conditions such as borderline personality disorder and depression also appear to be genetically influenced.

Treatment received
The administration of treatment following a traumatic event can reduce the occurrence or severity of emotional disorders in trauma survivors. Types of treatment that may be helpful include cognitive-behavioral therapy, pharmacotherapy, and group therapy.

Peritraumatic responses
The immediate physiological and psychological response to a traumatic event may predict the development of subsequent disorders. For instance, peritraumatic (acute) dissociation, panic attacks, elevated heart rate, and lower cortisol levels have all been correlated with a higher risk of ASD or PTSD. In addition, chronic PTSD is associated

with exhibiting a greater number of PTSD symptoms and particular symptoms such as interpersonal numbing.

Appendix A

Fatalities In Selected Industries		
Industry Sector	Fatality Rate (per 100,000 people)	Number of Fatalities
Agriculture, Forestry, Fishing, Hunting	31.2	707
Mining	26.9	141
Transportation and Warehousing	17.5	805
Construction	11.7	1,126
Wholesale Trade	4.2	191
Utilities	3.7	32
Professional and Business Services	3.3	452
Other Services (i.e. public administration)	2.8	194
Government	2.5	532
Manufacturing	2.5	416
Leisure and Hospitality	2.4	274
Retail Trade	2.1	343
Information	1.8	64
Financial Activities	1.4	130
Educational and Health Services	0.8	143

(Source: U.S. Department of Labor, Bureau of Labor Statistics, "Cause of Fatal Occupational Injuries, 2003 Data")

Fatalities In Selected Occupations			
Occupation	Common Mechanisms of Injury	Fatality Rate (per 100,000 people)	Number of Fatalities
Drivers and Sales Workers	Motor Vehicle Accidents (highway)	31.2	707
Farmers and Ranchers	Motor Vehicle Accidents (non-highway)	26.9	141
Construction Laborers	Falls	17.5	805
Grounds Maintenance Workers	Being Struck by Objects	11.7	1,126
Miscellaneous Agricultural Workers	Motor Vehicle Accidents (non-highway)	4.2	191
Police and Sheriff's Patrol Officers	Motor Vehicle Accidents (highway)	3.7	32
First-Line Supervisors and Managers of Retail	Homicide	3.3	452
Aircraft Pilots and Flight Engineers	Aircraft Accidents	2.8	194
Laborers and Freight, Stock, and Material Movers	Falls, Being Struck by Objects	2.5	532
Logging Workers	Being Struck by Objects	2.5	416

(Source: U.S. Department of Labor, Bureau of Labor Statistics, "Cause of Fatal Occupational Injuries, 2003 Data")

Nonfatal Injuries and Illnesses In Selected Industries			
Industry Sector (Private Industries)	Employment (in thousands)	Number of Fatalities (in thousands)	Fatality Rate (per 100,000 people)
GOODS PRODUCING	22,788.4	1,455.2	6.7
Natural Resources and Mining	1,465.1	73.44	5.1
Construction	6,672.4	408.3	6.8
Manufacturing	14,459.7	973.6	6.8
SERVICE PROVIDING	83,394.6	2,909.9	4.4
Trade/Transportation/Utilities	25,041.8	1,188.7	5.5
Information	3,180.8	61.2	2.2
Financial Activities	7,826.9	122.5	1.7
Professional and Business Services	15,858.5	288.9	2.5
Educational and Health Services	15,738.0	737.1	6.0
Leisure and Hospitality	12,162.2	411.0	5.1
Other	3,777.7	100.6	3.4

(Source: U.S. Department of Labor, Bureau of Labor Statistics, "Survey of Occupational Injuries and Illnesses, 2003")

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