# Injury Epidemiology

## Ten Basic Principles

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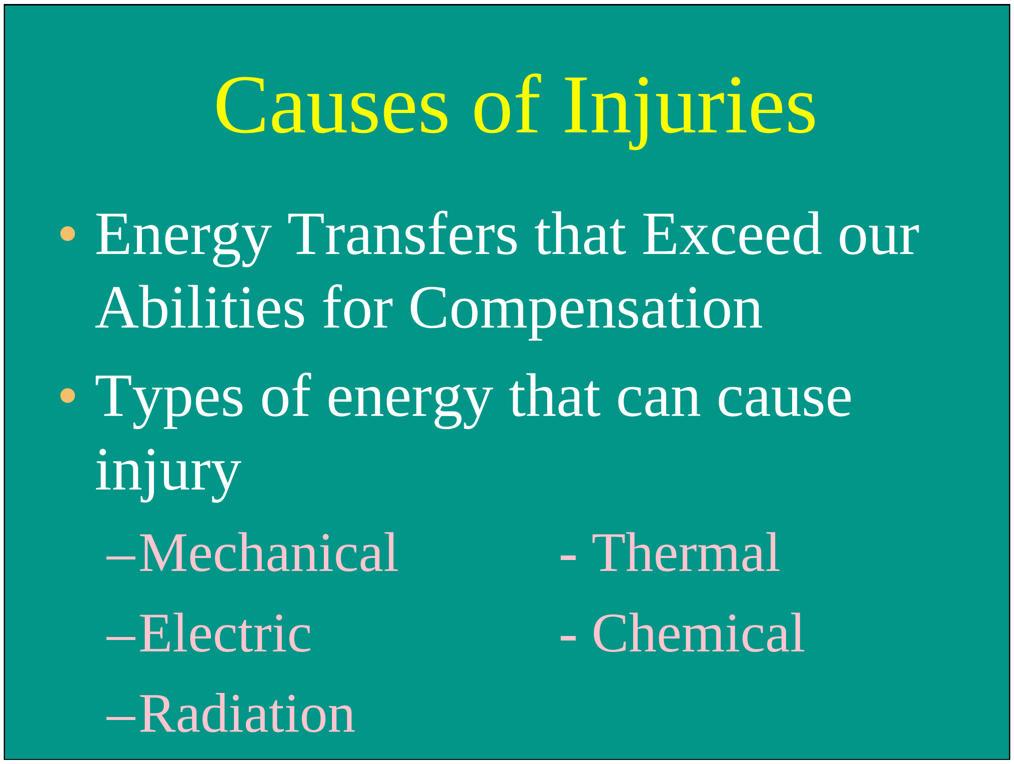
Our class, EPI 2670, presents a quick introduction to injury epidemiology by design. My approach for teaching the class is to provide an overview of the key points of the discipline with selected examples to highlight and enhance your understanding. This lecture represents what I feel are ten key concepts that a student should recognize to have an introductory understanding of injury epidemiology. The issues presented represent basic issues that researchers recognize and practice to further injury control and prevention. So, let’s get started!

Injuries occur as the result of energy transfer that is delivered in excess of a threshold

The first basic principle in injury epidemiology is the understanding of what injuries are and, in some sense, what they are not.  In general, injuries occur when humans encounter energy forces that are larger than the body's normal tolerance levels for energy absorption.  The level of energy encountered exceeds a threshold.




Get to know your local engineer or physicist, as injuries occur as the result of energy transfers. All injuries can be characterized from the perspective of a transfer of energy that exceeds a threshold. We deal with all forms of physical energy every day, whether mechanical (motion), thermal (heat), or other forms. Normally, we can withstand most shifts in energy forces. However, they are selected times when our personal thresholds for tolerance of energy transfer are exceeded and an injury occurs.

As an example, when we drive in an automobile, our bodies assume the rate of speed of the vehicle. When a crash occurs, the body is suddenly slowed, and energy transfers between the victim, his/her car, and the object struck (a tree, another car, etc.). Injuries arise when our threshold to withstand this energy transfer is exceeded.

Energy Transfer and Injuries

- Penetrating
- Non-Penetrating
- Compression
- Burn

If the energy transfer is localized in one area, the likely outcome may be a penetrating injury. If the energy transfer is dispersed over a broad area, the result will often be a non-penetrating injury. In situations involving thermal energy transfer, the result will be a burn. And so on, depending upon the mode of energy involved.

Most injuries (74%) arise from the transfer of physical or mechanical energy. This is due to the frequency in which we come into contact with events and vehicles that involve mechanical energy. The leading causes of death from mechanical energy transfer are injuries from motor vehicle accidents, firearms, and falls.


Now, let me diverge a bit to talk briefly about what many injury professionals feel that injuries are not.  “Injuries are not Accidents”.  This has been a common slogan spoken by injury research professionals.

It originated some time ago to counteract the perception that injuries occurred by chance.  In the past, many persons in the lay public and many legislators regarded injuries as accidents; events that you had little control over.  This thought probably arose from the publicity that natural disasters receive.

However, it is now well recognized that nearly all injuries are not the result of random events.  There are distinct patterns and circumstances that characterize their occurrence.  We understand that injuries most often occur to certain risk groups and are fairly predictable (whether it be to certain persons, at certain times, or in common locations).

In this light, many persons in the injury field refer to automobile accidents as “crashes” rather than “accidents”.  In reality, it does not matter whether or not crashes or accidents is the most appropriate term.  What is important is the recognition that injury events often have identifiable characteristics, and that we may be able to prevent future injuries by intervening on one or more of these characteristics.

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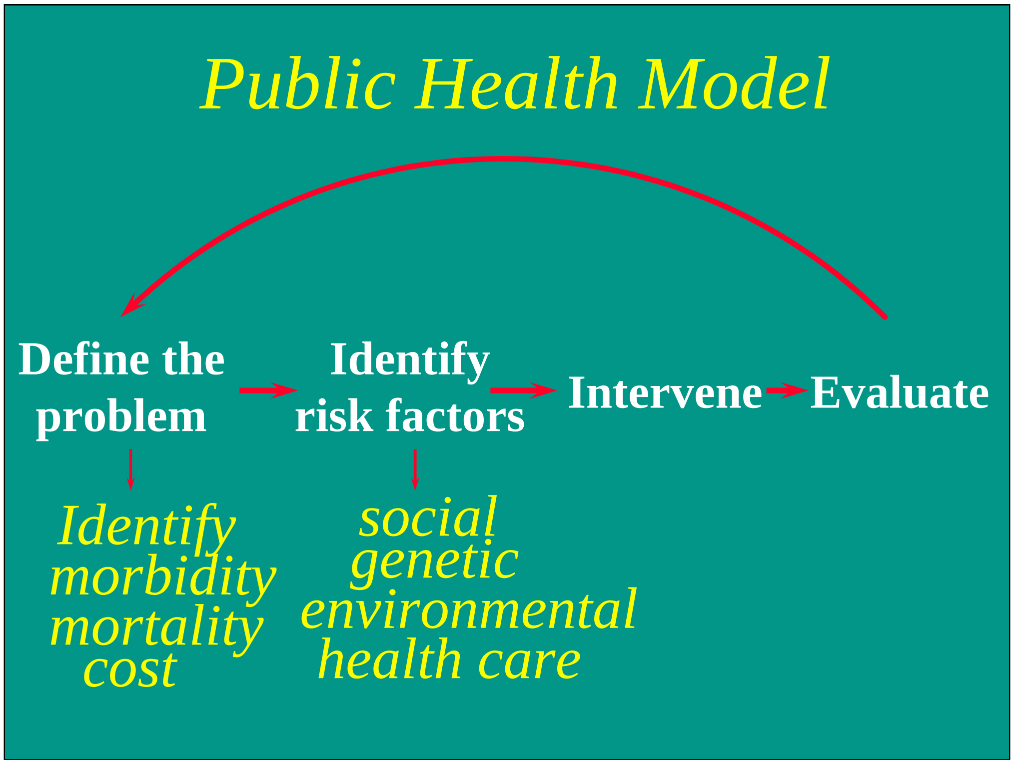
Models are used by epidemiologists to provide a framework for understanding injuries; their occurrence and their prevention

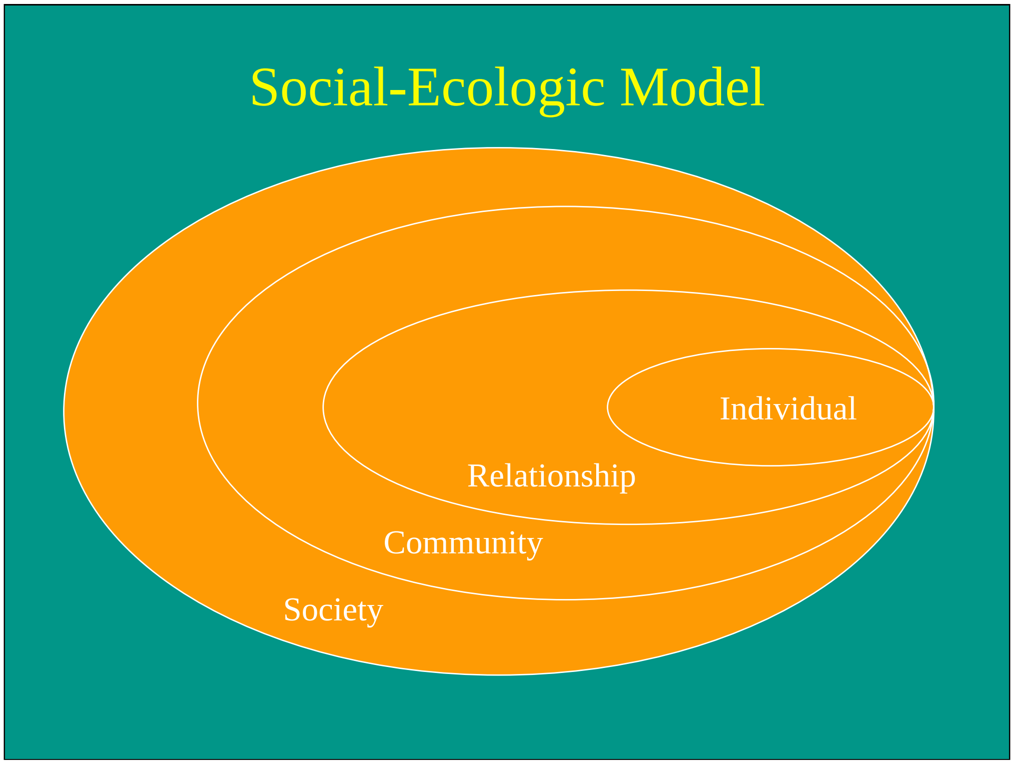
A second basic principle of injury epidemiology is that models form the basis for many approaches to understanding injuries in the community. Several models are used in this regard. The most common model is the Haddon Matrix used in injury prevention efforts. We will discuss the Haddon Matrix later in this lecture. For Injury Research, the “Public Health Model for Disease Control” is a very common perspective to guide research efforts. Other models are now being recognized as being important. For example, the social-ecologic model in violence research and prevention.




The public health model outlines a defined set of steps to undertake for reducing the burden of diseases or injuries.  The first step of the model is to identify the relative magnitude of the problem.  This is often done through the establishment of surveillance systems to quantify incidence or health outcomes.

The second step is to identify causal factors associated with the injury (i.e. risk factors).  This determination might arise from information contained within the surveillance system.  More often, though, it is done independently through analytic epidemiologic studies.

The third step is to utilize the information available on causal factors to develop an intervention.  After implementation of the intervention, it is then appropriate to consider an evaluation of it’s effect.  This evaluation may use data from the surveillance system to examine if there has been any change in the burden of disease.



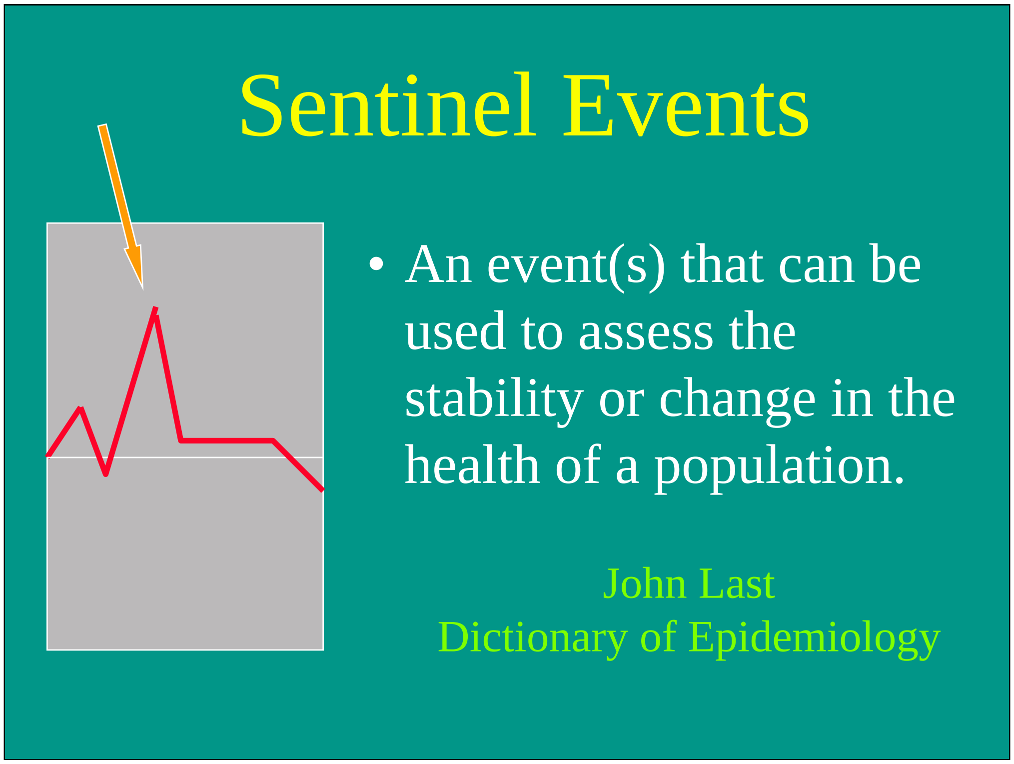

The social ecologic model illustrates that an injury (or more commonly) a violence issue has multiple components to explain its occurrence. As shown in this slide, there are several layers of issues that can influence a situation and lead to an injury. For example, individual (or host) factors) have a role to play in injuries and violence. These individual factors may be influences by family factors, which in turn, may be influenced by community factors, ….which can be set by societal norms and standards. The social ecologic model is now gaining widespread acceptance as a perspective to consider violence in communities.

# 3 Injury Surveillance Systems Form the Basis for Injury Control

Injury surveillance or monitoring systems are important for they provide us knowledge on how many injuries occur, when they occur, and to whom they occur! As was discussed before, this information lays the foundation for efforts to reduce injuries in the future.

All of the injury control measures that quickly come to mind, e.g. seat belts, airbags, helmets, were implemented after it became apparent that injuries were occurring in relatively high numbers and that we needed to do something about it.


What are injury surveillance systems? These systems represent the systematic collection of data on an injury. Over time they identify trends to show if injuries are increasing or decreasing in incidence, and which are changing in their distribution. This information is needed to identify emerging problems and also to assess the effectiveness of measures to control old problems. For more information, see Epidemiology for the Uninitiated, Chapter 1.




Surveillance systems are often used to identify sentinel events. Marked increases in these events generally provide an indication or warning to public health officials of an emerging problem. Many injury systems are set up for this purpose.

Deaths from automobile accidents are one example of a sentinel event that is followed closely by the injury community. If an increase in accident deaths were to occur, there would be an indication that someone should start to look into the factors behind it. However, many surveillance systems that monitor sentinel events, including those in the injury field, are not designed to answer research questions on the cause(s) of the sentinel event.

# 4 Injury Research Requires a System for Classifying Injuries

Injuries represent a broad area of circumstances, ranging from head trauma to lacerations, from gunshot wounds to burns.  Many even characterize drownings as injury events.

In this environment, it is important to categorize events with common characteristics.  This is where injury classification systems come into play.  A classification system allows researchers to identify and compare head injuries in Boston with head injuries in Australia.  The classification system provides a "standard" to allow for comparisons.

## ICD Codes

- Diagnosis Codes (N-Codes – ICD 9; S, T Codes – ICD 10)
  - Record the clinical nature of the injury and the area of the body injured
- Cause of Injury Codes
- E-Codes (ICD – 9)
  - Record the external cause of the injury
  - Often missing in the medical record
- V, W, X, Y Codes (ICD – 10)
  - record external causes

Most injuries are identified at the point when an individual comes into contact with the health care system. Injuries are usually defined in medical records by one of the most widely used classification systems in the world; the International Classification of Diseases (ICD) system and codes. Two types of ICD codes are of most interest; nature of injury codes which identify the anatomy involved in the injury, and external cause of injury codes which identify the events leading to the injury.

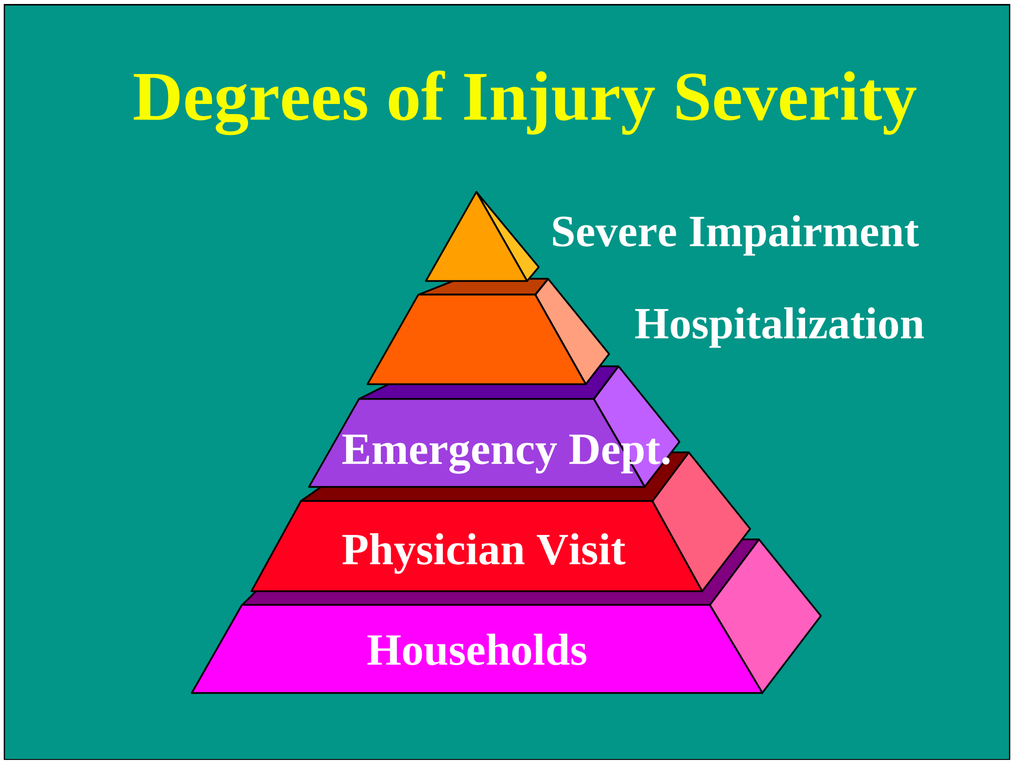
One major issue of concern for injuries, is that monitoring systems based upon medical records do not always provide details of the cause for the injury (E-codes or V, W, X, and Y codes).

Other types of classification schemes exist for injuries as well. These include systems to classify the severity of injury; such as the Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS). Also, there is a rubric recently adopted to classify the intent underlying the injury; i.e was it intentional or unintentional.

## 5

## Most injuries are relatively minor, and do not require any medical attention.

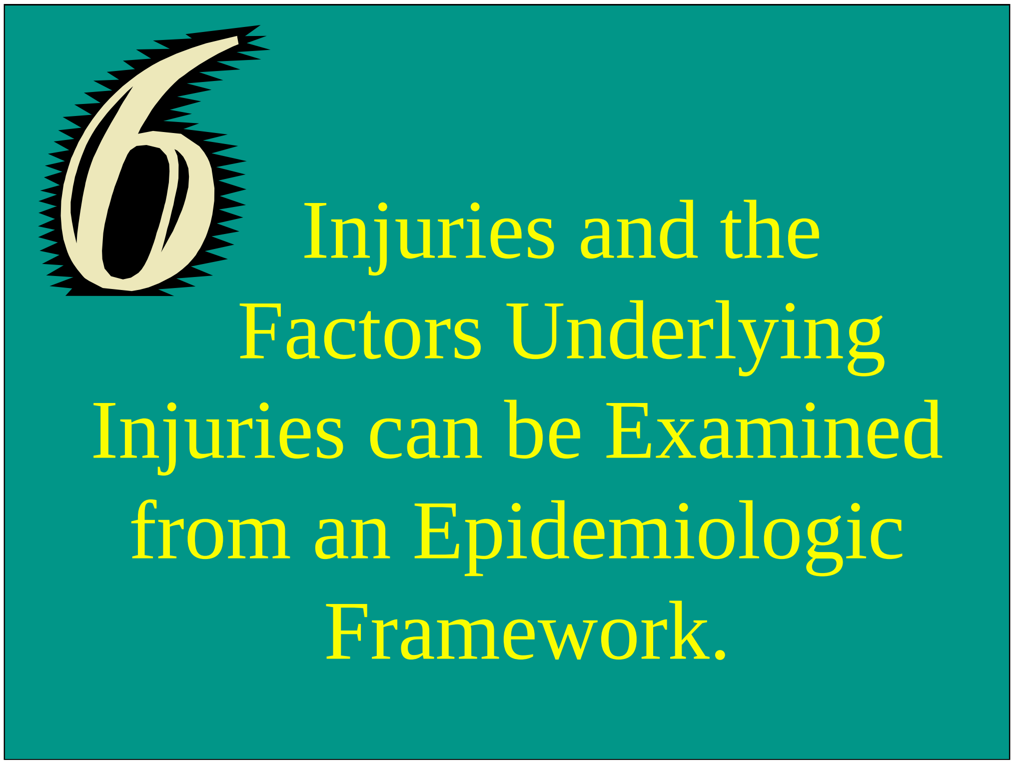
Injury severity is an important issue in injury monitoring, not only from a classification perspective, but also from the point of view of the data sources that make up the surveillance system. Nearly all injury surveillance systems utilize sources that identify relatively severe events; those that require medical attention. The reality, though, is that the vast majority of injuries are minor events that are treated at home.




The classic injury pyramid is shown here. From a absolute number perspective, most injuries are minor and can be treated without any medical attention (represented at the bottom of the pyramid). More severe injuries are fewer in number, but will require medical attention by a professional. Hospitalization from injuries is even less common, and fatalities from injuries (in absolute numbers) are fewer still. Events which result in death are considerably more severe, but occur less frequently.

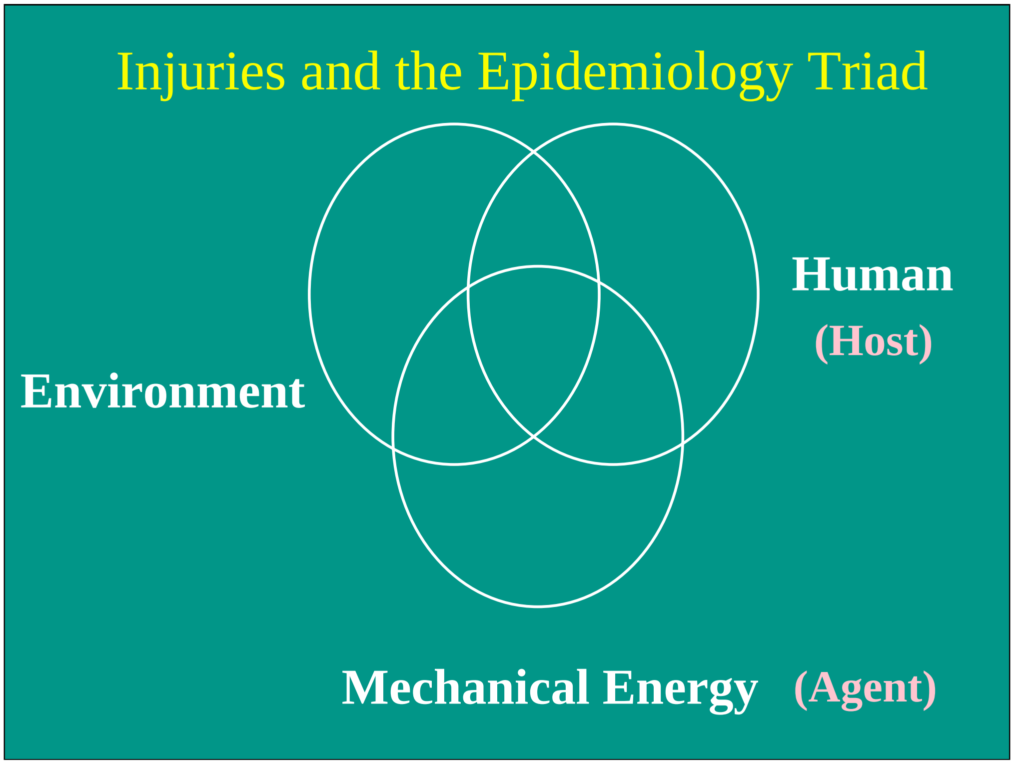
When evaluating a report or paper, an important item to consider is the source of the information on injuries. Where were the injuries identified from? What severity of injuries are captured by this source?

Consider injury deaths as an example. The pyramid provides an indication that injury deaths are likely to be relatively rare events. Injury deaths also do not always come to the attention of the medical system. Thus, a report which identifies deaths from hospital records will very likely undercount the number of events that occurred. If you want to have a comprehensive assessment, you might also have to consider events from other sources, such as the coroners’ or medical examiners’ office.

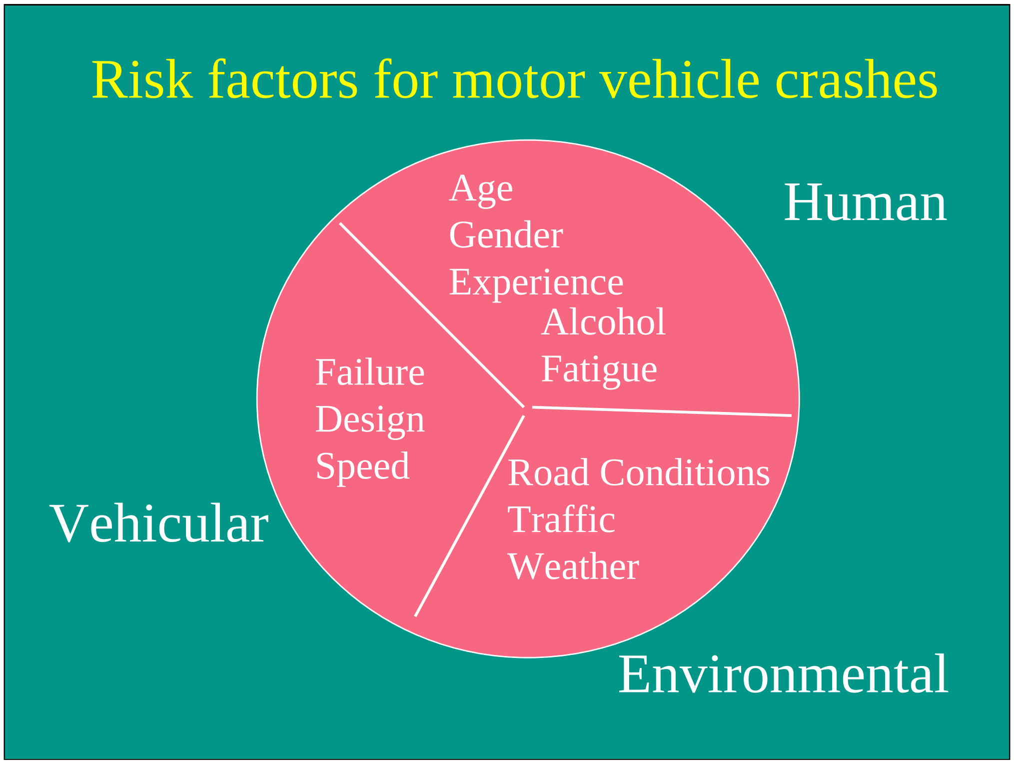



The visionary of injury epidemiology and injury control was William Haddon. Dr. Haddon was the director of the National Highway Traffic Safety Administration and the Insurance Institute for Highway Safety in the 1960s and 1970s. He used these positions to play a leading role in the cause of traffic safety.

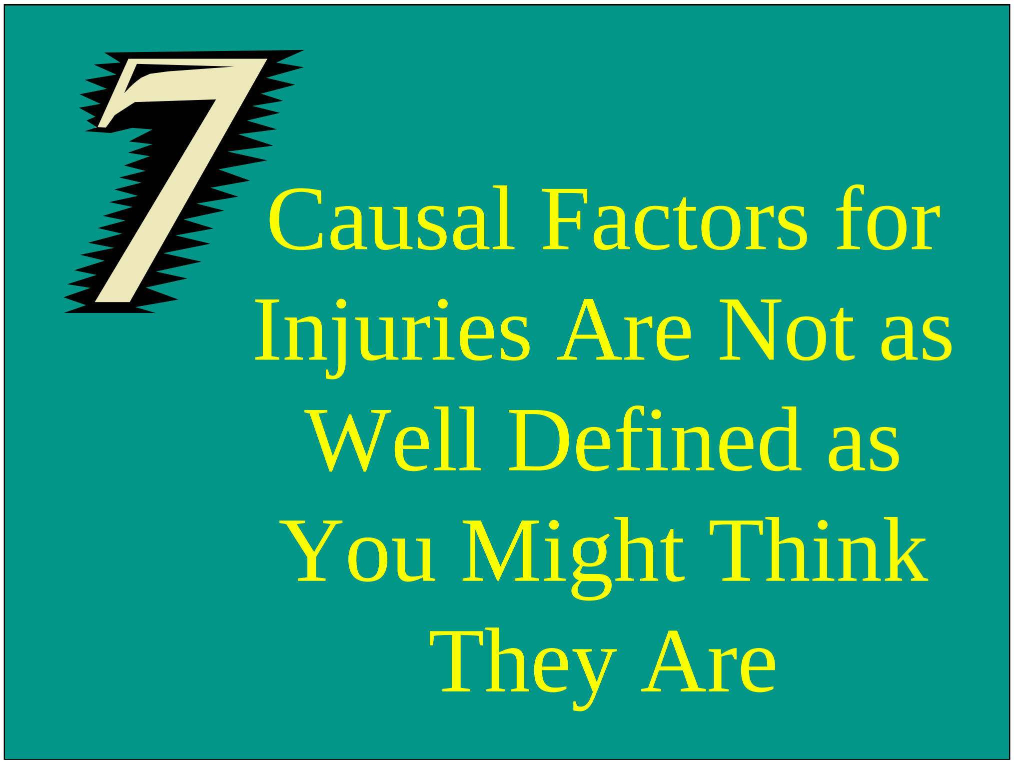
The basis behind his work was the simple argument that injuries can be examined within an epidemiologic framework. In it’s classic sense, the epidemiology triad considers the interaction of three factors in the development of disease; the host, the agent, and the environment. Dr. Haddon maintained that these factors also were key elements in the development of injuries.



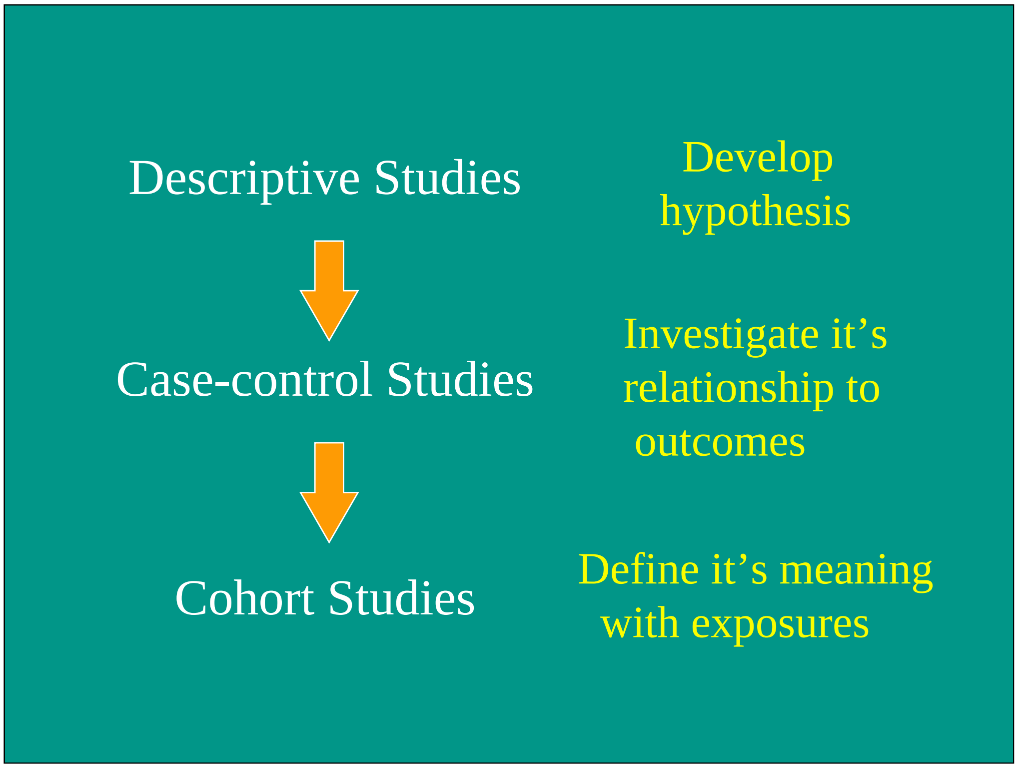

Here we see an illustration of the epidemiology triad as it relates to injuries. In this example, the host is the human being and their behavior in operating a motor vehicle. Physical energy is the agent in injury events. For motor vehicle events, this translates into the mechanical energy involved with motor vehicles. The environment is the milieu in which the vehicle and the human are interacting, such as the type of road, the weather conditions involved, etc.




Further illustration of the epidemiology triad and an evaluation of injuries from motor vehicles crashes is presented here. A key element in Dr. Haddon's work was the contention that the epidemiologic framework could be used to identify risk factors for injuries. Moreover, these risk factors were not just those related to the host, but also those pertaining to the vehicle, and the road (environment).




Ask someone to identify for you the primary risk factor for automobile crashes and they are likely to respond; alcohol use. Ask another person what the primary factor is behind head trauma, and they will probably indicate the non-use of a helmet. Many aspects of injury control have permeated our daily lives. The point to raise here, though, is that we should not take this and other information for granted. Many risk factors for injuries remain poorly defined. This is because they have been identified from surveillance systems that are generally poor at characterizing the population’s exposure to the factors.




Descriptive studies are the most common approaches used today in injury research. A sentinel event surveillance system is one example of a "descriptive study". It is very useful for identifying hypotheses to test in analytic studies. It is very poor at identifying causal agents.

For instance, a major flaw of studies which identify injuries from medical records, is that you only know the risk factors for people who have injuries. You do not know how these factors may differ from the people who are not injured. This is a crucial point if you want to be able to identify events that place someone at risk for an injury and the importance of that risk. This is where the importance of analytical epidemiologic studies is recognized.

Case-control studies and cohort studies are examples of analytic designs. Case-control studies are generally used to evaluate if the hypothesized factor is related to an injury. Cohort or longitudinal studies are subsequently applied to more clearly define the importance of exposure to the causal agent for the development of an injury.


One common theme to epidemiologic research today is the push to develop interventions to reduce the burdens of disease. The last three decades have seen remarkable advances in our understanding of disease. It is the sentiment, now, that the research community needs to move forward to focus on interventions rather than basic research.

This philosophy is already well-entrenched in the injury field. In fact, one could make the argument that the injury field is the most advanced discipline in terms of applying interventions. Interventions in the injury field are often referred to as measures for injury control. When someone speaks of injury control, they generally mean some type of intervention to reduce the impact of injuries.

# Traditional Approach to Injury Control

- Education
- Enforcement
- Engineering

Injury control initiatives (interventions) have been common practice since the 1950s and 1960s. We can thank both Ralph Nader and William Haddon for this scenario.

Injury control measures gained prominence after a series of events were observed. These circumstances included the development of the interstate highway system in the 1950s, the dangerous designs of automobiles in this period, and a continuing rise in injury deaths from motor vehicle crashes.

Injury control initiatives emerged to consider three areas of focus. The three Es include interventions based on education, law enforcement, and engineering.

Interventions were undertake to better educate the public on the rules of the road and proper driving techniques. Law enforcement initiatives, such as speed limits and traffic control laws, were used to provide a hand of authority to drivers. Most significantly, engineering changes in both road design and automobile design were undertaken to reduce injuries.


Many of the injury control initiatives from this time period arose from the eloquent work of William Haddon, or more specifically, the Haddon Matrix.

# The Haddon Matrix

use for planning, resource allocation, strategy identification

| | Human | Vehicle | Environment |
|---|---|---|---|
| Pre-event | | | |
| Event | | | |
| Post-event | | | |

To understand the factors underlying injuries from motor vehicle accidents, Haddon proposed that the elements of the epidemiology triad should be considered in unison with the crash sequence. The crash sequence can be examined in terms of three items; the circumstances surrounding the event prior to the crash occurring, the circumstances involved during the crash, and those involved after the crash.

The Haddon Matrix illustrates how the crash sequence interacts with human, environment, and vehicular factors to define the frequency and severity of injury.

## The Haddon Matrix

| | Human | Vehicle | Environment |
|---|---|---|---|
| Pre-event | alcohol | | night, rain |
| Event | no seat belt | no air bag | tree too close to road |
| Post-event | | | slow emergency response |

The Haddon Matrix changed our view of injuries from motor vehicle accidents and other injuries and provided a framework for the development of injury control interventions. Haddon's argument was that an appropriate understanding of the factors affecting injuries in each cell of the matrix could lead to more effective interventions. By identifying which factors are important and their location in the crash sequence, it will then be possible to understand where interventions may be most appropriate. Haddon applied this matrix to several other injuries in addition to those from motor vehicle crashes.

## Ten Methods for Limiting Energy Transfer

1. Prevent the development of energy form
2. Reduce the amount of energy
3. Prevent the energy release
4. Alter the rate of energy release from it's source or it's spatial distribution
5. Separate structures from the energy release by space or time

Haddon also provided further elaboration to the role of injury intervention programs by drawing on our first basic principle; that injuries represent energy transfer that exceeds a threshold. Considering that the primary agent involved in injuries is the transfer of energy, Haddon proposed 10 steps to reduce the impact of an energy transfer, and thus, reduce injuries. These steps are outlined here. They focus primarily on altering the environment in which the energy transfer takes place and the degree to which energy can be built up.

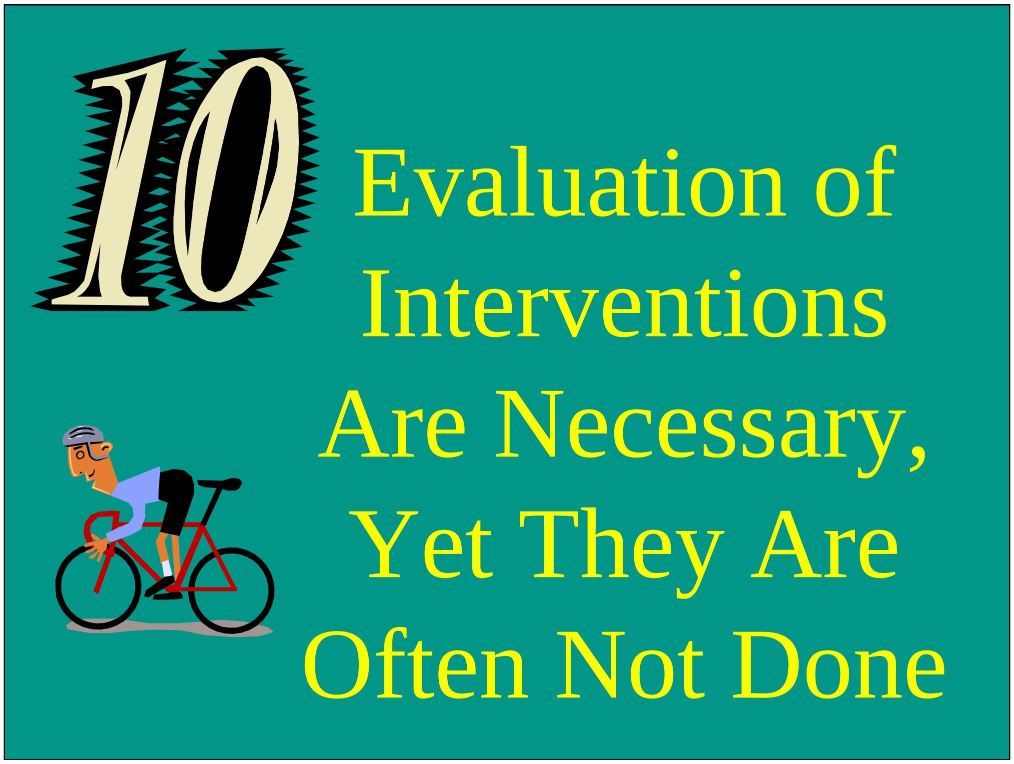
For example, speed limits aid in reducing the degree of energy that can potentially be involved in a crash. Engineering designs and changes in the automobile can affect the time and space is which energy transfer takes place. Overall, these principles transformed injury control efforts.

## Methods to limit energy transfer...

6. Place a barrier between the released energy and susceptible structures
7. Modify surfaces that can be impacted
8. Strengthen structures susceptible to damage from energy transfer
9. Prevent the extension of existing damage
10. Carry out intermediate and long-term repair and rehabilitation

Control programs to limit energy transfer (and thus reduce injuries or their severity) may be “active” or “passive”. Active programs include those in which individuals are encouraged to undertake safer practices to reduce their risk for injury. For example, wearing seat belts or motorcycle helmets.

Passive programs include those in which steps to reduce energy transfer are taken irrespective of an individual’s behavior. For example, the laws mandating air bags in cars are one form of a passive intervention. Many in the injury field prefer passive interventions because promoting changes in individual behavior has proven to be a difficult task in the past.




The last tenet of injury epidemiology that I want to convey reflects the evaluation of injury control interventions. In the injury field, there is a view held by some individuals that once an intervention is underway, the burden of injuries will be reduced. ‘If we do it, it will work.’ ‘If a helmet will reduce the energy transfer to the head, then by putting helmets on all kids, we will reduce head injuries.’

There are surprisingly few evaluations of the effectiveness of injury control interventions, despite the long history of injury control efforts.

When evaluations do exist, they often are based upon poor methodologic designs. Very few evaluations have incorporated the elements of a randomized clinical trial into their study design. Thus, it is difficult to know if improvements in injury circumstances were related to the intervention or to some other factor.