TOPIC 4

Road Safety

Introduction

- It is commonly accepted that there are many costs associated with vehicular mobility. These Include:
  - Air pollution
  - Noise
  - Visual intrusion
  - Crashes

- **Visual Intrusion** is human-caused change in the land form, water form, vegetation, or the addition of a structure which creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape

- Amongst all these costs associated with vehicular mobility, roadway safety is the greatest concern for all transportation agencies worldwide.

- Economic and social costs associated with road crashes greatly exceed other mobility costs

Introduction

- Besides fatalities, tens of millions of people suffer life-altering injuries with long lasting effects.
- These losses take a huge toll on families and communities.
- The World Health Organization (WHO) Global Status Report on Road Safety (2018) indicates that a total number of 1.35 million people die every year due to injuries sustained in road traffic crashes.
- This translates to nearly 3700 deaths per day or 1 death every 23 seconds.
- Even though the 2018 WHO report does not have data on the performance of Zambia with regards to deaths resulting from road traffic crashes, records from the 2015 report indicate that the country is no exception in recording staggering numbers of road traffic crashes
- Road traffic injuries are the number one cause of death among those aged 15–29

Introduction

- WHO (2004) has projected that traffic crashes will move from the 9th leading cause of injury and death in 1990 to 3rd leading cause in 2020

- Road traffic accidents result in injuries and property damage.

- These injuries can be serious and result in fatalities.

- Improved safety on roadways has considerable positive social and economic impacts in terms of:
  - Reduced fatalities and injuries
  - Reduced loss of property,
  - Reduced medical expenditure,
  - Savings of lost working days due to injury or loss of earning power due to death

Introduction

Table 1: Top 10 causes of death globally (WHO, 2018)

Rank	Cause	% of total deaths
	All Causes	
1	Ischaemic heart disease	16.6
2	Stroke	10.2
3	Chronic obstructive pulmonary disease	5.4
4	Lower respiratory infections	5.2
5	Alzheimer's disease and other dementias	3.5
6	Trachea, bronchus, lung cancers	3.0
7	Diabetes mellitus	2.8
8	Road traffic injuries	2.5
9	Diarrhoeal diseases	2.4
10	Tuberculosis	2.3

Introduction

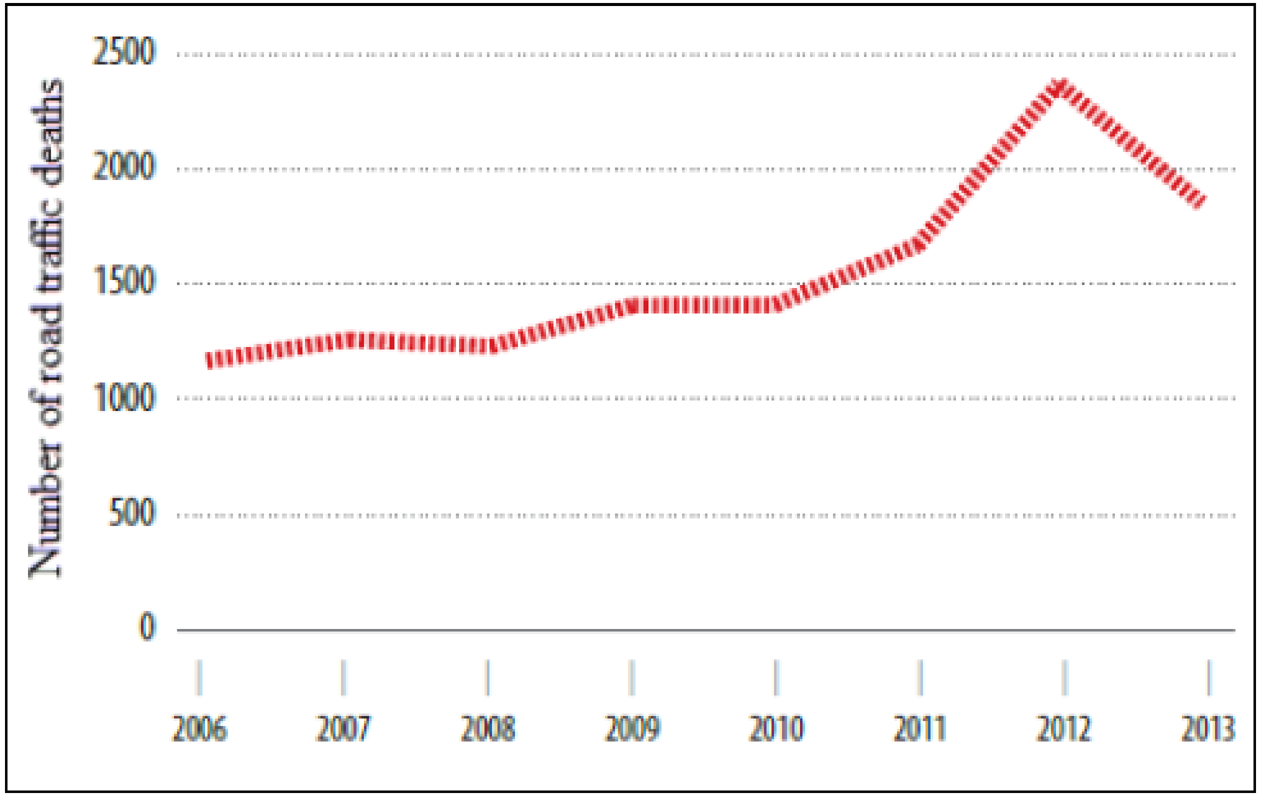


Figure 1: Reported road traffic deaths in Zambia from 2006 to 2013 (WHO, 2015)

Introduction

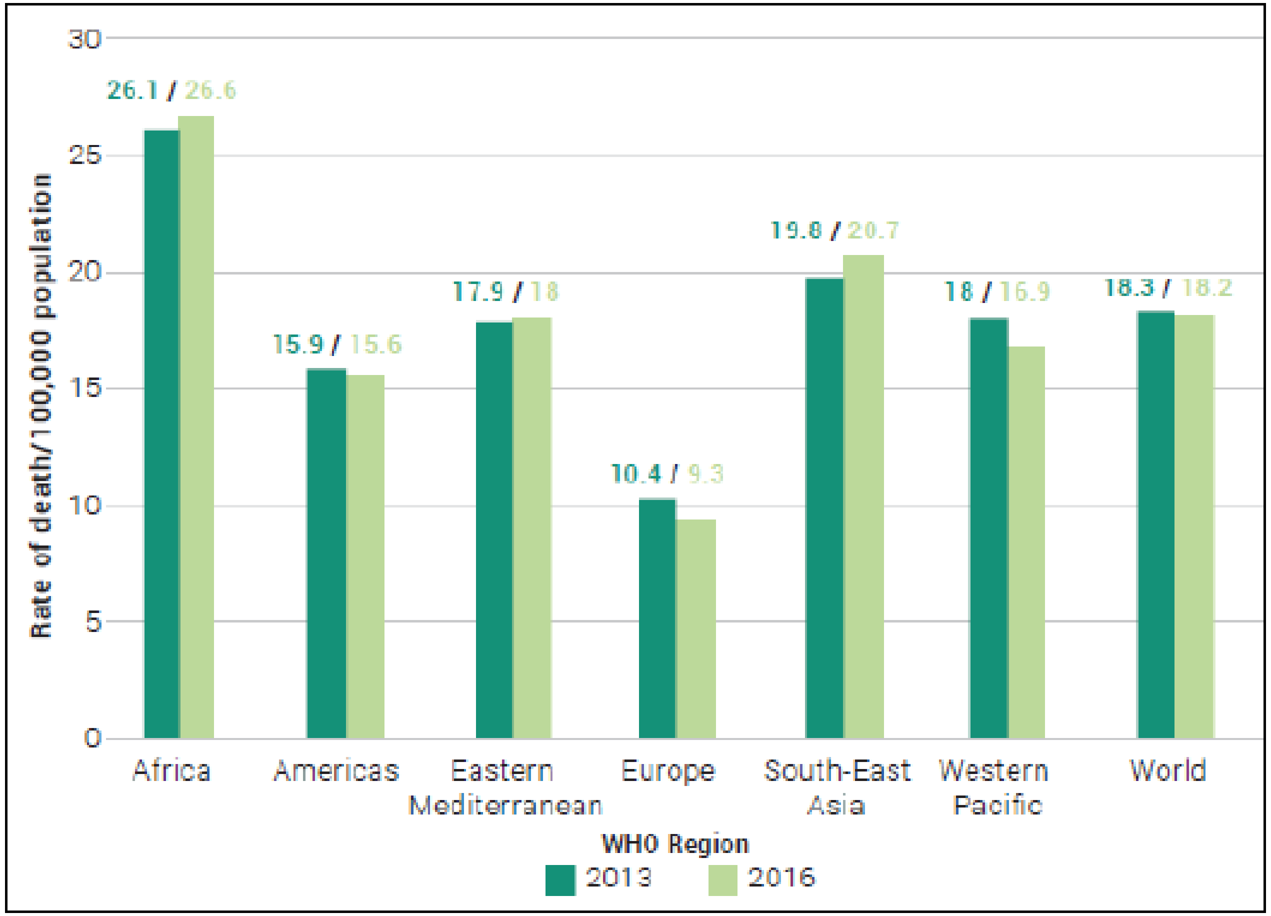


Figure 2: Rates of road traffic death per 100000 population by WHO regions (WHO, 2018)

‘Accidents’ or ‘Crashes’???

- ❖ Accident is the commonly accepted word for an occurrence involving one or more transportation vehicles in a collision that results in property damages, injury, or death.

- ❖ The term “accident” implies a random event that occurs for no apparent reason other than “it just happened.”

- ❖ If you are in a situation where something happened that was unintended, your immediate reaction might have been “sorry, it was just an accident.”

- ❖ In recent years, the National Highway Traffic Safety Administration has suggested replacing the word “accident” with the word “crash” because “crash” implies that the collision could have been prevented or its effect minimized by modifying driver behavior, vehicle design (called “crashworthiness”), roadway geometry, or the traveling environment.

Causes of Transportation Crashes

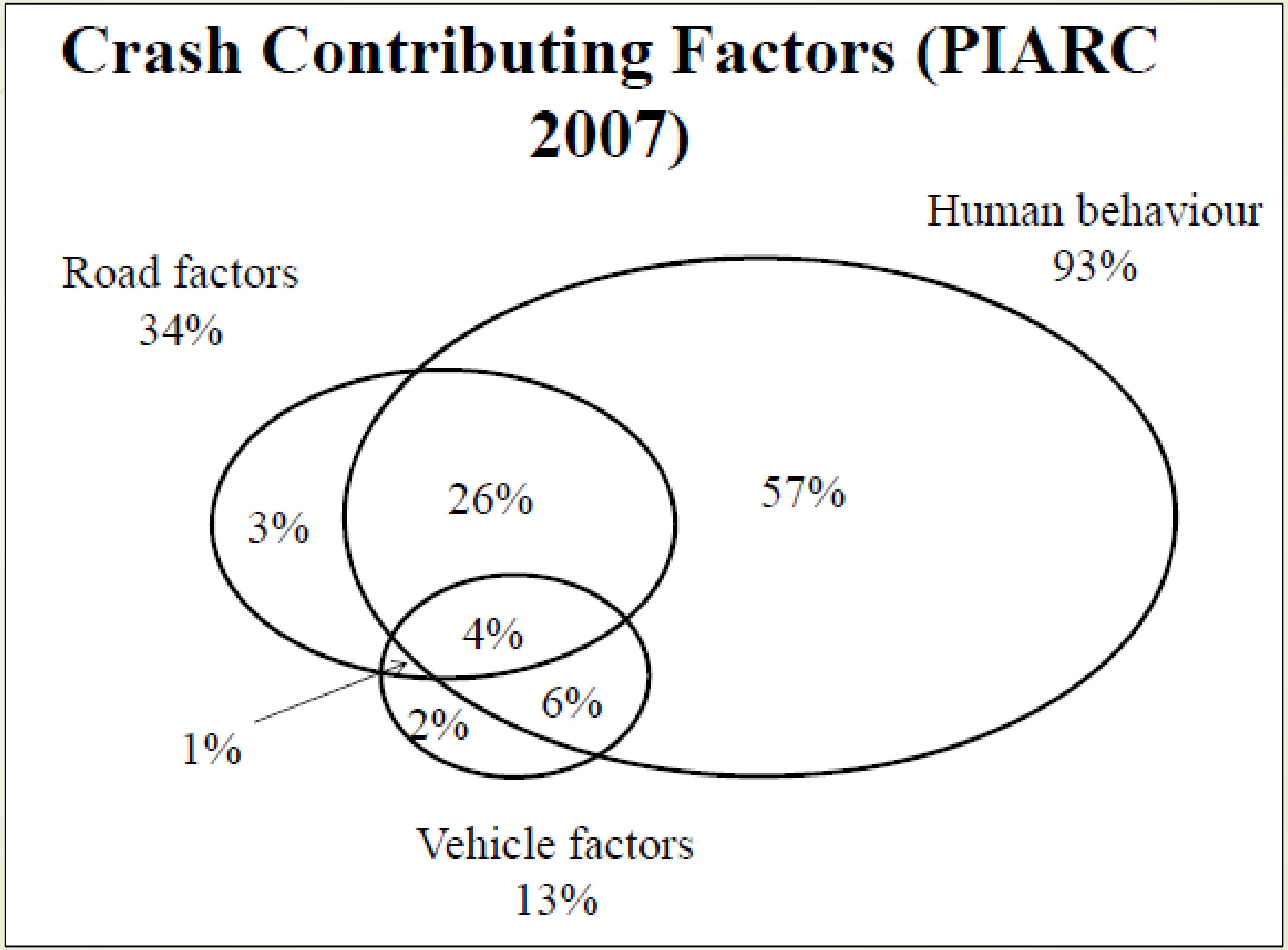
❖ While the causes of crashes are usually complex and involve several factors, they can be considered in four separate categories:

1. **Actions by the driver or operator** – Driver error can occur in many ways, such as inattention to the roadway and surrounding traffic, failure to yield the right of way, and/or traffic laws, etc

2. **Mechanical condition of the vehicle** – Include faulty brakes, Worn tires, etc

3. **The Roadway Condition** - The condition and quality of the roadway, which includes:
   – the Insufficient stopping sight distance
   – Insufficient sight distance at intersections or railroad crossings
   – Hidden intersections
   – Short weaving sections
   – Pavement-related factors
4. **The physical or climatic environment in which the vehicle operates** – wet or icy pavements, fog, etc

Causes of Transportation Crashes



Analysis of Crash Data

- The reasons for analyzing crash data are to:

1. **Identify** crash patterns that may exist,
2. **Determine probable causes** with respect to drivers, highways, and vehicles, and
3. **Develop countermeasures** that will reduce the rate and severity of future crashes.

- To facilitate the comparison of results obtained from either before and after the application of a safety countermeasure at a particular location, or comparison of safety conditions among different locations, one or more of the following procedures have been used.

1. Direct comparison of number of crashes
2. Direct comparison of crash rates
3. Crash patterns
4. Statistical comparison

Analysis of Crash Data

Direct comparison of crash rates

- ❖ These rates are determined on the basis of exposure data, such as traffic volume and the length of road section being considered.

- ❖ Commonly used rates are Crash Frequency (CF), Crash Rate (CR), Safety Performance Functions (SPFs), Crash Severity Ratio (CSR), etc.

Crash Frequency Measure (CF):

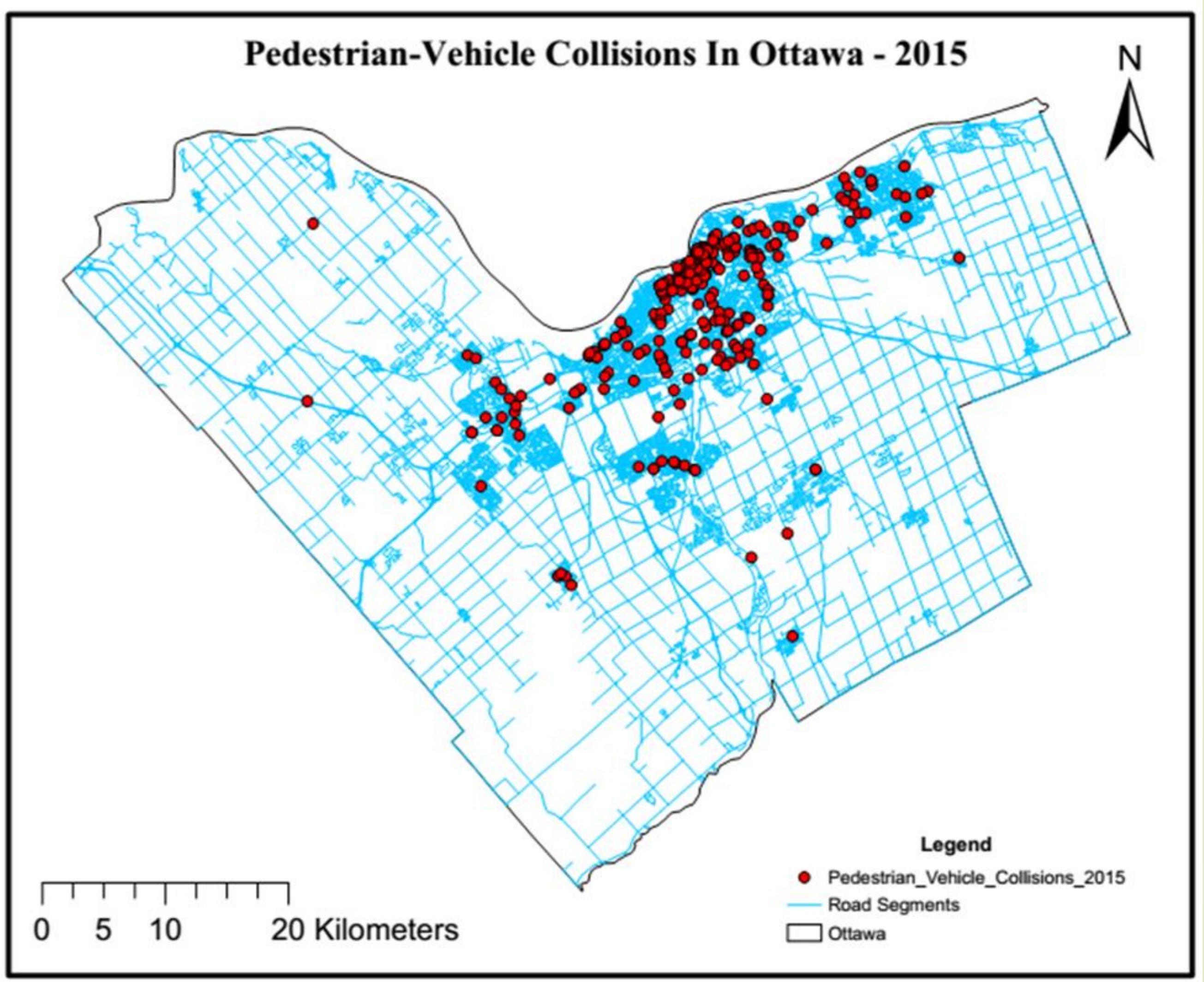
- ❖ The number of crashes per location during a specific time period (crash/year or crash/year/km)

- ❖ If the observed CF meets or exceeds a predefined value, the location is considered hazardous

- ❖ Such a predefined value varies by highway type and classification and area type (urban/rural)

Analysis of Crash Data

- ❖ One of the earliest methods of identifying hazardous locations is using a pin map:
  - – Each crash is identified by a pin on the map
  - – Different pin colours and sizes can be used to indicate crash types and severity
  - – From the map, locations which have clusters of crashes can be easily identified
  - – These are simply locations with high CF
- ❖ The process can be automated using a GIS software



Analysis of Crash Data

- The main advantage of the CF measure is that locations identified have a high number of crashes and consequently higher potential for crash reduction

- The disadvantage is that it does not account for the effect of traffic exposure

- Example:
  - 10 crashes/km may be considered high for a section with a 15,000 veh/d ADT
  - But considered low for another section with a 40,000 veh/d ADT

Analysis of Crash Data

- **Crash Rate (CR):**
- The number of crashes per million-entering-vehicles for intersections (crash/mev) or number of crashes per million-vehicle-kilometres (miles) for sections (crash/mvk(m))

Rate per Million of Entering Vehicles (RMEVs):

- The rate per million of entering vehicles (RMEVs) is the number of crashes per million vehicles entering the study location during the study period.

$$RMEV = \frac{A \times 1{,}000{,}000}{V}$$

where

$RMEV$ = crash rate per million entering vehicles

A = number of crashes, total or by type occurring in a single year at the location

V = average daily traffic $(ADT) \times 365$

This rate is often used as a measure of crash rates at intersections.

Analysis of Crash Data

Example

The number of all crashes recorded at an intersection in a year was 23, and the average 24-hr volume entering from all approaches was 6500. Determine the crash rate per million entering vehicles (RMEV).

$$RMEV = \frac{23 \times 1{,}000{,}000}{6500 \times 365} = 9.69 \text{ crashes / million entering vehicles}$$

Analysis of Crash Data

Rate per 100 Million Vehicle Kilometers (Miles) (RMVM):

❖ The rate per 100 million vehicle miles (RMVM) is the number of crashes per 100 million vehicle miles of travel. It is obtained from the expression:

$$RMVM = \frac{A \times 100{,}000{,}000}{VMT}$$

where

A = number of crashes, total or by type at the study location, during a given period

VMT = vehicle miles of travel during the given period

$= ADT \times$ (number of days in study period) $\times$ (length of road)

This rate is often used as a measure of crash rates on a stretch of highway with similar traffic and geometric characteristics.

Analysis of Crash Data

Example

It is observed that 40 traffic crashes occurred on a 17.5-mile long section of highway in one year. The ADT on the section was 5000 vehicles. Determine:

a. the rate of total crashes per 100 million vehicle-miles

b. the rate of fatal crashes per 100 million vehicle-miles, if 5% of the crashes involved fatalities

Solution:

$$\textbf{(a)}\ RMVM_T = \frac{40 \times 100{,}000{,}000}{17.5 \times 5000 \times 365} = 125.24 \text{ crashes/100 million veh–mi}$$

$$\textbf{(b)}\ RMVM_F = 125.24 \times 0.05 = 6.26 \text{ crashes/100 million veh–mi}$$

Analysis of Crash Data

- The advantage of the CR measure is that it allows comparisons between sites with similar characteristics but with different levels of exposure

- However, the CR measure introduces another bias when applied to low volume roads

- Example:
  - – 2 crashes/year may be considered low from a frequency point of view
  - – But may result in a high CR on a low volume road
  - – 2 crashes/year produce a CR = 2.03 crashes/mvk for a 1 km section with an AADT of 2,700 vpd

- Therefore, identifying hazardous locations using the CR may be misleading

Analysis of Crash Data

To Overcome Problems with CF and CR:

- ❖ To overcome the problems with using both CF and CR measures, alternative methods have been suggested

- ❖ The Frequency Rate Method uses both CF and CR to identify hazardous locations:

  – CF is used to select hazardous locations and CR is used to rank them

  – CR is used to select hazardous locations and CF is used to rank them

  – Locations are identified using double criteria, where a location must meet or exceed predefined values of CR and CF to be identified as hazardous

Analysis of Crash Data

Safety Performance Function:

- ❖ A safety performance function (SPF) is an equation used to predict the average number of crashes per year at a location as a function of exposure and, in some cases, roadway or intersection characteristics (e.g., number of lanes, traffic control, or median type).

- ❖ For highway segments, exposure is represented by the segment length and annual average daily traffic (AADT) associated with the study section

Crash Severity Ratio (CSR):

- ❖ CSR is a weighted proportion of fatal (F), injury (I), and property-damage-only (PDO) crashes to the total number of crashes

$$CSR = \frac{w_f \times F + w_i \times I + PDO}{F + I + PDO}$$

- ❖ By using the CSR, all crashes are weighted against the PDO crash, and is therefore known also as Equivalent PDO (EPDO)

Analysis of Crash Data

Other Road Safety Analysis Tools:

1. Rate Quality Control (RQC) method - An analytical method used in the identification of hazardous roadway locations.

    - RQC method assumes that collision frequency at a site within a period follows a Poisson distribution.

    - Other analytical methods include the Empirical Bayes' Method, Poison-Gammas Models, etc.

2. Safety Analyst - Developed by the cooperative efforts of American Association of State Highway and Transportation Officials (AASHTO) and Federal Highway Administration (FHWA), Safety Analyst is a software tool that aids highway agencies in the implementation of the highway safety management process. The software automates the earlier discussed RSIPs

Analysis of Crash Data

3. Interactive Highway Safety Design Model (IHSDM) - IHSDM Software is a toolset developed by the Federal Highway Administration (FHWA) to evaluate the performance of proposed or existing highway designs.

4. **GIS** - GIS is a specialized computer program designed for collection, storage, manipulation, retrieval and analysis of spatial data.

   - One particular application of GIS is in Hotspot Analysis. Hot Spot Analysis is the process of identifying areas showing higher or lower than normal behavior based on the available type of spatial data.

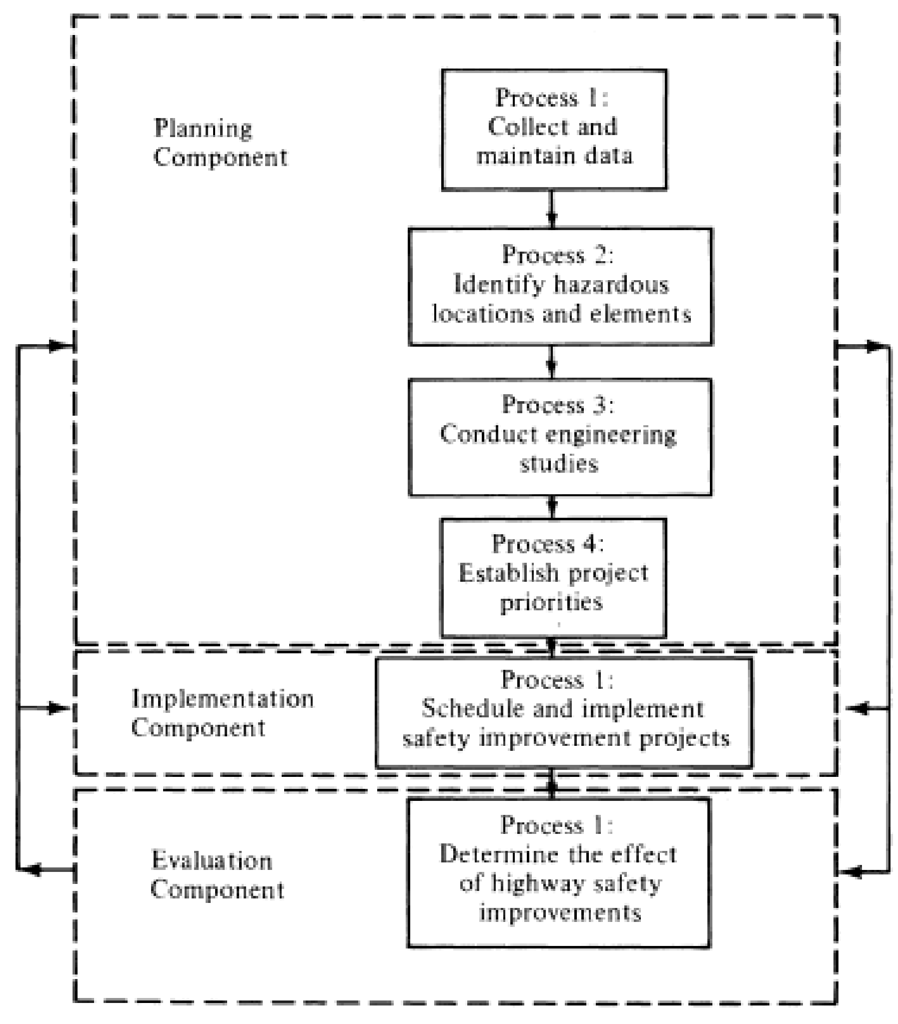
   - The statistical technique used in the analysis is mostly determined by type of spatial data available and the required output format. Two common hot spot analysis techniques are the Kernel Density Estimation (KDE) and the Hot Spot Analysis Tool (Getis-Ord Gi*)

Analysis of Crash Data

- A disadvantage of the quality control technique is considering the expected number of crashes at a site to be deterministic
- In reality, the number of crashes at a site is a random variable which fluctuates around some unknown mean
- A site with a low crash rate in the long run may still have a high crash rate over a short period of time and vice versa, that is the identification of hazardous locations is an inexact science
- The Bayesian analysis has the advantages of:
  - – Treating crash measures at any particular location as random variables
  - – Combining regional crash characteristics with site-specific crash histories
- Hazardous locations are identified based on the probability that crash rate or frequency exceeds a predefined level
- Two main assumptions:
  - – Number of crashes at a particular location follows Poisson distribution
  - – The probability distribution of the regional crash measure (the prior distribution) is the Gamma distribution

Strategic Highway Safety Plans

- **Strategic Highway Safety Plans (SHSP)** are a processes through which each transportation agencies identify its key safety needs such that investment decisions made achieve significant reductions in highway fatalities and serious injuries on public roads. SHSP include:
  - i. Road Safety Improvement Programs (RSIPs) - Black Spot Programs
  - ii. Highway Design Audits



Highway Safety Improvement Program at the Process Level

Strategic Highway Safety Plans

Road Safety Improvement Programs

- Road Safety Improvement Programs (RSIP's), are an example of SHSP. The specific objectives of RSIP include:
  1. **Location identification** (detection):
     – Which locations that are considered hazardous? A hazardous location is any location that exhibits higher potential for collisions than an established norm
     – The problem location can be a specific site (intersection or short road section) or relatively broader (route or area)
     – The higher potential for collisions can be expressed in terms of any crash measure
  2. **Problem identification** (diagnosis):
     – What causes the identified locations to be hazardous?
  3. **Solution identification** (remedy):
     – Given these locations and their problems, what countermeasures are effective to alleviate the problem?
- RSIP are an example of "black spot programs" used to identify hazardous locations

Strategic Highway Safety Plans

- According to the HSM, roadway safety management should involve six steps:
  1. Network screening: identify and rank locations with potential for safety improvement
  2. Diagnosis: identifying causes or contributing factors to collisions
  3. Select countermeasures: suggest treatments at the identified locations
  4. Economic appraisal: economic analysis to identify economically justifiable projects
  5. Prioritize projects: prioritize economically justifiable projects within the available budget based on the potential for safety improvement
  6. Safety effectiveness evaluation: evaluate effectiveness of implemented countermeasures for future use

Strategic Highway Safety Plans

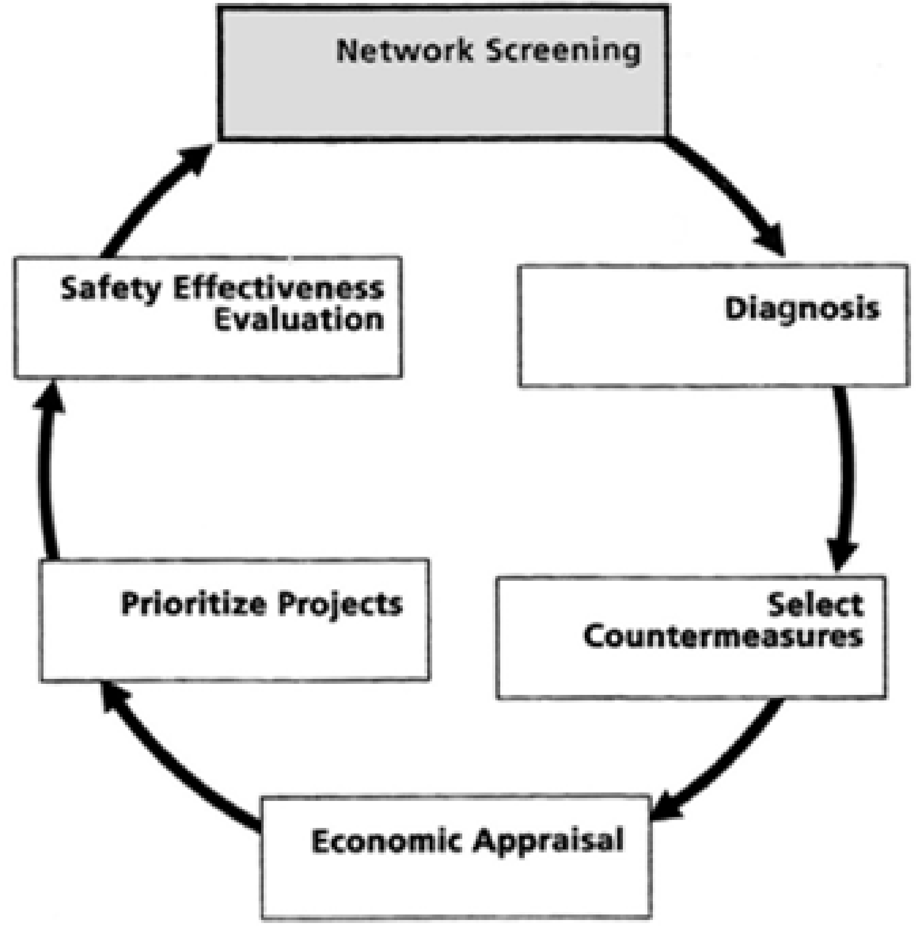


Figure 5.1 Roadway Safety Management Process

SOURCE: From *Highway Safety Manual* 1st Edition, 2010, AASHTO, Washington, D.C. Used by permission.

Thank You!!!