Traffic Safety Principles

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Injury, “Accident” & the Science of Road Safety

The Science of Traffic Crashes
Theory

Charles Perrow (1980s...)

“...what is attributed to operator error stems primarily from the structure they operate in, and thus, stems from the actions of elites”

‘Normal Accidents’

William J. Haddon (1960s .....)

- “accident” vs “injury control”

- “accident prevention” too limiting

- “injury” a disease public health approach
Experience

➢ Highly motorized country (HMC) success in controlling RTIs - post 1970s
➢ No less motorized country (LMC) particularly successful in controlling RTIs
➢ Policy makers in every country find it very difficult to institute changes which reduce road traffic injuries
➢ Individuals do not follow all the instructions given to them
➢ Propaganda and “education” not very successful

➢ Theoretical base of RTC control in HMCs not widely understood or appreciated
Products, environment and regulations should be designed such that:

- People on their own find it convenient to behave in a safe manner
- People should be able to behave safely without harming their basic needs to earn a living
- Safe behaviour should not prevent people from fulfilling societal obligations
- Road safety is a fundamental human right
➢ There is no fundamental difference between injuries and the occurrence of any other disease.

➢ Injury can be defined as a disease that results from an acute exposure of the human body to transfer of energy from the environment around it.

➢ “Accidents” and injuries are not acts of God.

➢ All injuries cannot be prevented.
Definitions

Prevention

• Reducing the incidence of the disease

• Reducing the prevalence of the disease

Control

• Ongoing programmes that reduce and prevalence
A Model of Injury Control

Monitor incidence
Identify risk factors
Intervene
Evaluate

Rates
Who
Location
Why
Cost
Where
When
How
Comparative Epidemiology of Malaria and Skull Fracture (as sustained by an unhelmeted motorcyclist crashing into a tree)

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>Host</th>
<th>Agent</th>
<th>Vector/Vehicle</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Man</td>
<td>Plasmodium sp.</td>
<td>Mosquito</td>
<td>Mosquito bite</td>
</tr>
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<td>Skull Fracture</td>
<td>Man</td>
<td>Mechanical energy</td>
<td>Motorcycle</td>
<td>Crash with tree</td>
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</table>
Traffic Death Rates: High Income Countries (OECD)

Source: death registration data

Research Centres

Independe

Agence

Research

Centres

New vehicle/road standards

Seatbelt Helmet Speed Alcohol

Source: death registration data

Graph showing trends in road traffic death rates per 100,000 population from 1950 to 2010 for various countries in the OECD. The graph highlights the impact of new vehicle/road safety standards, seatbelt usage, helmet use, and speed limits on reducing traffic death rates.
INDIA: OFFICIAL STATISTICS

Amended MVA 2019

Supreme Court Committee 2014

Sundar Committee 2005-7

MVA 1989
NHAI Act 1988

C 1934
IRA 1939

Year

Fatalities
Fatalities per 100,000 persons

RTI fatalities per 100,000 persons

Estimated 30,00,000 hospitalised in 2018
Road Safety Policy Models

Intuitive model

(penalties, education, driver training, licensing)

Vehicle centric model

(vehicle standards for occupants, road standards vehicles),

Human Centric model

(road design, city planning for Limitations of the road users)
Discussion on a paradigm shift

Relative contribution

Driver failures: 'excess'

'System' failures driver / vehicle / road

Driver failures: inexperienece
Our fundamental road safety problem

- Today’s road traffic is inherently unsafe
- The road system of today has not been designed with safety in mind, as is the case with air transport or rail transport
- Which means we are almost fully dependent on whether a road user makes a mistake or error in preventing a crash
- Another approach is needed: Safe System Approach
Systems Approach

• Structural analysis of injury producing systems

• Focus is on the injury causing properties of systems rather on the errors of owners, designers, operators.

• Moving away from conventional explanations which are myopic overlooking the interrelationships between the various components of the system.
Key Principles of Safe System Approach (SSA)

• Principle 1: Recognition of human frailty
• Principle 2: Acceptance of human error
• Principle 3: Creation of a Forgiving environment and appropriate crash energy management.

Thus design of roads play an important role in road safety and improved geometric design of road infrastructure could in turn improve road safety.
SAFE SYSTEM APPROACH

- Forgiving roads/streets
- Speed management by design
- Forgiveing roads/streets
Road Safety Theories (Elvik, 2004)

- Engineering Effect
- Behavioural Adaptation

- Improved lighting: Improves visibility - Engineering effect
- Road users tend to be less alert - behavioural adaptation
PHYSICAL FORGIVINGNESS

- Forgiving road (side) environment
  - Matted (hard and semi-hard) shoulders
  - Obstacle-free zones
  - Shielded obstacles
Impact angle, Kinetic energy and travel speed

![Graph showing the relationship between transferable kinetic energy (lateral) and impact angle for different travel speeds. The graph indicates that kinetic energy decreases as the impact angle increases.]
Roundabout safety

Roundabout

- 8 Vehicle conflicts
- 8 Pedestrian conflicts

Intersection

- 32 Vehicle conflicts
- 24 Pedestrian conflicts
Measures to enhance road safety

• Speed control
• Containment
• Protection from road side hazards
• Information through markings, signage
• Traffic Management
Speed and Safety

• Driving speed, is one of the behaviors affected by the driver’s perception of the road’s safety, and it is not necessarily compatible with the road’s design speed (Misaghi and Hassan, 2005).

• If a road design is very forgiving – i.e., wide shoulders, wide lanes, and no curves – the drivers’ confidence will rise and they will compensate by speeding (Shinar, 2007).

• If the speed chosen is not appropriate in a given situation, it may result in lose control and run-off-road accidents (Janssen et al., 2006).
Injury is a disease that results from an acute exposure of the human body to transfer of energy from the environment around it.

Energy

- Chemical
- Electrical
- Mechanical
- Thermal
- Radiation

Injury severity

\[ F = ma \]
\[ a = \frac{V^2}{2s} \]
\[ \sigma = \frac{F}{A} \]
For Acceleration
\[ V_f^2 = V_i^2 + 2as \]

For Deceleration
\[ V_f^2 = V_i^2 + 2(-as) \]

In case of impact, final velocity = 0

\[ 0 = V_i^2 - 2as \]

OR

\[ a = \frac{V^2}{2s} \]
Injury is a disease that results from an acute exposure of the human body to transfer of energy from the environment around it.

Energy ➔ Injury severity

- Chemical
- Electrical
- Mechanical
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- Radiation

\[ F = ma \]
\[ a = \frac{V^2}{2s} \]
\[ v = \frac{F}{A} \]
**Typical Crash Analysis**

- Car approaches road junction and goes through red light which has just turned red.
- Hits motorcyclist, and then hits median.
- Motorcyclist gets thrown sideways, hits pedestrian walking on road.
- Car driver gets facial injuries, motorcyclist head injuries, and pedestrian leg fracture.

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<tr>
<th>Time</th>
<th>Cause</th>
<th>Solution</th>
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<td></td>
<td>• Rash and negligent driving by car driver</td>
<td>• Driver, pedestrian education</td>
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<td>• Pedestrian walking on the road</td>
<td>• Strict punishment</td>
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**Motorcycle Crash**

\[ T \text{ (duration of crash - 100-200 ms)} \]
# Scientific Crash Analysis

## Haddon’s Matrix

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Scientific Crash Analysis
Cell 1
Preventing the possibility of a crash: Human error based measures

- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C
- Drunk

Duration of Crash

No crash
Less or no injury
Reduce outcome

Time
## Scientific Crash Analysis
### Haddon’s Matrix

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Scientific Crash Analysis

Cell 2

Preventing the possibility of a crash:
Vehicle based measures

Countermeasure
- Disc brakes
- Daytime headlights, daytime compulsory use
- Very visible M/C
- Speed limiters
- Automatic breaking
- Pedestrian detection

- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

Time

No crash

Reduce outcome

Duration of Crash

Less or no injury
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Preventing the possibility of a crash: Environment based measures

- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C
- Disc brakes
- Headlights, daytime compulsory use
- Very visible M/C
- Speed limiters
- Countermeasure
  - Vigilant policing
  - Red light cameras
  - Bright illumination of crossings
  - Adequate sidewalks
  - No left turn on red
  - Alcohol checking
  - Use of roundabouts
- Duration of Crash
  - Reduce outcome
  - Less or no injury

Time
## Scientific Crash Analysis

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Scientific Crash Analysis

Cell 4

Preventing injuries during the crash: Human victim based measures

- Vigilant policing
- Red light cameras
- Bright illumination of crossings
- Adequate sidewalks
- No left turn on red
- Alcohol checking
- Use of roundabouts
- Disc brakes
- Strong headlights
- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

Countermeasures
- Protective clothing
- Helmets

- No crash
- Less or no injury
- Reduce outcome

Duration of Crash

Time
Scientific Crash Analysis  
Haddon’s Matrix

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Scientific Crash Analysis
Cell 5

Preventing injuries during the crash: Vehicle based measures

- Vigilant policing
- Red light cameras
- Bright illumination of crossings
- Adequate sidewalks
- No left turn on red
- Alcohol checking
- Use of roundabouts
- Disc brakes
- Strong headlights
- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

Counter-measures
- Airbags, Seat belts
- Crashworthiness

Counter-measures
- Protective clothing
- Helmets

No crash ➔ Reduce outcome
Less or no injury ➔ Duration of Crash

Time
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Scientific Crash Analysis
Cell 6

Preventing injuries during the crash: Environment based measures

- Vigilant policing
- Red light cameras
- Bright illumination of crossings
- Adequate sidewalks
- No left turn on red
- Alcohol checking
- Use of roundabouts
- Disc brakes
- Strong headlights
- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

Counter-measures
- Airbags, Seat belts
- Safer fronts
- Smooth railings
- No sharp edges

Duration of Crash

Less or no injury

No crash

Reduce outcome
## Scientific Crash Analysis
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Managing injuries after the crash: Victim based measures

- Vigilant policing
- Red light cameras
- Bright illumination of crossings
- Adequate sidewalks
- No left turn on red
- Alcohol checking
- Use of roundabouts
- Disc brakes
- Strong headlights
- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

- Airbags, Seat belts
- Safer fronts

- Smooth railings
- No sharp edges

- Protective clothing
- Helmets

- First Aid
- Treatment
- Rehabilitation

Duration of Crash

Less or no injury

Time
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Cell 8
Managing injuries after the crash: Vehicle based measures

- Vigilant policing
- Red light cameras
- Bright illumination of crossings
- Adequate sidewalks
- No left turn on red
- Alcohol checking
- Use of roundabouts
- Disc brakes
- Strong headlights
- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

- Airbags, Seat belts
- Safer fronts
- Smooth railings
- No sharp edges

Countermeasures
- Automatic s/o
- No fuel leakage

- Protective clothing
- Helmets

No crash

- First Aid
- Treatment
- Rehabilitation

Reduce outcome

Duration of Crash

Less or no injury

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Managing injuries after the crash: Environment based measures

- Vigilant policing
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- Use of roundabouts
- Disc brakes
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- Very visible M/C
- Speed limiters
- Training of drivers
- Pedestrians to walk facing traffic
- Bright clothing M/C

- Airbags, Seat belts
- Safer fronts
- Protective clothing
- Helmets

Counter-measures
- Clear the scene
- Police system
- Hospital, Rehab Ctrs

- Smooth railings
- No sharp edges
- Automatic s/o
- No fuel leakage
- First Aid
- Treatment
- Rehabilitation
- Hospital, Rehab Ctrs

Duration of Crash
Less or no injury
Reduction outcome

Time
Conclusion/way forward

........realization of vision zero also requires generation of new knowledge and establishing a process which enables generation of new knowledge to ensure safe highways in LMICs. Given the complexity of traffic safety science and its implementation in field, continuous experimentation is required in LMICs to develop safe highways based on the principles of safe systems approach.
Questions?