Vulnerable Road Users and Traffic Calming

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Share of deaths by road users – global, WHO 2018
Road safety status in India, 2019

Official data reports (Ministry of Road Transport and Highways 2022) –

- 1,68,491 persons were killed in 2022.
- Reported increase in road deaths from -
  - 11.7 deaths per 100,000 population => 2018
  - 12.2 deaths per 100,000 population => 2022
  - While the WHO estimates 22.2 road related deaths per 100,000 population in 2018.

- Road-related injuries are 13th largest contributor to health burden in India.
- Amongst working population, it is the 6th largest contributor.
How people travel in Indian cities?
Vulnerability on urban roads

Fatalities by road users and population size, source FIR data

- Delhi (2018)
- Agra (2013-15)
- Amritsar (2013-15)
- Bhopal (2013-15)
- Ludhiana (2013-15)
- Vadodara (2013-15)
- Visakhapatnam (2013-...)
- Patiala (2015-2018)
- Bulandshahr (2015-...)

- Other
- Truck
- Bus
- Car & taxi
- Auto-rickshaw
- MTW
- Bicycle
- Pedestrian
- Population
Who is vulnerable on Indian Roads?

- The share of vulnerable road users is increasing
- There is under-reporting of vulnerable road users in reported officials
Vulnerability by age and gender

- Note: The fatality rate is not as same as exposure; exposure is related to how people travel.
Risk exposure is different from fatality rate or share of fatalities

<table>
<thead>
<tr>
<th>Mode</th>
<th>Car</th>
<th>MTW</th>
<th>Bus</th>
<th>IPT</th>
<th>Walk</th>
<th>Bicycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of total fatalities</td>
<td>1%</td>
<td>34%</td>
<td>2%</td>
<td>6%</td>
<td>49%</td>
<td>6%</td>
</tr>
<tr>
<td>Risk exposure (Total fatalities to total users by the mode)</td>
<td>0.021</td>
<td>0.073</td>
<td>0.003</td>
<td>0.022</td>
<td>0.029</td>
<td>0.045</td>
</tr>
</tbody>
</table>

**Risk Exposure – ex. Vizag – Vulnerable road users (VRUs)**

- Bicyclists have the highest risk of exposure to road related fatalities
Who hits who?

2011 - 2014 - Vishakhapatnam

- Pedestrians
  - MTW, Trucks, cars
- Bicyclist
  - MTW and Trucks
- MTW
  - Trucks
  - Car
  - Bus
  - IPT
  - MTW
Where does bicyclist fatalities take place?

50% of existing bicyclist fatalities occur on arterial roads in Vishakhapatnam.

Improving safe conditions on arterial roads can help in reducing risks to bicyclists.
## Infrastructure development and change in fatality rates

<table>
<thead>
<tr>
<th>City</th>
<th>Years</th>
<th>Growth in Bikeway Network, %</th>
<th>Growth in Bicycle Trips, %</th>
<th>Change in Crashes per 100 000 Trips, %</th>
<th>Change in Fatalities and Severe Injuries per 100 000 Trips, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland, OR</td>
<td>2000–2015</td>
<td>53</td>
<td>391</td>
<td>−62</td>
<td>−72</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>2000–2015</td>
<td>101</td>
<td>384</td>
<td>−46</td>
<td>−50</td>
</tr>
<tr>
<td>New York, NY</td>
<td>2000–2015</td>
<td>381</td>
<td>207</td>
<td>NA</td>
<td>−72</td>
</tr>
<tr>
<td>Minneapolis, MN</td>
<td>2000–2015</td>
<td>113</td>
<td>203</td>
<td>−75</td>
<td>−79</td>
</tr>
<tr>
<td>San Francisco, CA</td>
<td>2000–2015</td>
<td>172</td>
<td>167</td>
<td>−36</td>
<td>NA</td>
</tr>
<tr>
<td>Cambridge, MA</td>
<td>2000–2015</td>
<td>27</td>
<td>134</td>
<td>−57</td>
<td>NA</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>2005–2015</td>
<td>135</td>
<td>167</td>
<td>−54</td>
<td>−60</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>2005–2015</td>
<td>130</td>
<td>114</td>
<td>NA</td>
<td>−43</td>
</tr>
<tr>
<td>Philadelphia, PA</td>
<td>2008–2015</td>
<td>17</td>
<td>51</td>
<td>NA</td>
<td>−49</td>
</tr>
</tbody>
</table>

Source: Buehler and Dill (2015)
Safety is linked with other sustainable development goals

SDG 3 (PROMOTE HEALTH), SDG 5 (GENDER EQUALITY), SDG 7 (EQUAL AND AFFORDABLE ACCESS TO CLEAN ENERGY), SDG 10 (SUSTAINABLE AND RESILIENT INFRASTRUCTURE), SDG 11 (SUSTAINABLE CITIES AND COMMUNITIES)
Who is vulnerable on road – relation between gender, income and mobility?

Modal shares amongst SEWS groups by gender

- Car
- MTW
- Auto Rickshaw
- Bus
- Bicycle
- Walk

Most vulnerable

Low SEWS | Low-middle SEWS | Middle-high SEWS | Very-high SEWS | Low SEWS | Low-middle SEWS | Middle-high SEWS | Very-high SEWS

Females | Males
Key understanding

The burden of safety is distributed unequally between different groups of society.

Most vulnerable by total fatalities are pedestrians and two-wheelers.

Most vulnerable by the risk of exposure are two-wheelers, bicyclists, and pedestrians.

Pedestrians and bicyclists belong to lower income group.

Walking is more undertaken by women.

The groups of society does not have access to other modes.

Prof. Mohan – It’s the responsibility of society and community to provide safe access to all.
Accidents do not happen accidentally
• Various components in which road users are exposed are designed
• Traffic typology, design of geometries, infrastructure environment affect road users safety

It is the responsibility of the state to design and provide for safe road user environment

System—based approach
• There is linear and non-linear interaction between multiple components
• Feedback loops complicate the system’s understanding
• Improvement in one sub-system may not result in improvement in the overall system.

Therefore, less is known about the effectiveness of strategies for improving road safety

Errors can happen - Need for forgiving roads
• Need to understand road users’ frailty
• Errors can happen by human or by system

System needs to account for all types of errors to ensure safety of road users
Road crashes and related injury depend on three factors

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Accident/crash Rate</th>
<th>Injury Severity</th>
</tr>
</thead>
</table>
| • the amount of activity in which crash may occur  
  • the amount of travel,  
  • the number of person kilometres of travel performed  
  • Depends on type of mode used | • Risk of crashes per unit of exposure  
  • Probability of occurring an crashes  
  • Risk of crash, level of risk or crash risk  
  • Depends on type of transport infrastructure, traffic control devices, vehicles type and road users | • Outcome of crashes in terms of injuries to people and damage to property  
  • Usage of safety equipment like helmets by road users  
  • Speed of vehicles and vehicle mass  
  • Design of vehicles, including materials |
How to address safety of VRUs?

- Infrastructure design
- Environment design
- Safe road user

**Pedestrians**
- Infrastructure
- Environment

**Bicyclists**
- Infrastructure
- Environment
- Protection gears

**Two-wheelers**
- Infrastructure
- Vehicles
- Protection gears
Understanding VRU in Delhi
Fatalities by type of road users

Percentage of total fatalities:

- Pedestrian: 45%
- MTW: 40%
- Car: 5%
- M3W: 5%
- Bicycle: 5%
- Other: 0%
- Bus: 0%
Fatalities by road users type by infrastructure
Majority is vulnerable
Treatment shall vary by cities
Understanding vulnerability of pedestrians – vehicle design

Source: Subramanian and Chawla (2011), Optimization of vehicle front for safety of pedestrians
Understanding pedestrians’ vulnerability – speed of vehicles

Source: Kroyer (2015), Is 30 km/h a ‘safe’ speed? Injury severity of pedestrians struck by a vehicle and the relation to travel speed and age
Urban speed limit laws

Source: WHO 2015
Need, issues and challenges

Non existing infrastructure in most of the places.

Need to share same space by different modes of transport that vary by

- speed
- size
- mass
- usage, etc.
However, on roads in Indian scenario, all types of users share one space, with pedestrians exposed to multiple conflicts in difficult weather conditions.
Challenges of widening road infrastructure

- Inaccessible road infrastructure
- Vehicle centric approach for development
- Designing for minimum users
How existing infrastructure adds to vulnerability?
Same area, when people try to cross roads
CROSSING FACILITIES DO NOT ADDRESS THE NEED OF MAJORITY
WHAT IS THE KIND OF STREET LIGHTING IS APPROPRIATE?
Risk factors for pedestrians

- Inadequate visibility of pedestrians
- pedestrian-vehicle conflict at pedestrian crossing points;
- reduced reaction time and reduced walking speed for the elderly;
- inability of children to gauge vehicle speed and other relevant information in order to cross the street safely alone;
- lack of supervision of children who are too young to make safe judgements;
- pedestrian distraction, including mobile phone use (see Box 1.3);
- attitudes of drivers and pedestrians;
- failure of drivers to respect right-of-way for pedestrians, including failure to yield at pedestrian crossings;
- vehicle condition and defects (e.g. brakes, lighting, windscreen); and
- quiet (electric) vehicles, whose presence cannot be detected by normal auditory means.
Risk Factors

• Pedestrian facilities such as footpaths, safe crossing facilities are not present in most Indian cities. Even when present, their poor maintenance and poor construction quality make them unusable. As a result, pedestrians are forced to share the road space with motorized vehicles and to cross the roads where there is no safe pedestrian crossing.

• Night-time travel is one of the greatest risk factors for pedestrians.
Measures

Traffic control measures

3.1 Area-wide traffic calming
3.2 Environmental streets
3.3 Pedestrian streets
3.4 Urban play streets
3.5 Access control
3.6 Priority control
3.7 Yield signs at junctions
3.8 Stop signs at junctions
3.9 Traffic signal control at junctions
3.10 Signalised pedestrian crossings
3.11 Speed limits
3.12 Speed-reducing devices
3.13 Road markings
3.14 Traffic control for pedestrians
3.15 Stopping and parking control
3.16 One-way streets
3.17 Reversible traffic lanes
3.18 Bus lanes and bus stop design
3.19 Dynamic route guidance

General policy measures

10.1 Organisational measures
10.2 Information for decision-makers
10.3 Quantified road safety targets and road safety programmes
10.4 Safe community programmes
10.5 Exposure control
10.6 Land use plans (urban and regional planning)
10.7 Road plans and road construction
10.8 Road safety audits and inspections
10.9 Motor vehicle taxation
10.10 Road pricing
10.11 Changes in the modal split of travel
10.12 Road traffic legislation
10.13 Regulating commercial transport
For pedestrian and bicyclists safety:

- Traffic reduction
- Speed reduction
- Junction treatment
- Redistribution of road space
- Provision of special facilities like pedestrian island and bicycle box
### Reduce Pedestrian Exposure To Vehicular Traffic

<table>
<thead>
<tr>
<th>Examples of interventions</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proven</td>
</tr>
<tr>
<td>Provide sidewalks</td>
<td>Yes</td>
</tr>
<tr>
<td>Install and/or upgrade traffic and pedestrian signals</td>
<td></td>
</tr>
<tr>
<td>Construct pedestrian refuge islands and raised medians</td>
<td>Yes</td>
</tr>
<tr>
<td>Construct enhanced marked crossings</td>
<td></td>
</tr>
<tr>
<td>Provide vehicle restriction/diversion measures</td>
<td></td>
</tr>
<tr>
<td>Install overpasses/underpasses</td>
<td></td>
</tr>
<tr>
<td>Improve mass transit route design</td>
<td></td>
</tr>
<tr>
<td>Reduce traffic volumes by switching journeys from the car to public transport, walk and cycle for distances and purposes where these options work well</td>
<td></td>
</tr>
<tr>
<td>Examples of interventions</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Proven</td>
</tr>
<tr>
<td>Reduce speed limit</td>
<td>Yes</td>
</tr>
<tr>
<td>Implement area-wide lower speed limit programmes, for example, 30km/hr</td>
<td>Yes</td>
</tr>
<tr>
<td>Implement road-narrowing measures</td>
<td></td>
</tr>
<tr>
<td>Implement speed management measures at road sections</td>
<td></td>
</tr>
<tr>
<td>Install speed management measures at intersections</td>
<td>Yes</td>
</tr>
<tr>
<td>Provide school route improvements</td>
<td></td>
</tr>
<tr>
<td>Implement roundabouts</td>
<td></td>
</tr>
<tr>
<td>Implement raised pedestrian crossings, rumble strips and texture change</td>
<td></td>
</tr>
<tr>
<td>Examples of interventions</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Provide crossing enhancements</td>
<td>Yes</td>
</tr>
<tr>
<td>Implement lighting/crossing illumination measures</td>
<td>Yes</td>
</tr>
<tr>
<td>Reduce or eliminate obstruction by physical objects including parked vehicles</td>
<td>Yes</td>
</tr>
<tr>
<td>Install signals to alert motorists that pedestrians are crossing</td>
<td>Yes</td>
</tr>
<tr>
<td>Improve visibility of pedestrians/ dedicated lighting on pedestrian paths</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Key strategies – crossings

- At grade crossing is the most preferred
- It is the best form of ensuring safe and comfortable crossing for pedestrians.
- Care can be taken to design pedestrian crossing that that lead to essential destinations.
Different road need different treatment

<table>
<thead>
<tr>
<th>Type of Road</th>
<th>Speed (km/hr)</th>
<th>Minimum Width (m)</th>
<th>Maximum Width (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Expressway</td>
<td>80</td>
<td>45-75</td>
<td></td>
</tr>
<tr>
<td>Arterial Road</td>
<td>50</td>
<td>45-60</td>
<td></td>
</tr>
<tr>
<td>Sub Arterial Road</td>
<td>50</td>
<td>30-45</td>
<td></td>
</tr>
<tr>
<td>Collector Street</td>
<td>30</td>
<td>15-30</td>
<td></td>
</tr>
<tr>
<td>Access Street</td>
<td>6 - 15</td>
<td>10-15</td>
<td></td>
</tr>
</tbody>
</table>
Traffic calming measures – IRC 99 : 2018

Traffic calming techniques

Active measures
- Physical Warnings
  - Rumble strips
  - Thumps
  - Humps

- Road design
  - Roundabout

- Vehicle design
  - Traffic circles
  - Staggering

Passive measures
- Electronic
  - Speed cameras
  - Electronic speed warning

- Manual
  - Police enforced
  - Electronic speed warning

- Visual
  - Gates
  - Signs
  - Markings
Active traffic calming measures

Physical warning
- Influences driver behavior by means of jerk or vibrations
  - Rumble strips
  - Speed Humps
  - Thumps

Lane narrowing
- Influences car drivers.
- Little to no impact on Motorized two wheelers.

Speed breakers
- Indicates driver about the impending inconvenience.
- Easy to place in any location.
- The degree of the effect varies by design and material.
Traffic calming measures
Types of speed breakers

**Circular humps**
- Moderate discomfort for cars and heavy vehicles need to move very slow.
- Flat surface can be connected with pedestrian footpaths.

<table>
<thead>
<tr>
<th>Desired Speed</th>
<th>Radius</th>
<th>Chord Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 km/hr</td>
<td>11 m</td>
<td>3.0 m</td>
</tr>
<tr>
<td>25 km/hr</td>
<td>15 m</td>
<td>3.5 m</td>
</tr>
<tr>
<td>30 km/hr</td>
<td>20 m</td>
<td>4.0 m</td>
</tr>
<tr>
<td>35 km/hr</td>
<td>31 m</td>
<td>5.0 m</td>
</tr>
<tr>
<td>40 km/hr</td>
<td>53 m</td>
<td>6.5 m</td>
</tr>
<tr>
<td>45 km/hr</td>
<td>80 m</td>
<td>8.0 m</td>
</tr>
<tr>
<td>50 km/hr</td>
<td>113 m</td>
<td>9.5 m</td>
</tr>
</tbody>
</table>

**Trapezoidal**
- Flat in center and ramps on both the sides.
- Moderate discomfort for cars and heavy vehicles need to move very slow.
- Flat surface can be connected with pedestrian footpaths.

**Rumble strips**
- To be provided where speed control is unavoidable.
- Examples – NH and SH
- To be placed across entire carriageway and paved shoulder.
Speed calming measures around pedestrian crossing example

• Raised zebra crossing at Lodhi Road, Delhi.
• Ramp from footpath leading to zebra crossing.
• Along with speed limit signages.
Traverse bar marking

- IRC 88:2018
- Treatment to alert and to reduce the speed.
- Number of sets of transverse bar markings depends on the speed.
- Each set comprises of 6 bars with 5 mm high
Textured paving over raised crossings
Uneven road surface
Feedback signs
Case examples
Patiala, Punjab

**Proposed design**

- **A.** Provided segregated area for the Vendors
- **B.** Median for dividing Road and slowing down/diverting vehicular traffic
- **C.** TSR Parking Bay for Auto rickshaws
- **D.** Parking Bay for 4 wheelers
- **E.** TSR Parking Bay for Auto rickshaws
- **F.** Parking Bay for 2 wheelers
- **G.** Raised crossing for the pedestrian crossing

**Existing situation**

- Petrol Pump Area
- 4&2 Wheelers parked and Vendors are standing
- Stadium Road
  - RDW – 16-20m
  - Two way, Divided Road
- Lower Mall Road
  - RDW – 24m
  - Two way, Divided Road
- Patiala - Mall Road
  - RDW – 36m
  - Two way, Divided Road
- Rajbaha Road
  - RDW – 30 m
  - Two way, Divided Road

**Map area details**

- Petrol Pump
- Road Width (RDW)
- Type of Road (Two way, Divided Road)
- Pilot corridor – key map
**Bulandshahr**

### KALA AAM JUNCTION

#### Issues
- No provision for current activities such as hawking and parking
- No safe/segregated infrastructure for pedestrians
- No safe pedestrian crossings
- Poor traffic circulation and conflicts due to missing junction geometry

#### Activity Survey

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2W</td>
<td>199</td>
</tr>
<tr>
<td>4W</td>
<td>23</td>
</tr>
<tr>
<td>Bicycle</td>
<td>68</td>
</tr>
<tr>
<td>E Rick</td>
<td>13</td>
</tr>
<tr>
<td>TSR</td>
<td>5</td>
</tr>
<tr>
<td>Hawkers</td>
<td>32</td>
</tr>
</tbody>
</table>

#### Type of Roads
- **Delhi Road**
  - ROW – 20-24m
  - Two way, Divided Road
- **Bulandshahr - Sayana Road**
  - ROW – 24m
  - Two way, Divided Road
- **DM Road**
  - ROW – 14m
  - Two way, Divided Road
- **Police Line Road**
  - ROW – 10m
  - Two way, Un-Divided Road
- **Preet Vihar Road**
  - ROW – 16-20m
  - Two way, Divided Road
- **Existing Roundabout**
**Bulandshahr - proposal**

**KALAAM JUNCTION**

**Proposal 1**

Because of central structure, junction already works as an unplanned rotary – better geometry can convert this to a modern roundabout increasing efficiency and safety.

Planned and designated 2-wheeler and 4-wheeler bays all around the junction to reduce congestion due to friction with parked vehicles.

Provision of raised crossing nearer to junction ensure the safety of crossing pedestrians.
Streets and its function

- Drive
- Walk
- Wait
- Shop
- Sit
- Cross
- Talk
- Play

Need for rethinking
Risk factor for MTW

- Speed
- Alcohol
- Road design and road maintenance
- Susceptibility of speeding and risky maneuvers
- Vehicle condition
- Engine size
Potential strategies

<table>
<thead>
<tr>
<th>Examples of interventions</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separate Motorcycle lane</td>
<td>Yes</td>
</tr>
<tr>
<td>Traffic markings, roadside installations</td>
<td>Yes</td>
</tr>
<tr>
<td>Exclusive stopping space (ESS) at signalized intersections</td>
<td>Yes</td>
</tr>
<tr>
<td>Traffic calming interventions</td>
<td>Yes</td>
</tr>
<tr>
<td>Antilock braking systems</td>
<td>Yes</td>
</tr>
<tr>
<td>Examples of interventions</td>
<td>Effectiveness</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td></td>
<td>Proven</td>
</tr>
<tr>
<td>Helmet wearing</td>
<td>Yes</td>
</tr>
<tr>
<td>Safety training of drivers /licensing</td>
<td></td>
</tr>
<tr>
<td>Alcohol drunk driving law</td>
<td>Yes</td>
</tr>
<tr>
<td>Interventions related to licensing</td>
<td>Yes</td>
</tr>
<tr>
<td>Improve sight distance and/or visibility</td>
<td></td>
</tr>
<tr>
<td>Daytime running lights and reflective clothing</td>
<td></td>
</tr>
<tr>
<td>Measure</td>
<td>Country</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Speed control measures like speed humps, rumble strips, signage and marking</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Helmet enforcement</td>
<td>India</td>
</tr>
<tr>
<td>Roundtable with table raised crossing</td>
<td>India</td>
</tr>
</tbody>
</table>
Thank you