Course Code: CE 455
Course Title: Traffic Engineering and Management

Lecture 5: Accident studies

Course Teacher: Saurav Barua (SB)

Assistant Professor, Dept. Of Civil Engineering, DIU

Contact No: 01715334075

Email: saurav.ce@diu.edu.bd

Outline

- Introduction to road accident black spot
- Highway safety mitigation framework
- Haddon Matrix
- Road accident in Dhaka city
- Accidents in highways of Bangladesh
- Risk factors
- Reasons for more accident in developing countries
- Urban intersection accident prediction
- Crash coding

Accident black spot

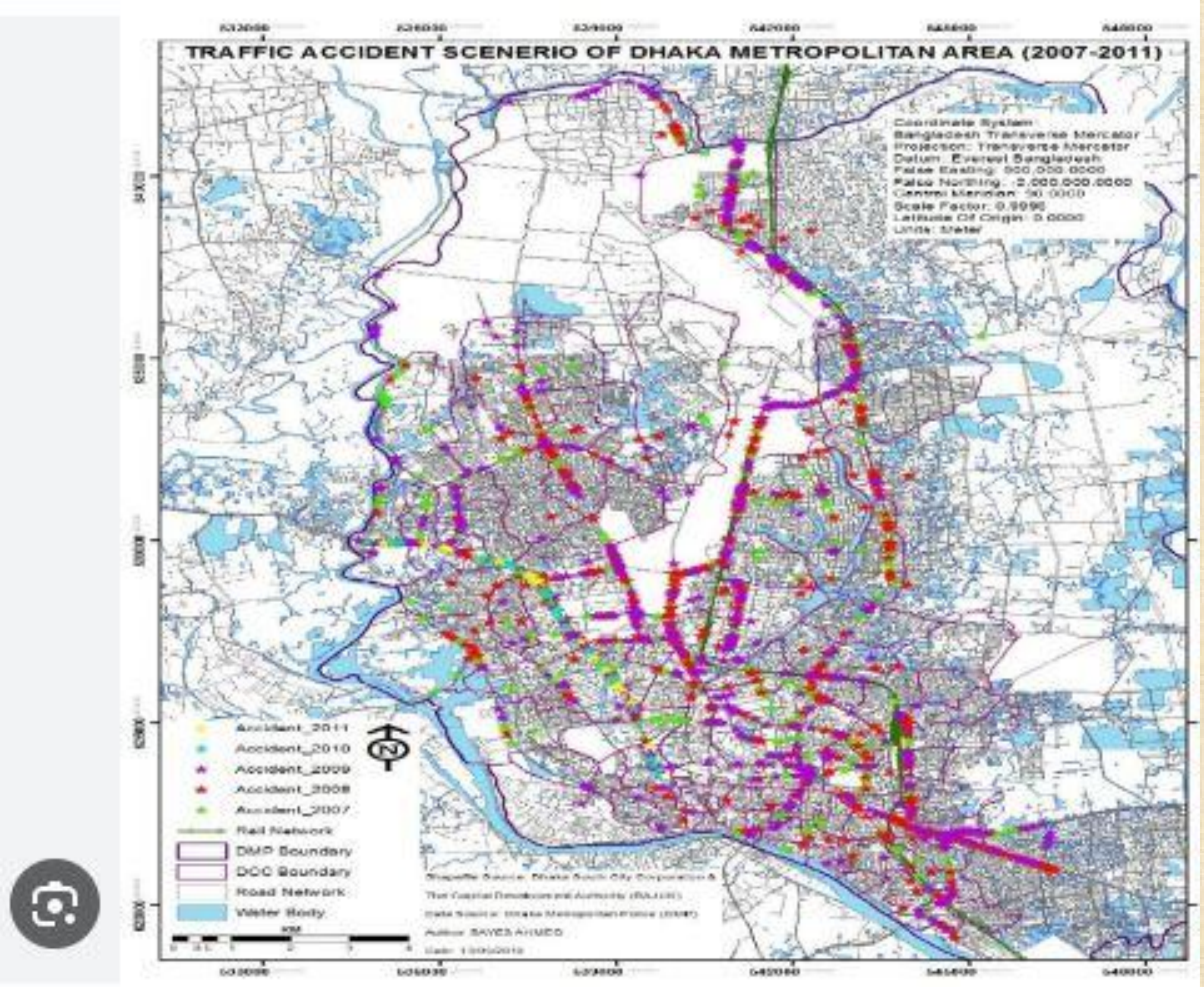
- In road safety management, an accident black spot or hotspot is a place where road traffic collisions have historically been concentrated.
- It may have occurred for a variety of reasons, such as a sharp drop or corner in a straight road, so oncoming traffic is concealed, a hidden junction on a fast road, poor or concealed warning signs at a crossroads.

Accident black spot

- For some decades treatment of accident black spots (e.g. by signage, speed restrictions, improving sightlines, straightening bends, or speed cameras) was a mainstay of road safety policy, but current thinking has it that the benefits of these interventions are often overstated.
- Effects such as regression to the mean, risk compensation and accident migration combine to reduce the overall benefit.

Traffic sign used in some countries to warn of an accident blackspot

Accident black spot sign in Marsaskala, Malta.



Road accident locations on the DMP map (2007-2011) | Download Scientific Diagram

Highway safety Framework

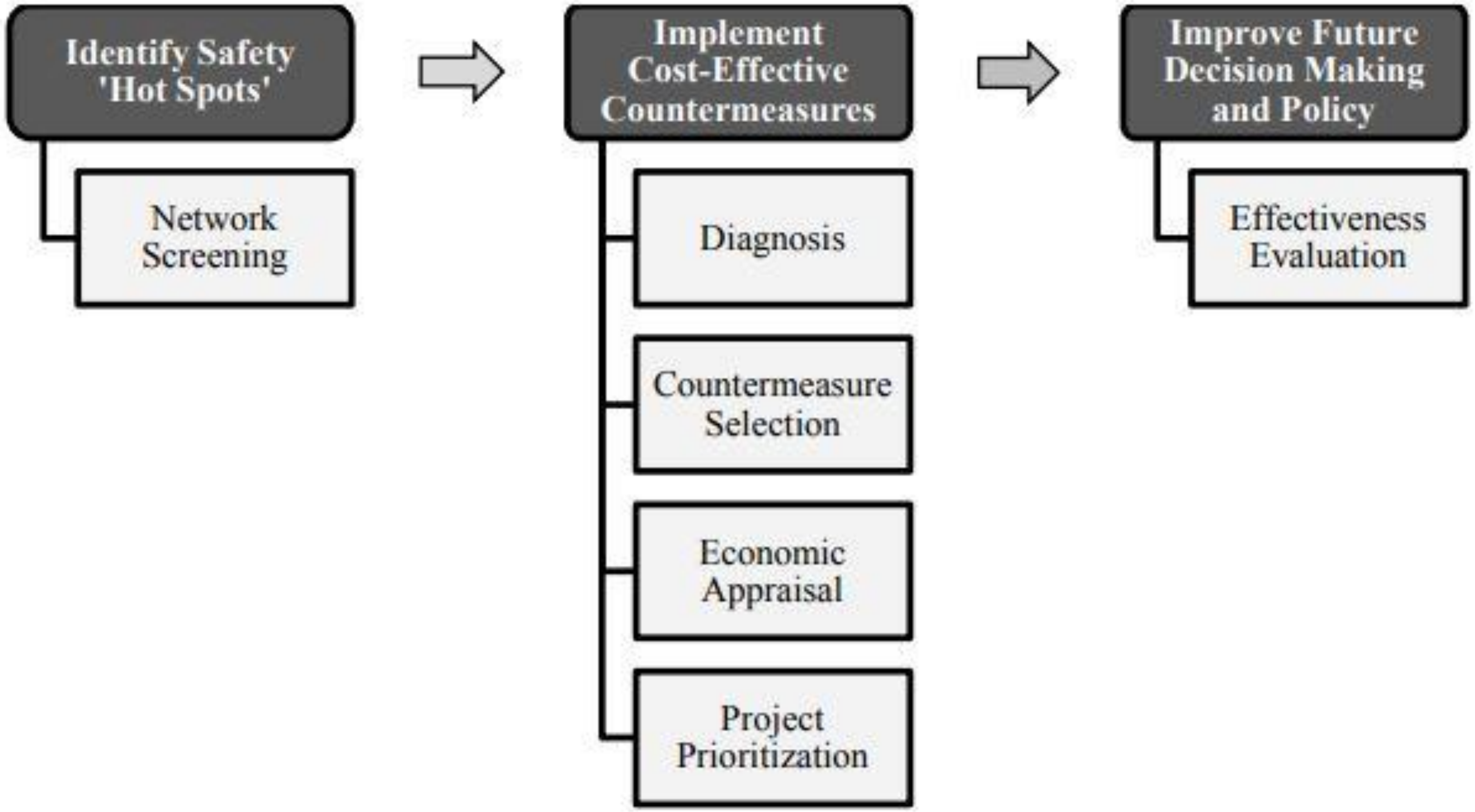


Figure 1-1: Framework for highway safety mitigation (Schultz et al 2011).

Haddon Matrix

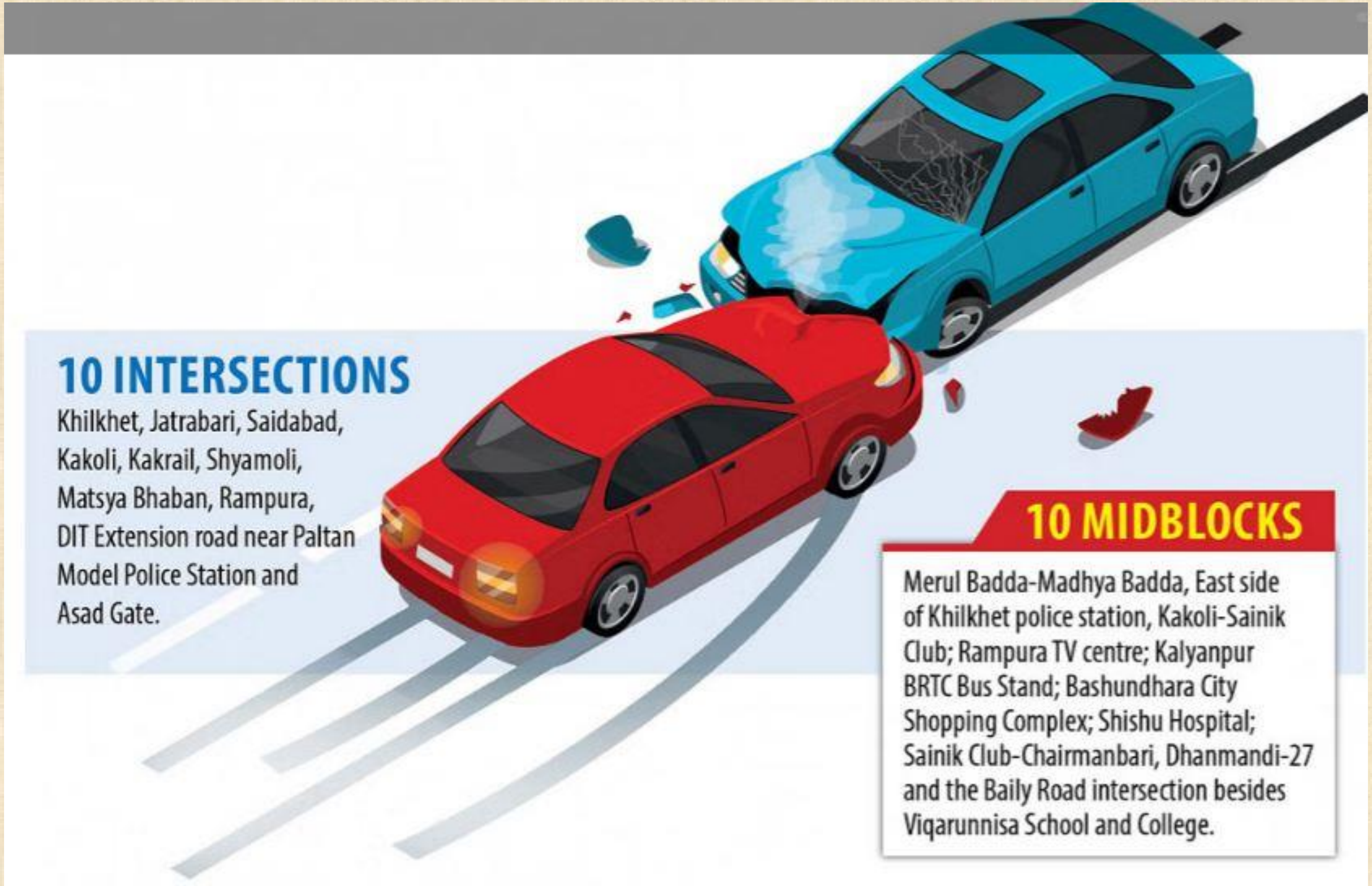
The **Haddon Matrix** is the most commonly used paradigm in the injury prevention field.

Developed by William Haddon in 1970, the matrix looks at factors related to personal attributes, vector or agent attributes and environmental attributes; before, during and after an injury or death. By utilizing this framework, one can then think about evaluating the relative importance of different factors and design interventions.[1]

A typical Haddon Matrix :

Phase	Human Factors	Vehicles and Equipment Factors	Environmental Factors
Pre-crash	• Information • Attitudes • Impairment • Police Enforcement	• Road Worthiness • Lighting • Braking • Speed Management	• Road design and road layout • Speed limits • Pedestrian facilities
Crash	• Use of restraints • Impairments	• Occupant restraints • Other safety devices • Crash-protective design	• Crash-protective roadside objects
Post-Crash	• First-aid skills • Access to medics	• Ease of access • Fire risk	• Rescue facilities • Congestion

Road accident prone locations in Dhaka



Source: Accident Research Institute (ARI) of BUET, Dhaka Transport Coordination Authority (DTCA) 2022

Problems of accident prone locations

- Uncontrolled road development and unplanned landscaping in urban areas have resulted in a disorganized and ineffective road network along with non-standard road geometric features, which leads to a poorly organized road transportation system in the city.
- sub-standard bus service, poor driving practice, lack of pedestrian or user discipline coupled with ill-designed and ill-maintained road infrastructure result in poor road safety situation.
- The diverse characteristics of traffic, and operating vehicles of varying speed and maneuvering time make the city's intersections more complex.

Accidents in highways of Bangladesh

- The loss to the workforce caused by road accidents across the country amounted to Tk 23,460 crore, and the figure would be more than 1.5% of the country's Gross Domestic Product (GDP) if the property damages are also taken into consideration.
- According to the organization, the number of road crashes and deaths last year were 27.14% and 22.74% higher than that of the previous 2021 year.

- Motorcycles were involved in 2,973 road crashes, which left 3,091 people dead last year. The figures were 43.53% and 40.07% of the total crashes and deaths that year.

Causes of road accidents

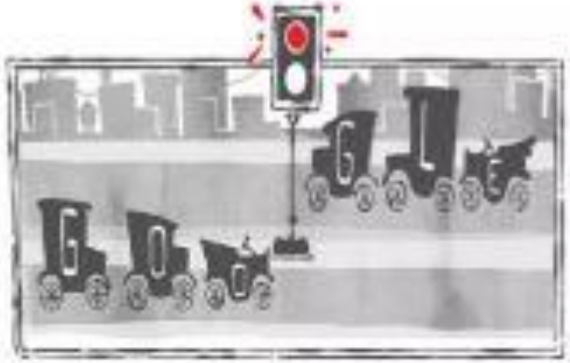
Major reasons behind road accidents, including

- faulty vehicles,
- speeding,
- unskilled and unfit drivers,
- unfixed working hours for professional drivers,
- operation of slow-moving vehicles on highways,
- reckless bike driving by youths,
- poor traffic management, and
- extortion in the transport sector.

Positioning of Country in Region (Compared to Countries with the Lowest Traffic Fatalities in the Region and Globally)

	2016 WHO Estimated Road Fatalities	2016 GBD Estimated Road Fatalities	2016 WHO Estimated Fatality Rate/100,000 pop.	2016 GBD Estimated Fatality Rate/ 100,000 pop.	% Trend in Fatality Rate/100,000 (2013-2016)	Motorization Registered Vehicles/100,000 pop.
Bangladesh	24,954	11,825	15.3	7.61	-4.4%	1,767
BEST PERFORMING COUNTRIES IN REGION						
Maldives	4	32	0.9	7.25	-4%	21,737
Pakistan	27,582	52,708	14.3	25.16	-3.1%	9,499
BEST PERFORMING COUNTRIES GLOBALLY						
Switzerland	223	334	2.65	3.89	-5.4%	71,182
Norway	143	215	2.72	4.09	2.4%	75,544
Singapore	155	197	2.76	3.53	-4.9%	16,604
Sweden	278	390	2.83	3.88	-3.2%	62,037

Risk Factors



1.Speed:

Pedestrians has 90% chance of surviving a car crash at 30Km/h or below.

Reducing respiratory problems associated with car emissions

2.Drink – Driving: Blood Alcohol Concentration(BAC)of 0.05g/dl or below reducing the alcohol related crashes.

Enforcing Sobriety Check points & Random breath testing can reduce 20%of alcohol related crashes.

Risk Factors Cont…

3. Motor cycle Helmets: Reduce the risk of death by 40% and risk of severe injury by 70%

Strict Laws should be enforced

4.Seat –Belts and Child Restriants:

Reduces risk of fatality among Front seat passengers by 40-50%

Rear –seat passengers by 25-75%

5. Mobile Phone usage - 4 times the risk of crash increases

Risk Factors – cont....

6.Factors influencing exposure to risk:

- Rapid motorization
- Demographic factors
- Transport, land use and road network planning
- Increased need for travel
- Choice of less safe forms of travel

7.Risk factors influencing crash involvement:

- Speed
- Pedestrians and cyclists
- Young drivers and riders
- Alcohol
- Medicinal and recreational drugs
- Driver fatigue
- Hand-held mobile telephones

Risk Factors – cont....

8.Risk factors influencing injury severity:

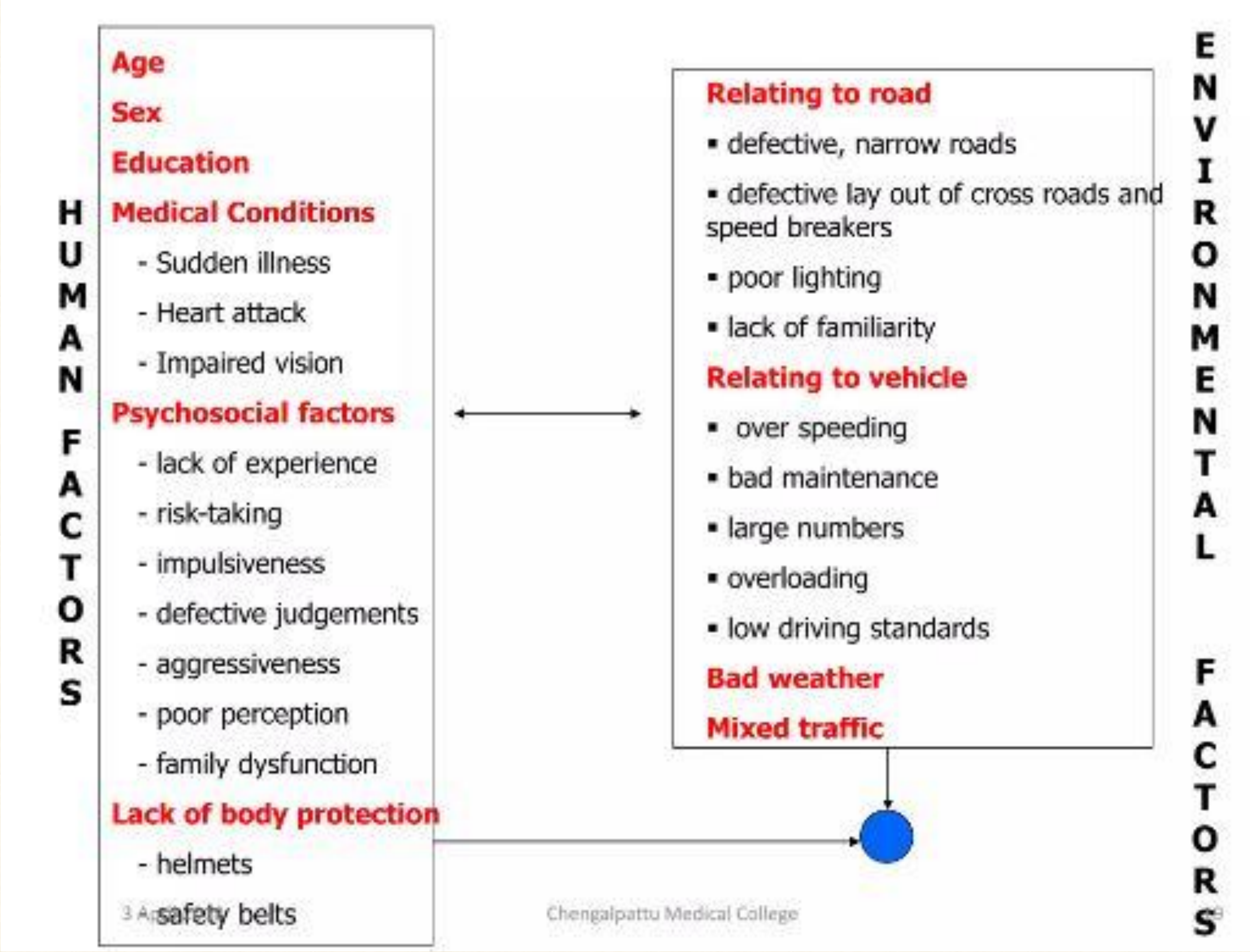
- Lack of in-vehicle crash protection
- Non-use of crash helmets by two-wheeled vehicle users
- Non-use of seat-belts and child restraints in motor vehicles
- Roadside objects

9.Risk factors influencing post-crash injury outcome:

- Pre-hospital factors
- Hospital care factors

Reasons for more Accidents in Developing countries

- Large numbers of pedestrians and animals share the common roadway
- Large number of old , poorly maintained vehicles
- Large numbers of buses often overloaded
- Large number of motor cycles, scooters and mopeds
- Low driving standards
- Widespread disregard of traffic rules
- Defective roads, poor street lighting, defective layout of cross roads and speed breakers
- Unusual behaviour of men and animals


HUMAN FACTORS
Age
Sex
Education
Medical Conditions
- Sudden illness
- Heart attack
- Impaired vision
Psychosocial factors
- lack of experience
- risk-taking
- impulsiveness
- defective judgements
- aggressiveness
- poor perception
- family dysfunction
Lack of body protection
- helmets
- safety belts
ENVIRONMENTAL FACTORS
Relating to road
▪ defective, narrow roads
▪ defective lay out of cross roads and speed breakers
▪ poor lighting
▪ lack of familiarity
Relating to vehicle
▪ over speeding
▪ bad maintenance
▪ large numbers
▪ overloading
▪ low driving standards
Bad weather
Mixed traffic
Chengalpattu Medical College

2.Safety education

- *‘If **Accident** is a disease, Education is its vaccine’*
- Initiated at the school level
- Educate regarding risk factors, traffic rules, safety precautions and first aid.

3.Promotion of safety measures

- Seat belts
- Safety helmets
- Safety measures for children
- Others like door locks, proper vehicle design ,air bags and so on

4.Alcohol and other drugs

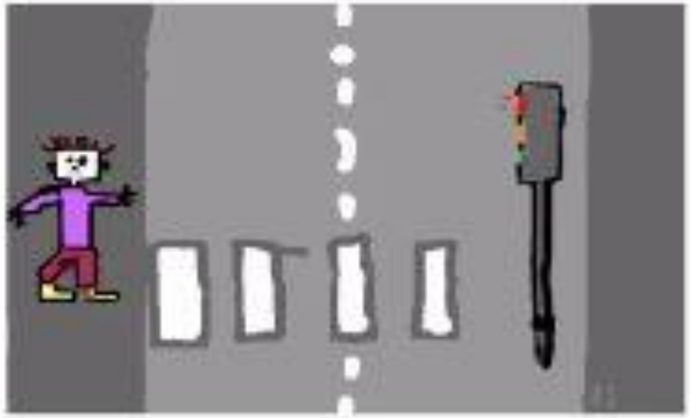
- Abstinence from alcohol and depressant drugs before and during driving
- Barbiturates , amphetemines and Cannabis –impairs driving ability
- Education
- Law enforcement

5.Primary care

- ✓ Planning, organization and management of trauma and emergency care services improved
- ✓ At accident site --→Transportation-→Hospital
- ✓ Skill of the Health Care Provider
- ✓ **Accident Services Organization** and one fully equipped specialised trauma care hospital in all major cities

6.Elimination of Causative factors

- Improve roads
- Impose speed limits
- Mixed Traffic
- Bad weather
- Mark danger zones
- Improve the Vehicle Conditions
- Drunk and drive
- Lack of body protection



7.Enforcement of laws

- Driving tests
- Medical fitness to drive
- Speed limits
- Compulsory wearing of seat belts
- Compulsory wearing of helmets
- Checking for blood alcohol concentration
- Road side breath analyzer,
- Regular and periodic inspection of vehicles,
- Periodic examination of drivers above the age of 55 yrs .

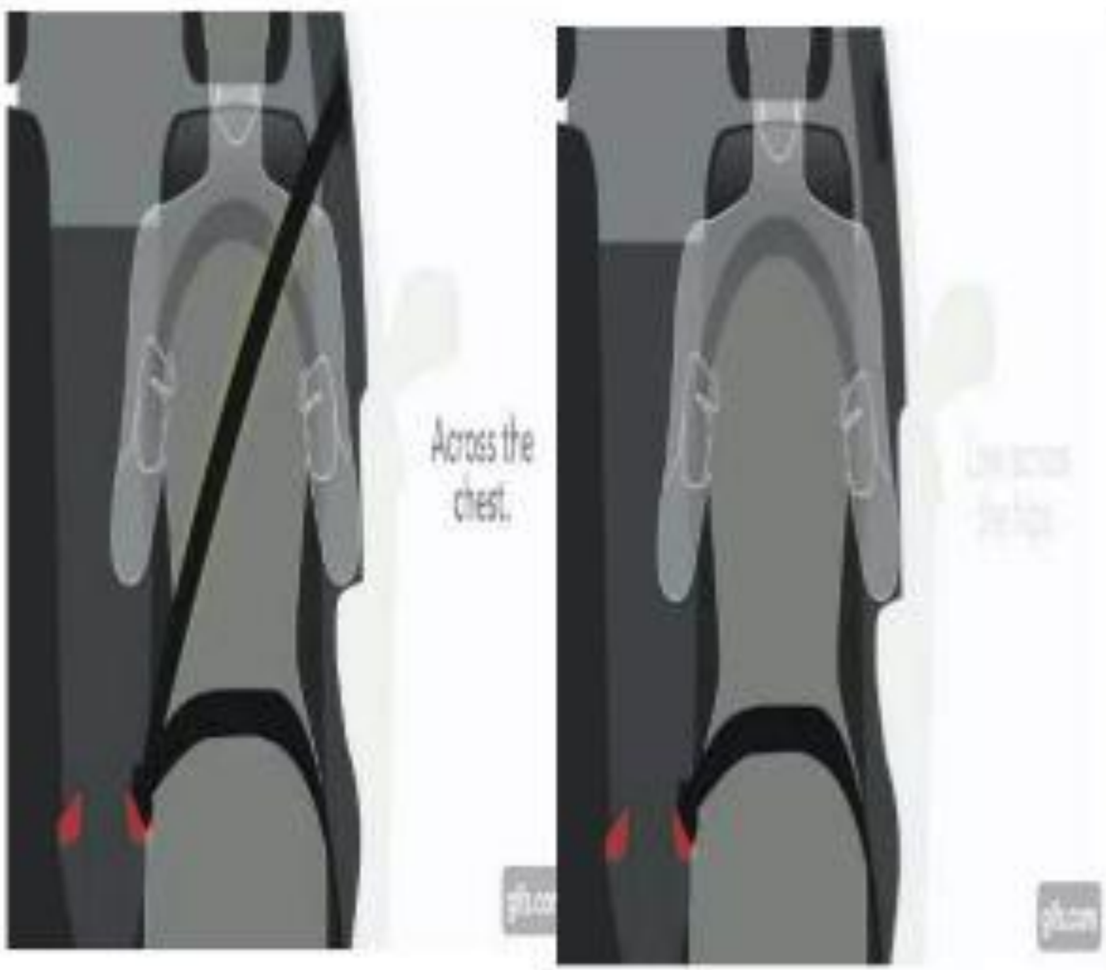
Government Initiatives

- ✓ Multi-pronged road safety programmes and initiatives
- ✓ Mass awareness/ education programmes,
- ✓ Engineering measures (both road and vehicle),
- ✓ Enforcement of safety laws
- ✓ Emergency care to road accident victims.

4 E's for Injury Prevention

- ✓ Education
- ✓ Envronmental modification
- ✓ Enforcement of Laws
- ✓ Engineering

Seat Belt Importance



2.6 Urban Intersection Accident Prediction

The accident prediction equations for urban intersections currently used in the PEM are based on work by Gabites Porter (1991) and are of the linear form:

$$A_T = b_0.Q_T$$

where:

A_T = total number of reported injury accidents in a five year period
Q_T = total flow entering the intersection

These superseded a quadratic relationship of the form:

$$A_T = b_0.Q_T^2$$

which was used from September 1993 to March 1995, based on the same research but with modified coefficients b_0. Prior to September 1992, the linear form was used (note that from September 1992 to August 1993 the $A_T = b_0.Q_T$ model form was used but with incorrect coefficients).

2.7 Mid-Block Accident Prediction

The accident prediction model currently used in the PEM for urban and rural mid-block crashes is:

$$A_T = b_0.X_T$$

where X_T is the exposure in 100 million vehicle kilometres over the mid-block section length. Values of b_0 have been fitted to this model from analysis of the crash accident database, distinguishing between speed limit zones, presence or absence of a solid median, and by traffic volume band for rural roads. A separate value of b_0 has been determined for motorways and other multilane median divided roads.

2.9.2 The Turner accident prediction equations

Turner (1995) developed accident prediction models for urban intersections based on conflicting flow volumes. The models were developed using generalised regression techniques for over 360 T- and X-intersections including traffic signals, roundabouts, priority control and uncontrolled. The models were then tested in predictive models for three road networks in Christchurch and Lower Hutt and yielded promising results.

The Turner models are either of a Negative Binomial or Poisson error structure, the latter being adopted for situations in which the variance is equal to or less than the mean:

$$A_k = b_0 . q_{j1}^{b1} q_{j2}^{b2}$$

where:

A_k= conflicting flow crash type between flows q_{j1} and q_{j2}
q_{j1}, q_{j2} = conflicting turning volume counts.
and b_0 , b_1 and b_2 are regression coefficients

5.1.1.1 *Signalised Cross-roads*

The accident rates at signalised cross-roads are predicted by accident type and approach using the equations in Table 5.1 and the parameters in Table 5.2. Figure 5.1 illustrates the different conflicting and approach flows at crossroads.

Table 5.1 Signalised Cross-road Accident Prediction Equations

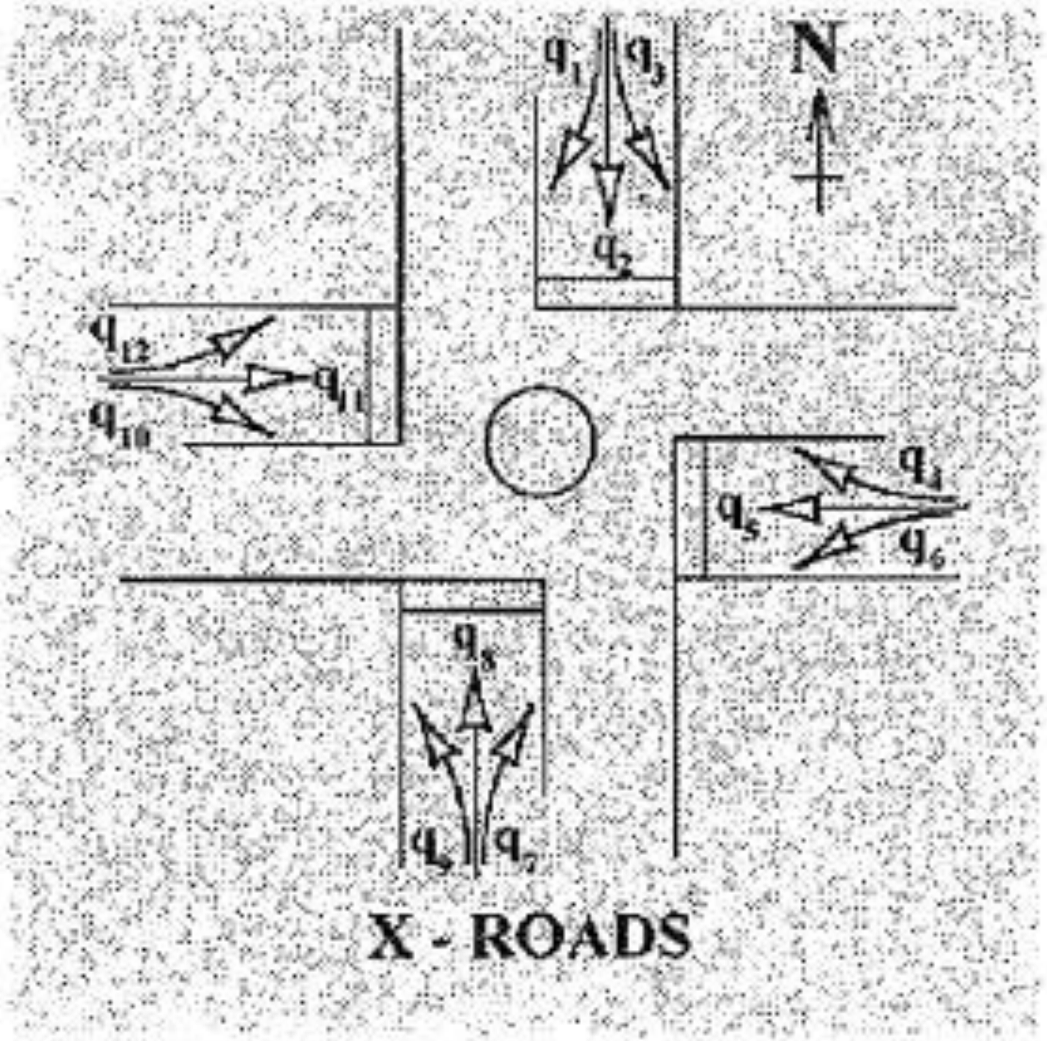
Accident Type	LTSA	Equation (accidents per approach)
	HA	$A = b_0 * q_2^{b1} * q_{11}^{b2}$
Right Turn Against	LB	$A = b_0 * q_2^{b1} * q_7^{b2}$
Rear-end	FA to FE	$A = b_0 * Q_e^{b1}$
Loss-of –control	C & D	$A = b_0 * Q_e^{b1}$
Others		$A = b_0 * Q_e^{b1}$

Figure 5.2 Conflicting and Approach Flow Types (Cross-roads)

Accident Type	LTSA Codes	b_0	b_1	b_2	K
Crossing (No	HA	$1.00E^{-3}$	0.34	0.37	1.1
Right Turn Against	LB	$4.85E^{-4}$	0.49	0.41	1.9
Rear-end	FA to FD	$8.52E^{-6}$	1.07	-	1.7
Loss-of –control	C & D	$1.56E^{-5}$	0.94	-	0.8
Others		$6.11E^{-3}$	0.46	-	1.5

* is the Gamma Shape Parameter. This is required when using Empirical Bayes Method (see section 7).

Table 5.2 Signalised Cross-roads – Prediction Model Parameters



5.1.1.7 *Product-of-Link-Flow Models*

The models in this section predict the accident rate at an intersection from the link (two-way) flows on each of the intersecting roads. These models should be used only when turning movement counts are not available, or can not be predicted using transport models.

These models should not be used when the volume of traffic on opposite arms of an intersection differs by more than 25% of the higher flow. If the majority of traffic on a link turns left or right at a cross-roads intersection, so that the opposing arm has a lot less traffic, then this type of model is inappropriate. Where volumes on both approaches of a link are available then the two approach flows should be summed to calculate the link volume.

The total reported accident rate for each intersection types is determined using the equation:

$$A_T = b_0 * Q_{minor}^{\ b1} * Q_{major}^{\ b2}$$

where Q_{minor} is the lowest of the two-way link volumes for cross-roads, and the stem flow for T-junctions.

Table 5.13 Product-of-Link-Flow Models

Intersection Type	b_0	b_1	b_2	K values
Signalised Cross-roads	2.04E^{-2}	0.14	0.45	3.0
4 –arm Roundabout	1.81E^{-3}	0.48	0.37	3.0
Priority Cross-roads	7.09E^{-3}	0.51	0.21	2.3
Signalised T-junctions	0.778	0.13	0.04	3.0
Priority T-junction	3.70E^{-4}	0.19	0.75	3.0
Uncontrolled T-junction	1.44E^{-2}	0.19	0.36	2.6

5.2 Urban Mid-block Sections, 50 km/h and 70 km/h Speed Limit Areas

For urban arterial, collector and local mid-block accidents, average injury accident rates can be associated with speed limit, roadside development and for arterials the presence of a solid median. The accident types predicted for urban mid-blocks sections, and the model types, are given in Table 5.14. The flow variable used in all models is the two-way traffic volume per day (Q_T).

Table 5.14 Urban Mid-block Accident Prediction Equations

Accident Type	LTSA Codes	Equation (accidents per approach)
Rear-end (both straight)	FA to FF	$A = b_0 * Q_T^{b1}$
Rear-end (one turning right)	GC to GE	$A = b_0 * Q_T^{b1}$
Loss-of-control	C & D	$A = b_0 * Q_T^{b1}$
Manoeuvring & Hit Object	M & E	$A = b_0 * Q_T^{b1}$
Other		$A = b_0 * Q_T^{b1}$

Accident prediction models and parameters for the major accident types are given for arterials, collectors and local streets in Tables 5.15 to 5.17.

Table 5.15 Urban Arterials, 50 and 60 km/h Areas

	Commercial/Industrial		Residential		K values
Accident Type	b_0	b_1	b_0	b_1	
Rear-end (both straight)	$6.93E^{-7}$	1.59	$6.03E^{-7}$	1.59	1.3
Rear-end (one turning right)	$3.21E^{-3}$	0.64	$2.25E^{-3}$	0.64	0.8
Loss-of-control	$4.07E^{-4}$	0.90	$5.88E^{-4}$	0.90	1.5
Manoeuvring & Hit Object	$2.92E^{-2}$	0.45	$2.13E^{-2}$	0.45	0.8
Other	$1.07E^{-5}$	1.34	$8.68E^{-6}$	1.34	1.2

5.4 Rural Mid-block Sections, 80 km/h and 100 km/h Speed Limit Areas

For rural highways (both Transit NZ and district) and local streets (all other 80 and 100 km/h streets), the average injury accident rates can be associated with the terrain type (flat, rolling and mountainous). The accident types predicted for rural mid-blocks sections, and the model types, are given in Table 5.19. The flow variable used in all models is the two-way traffic volume per day (Q_T). In the head-on model it is assumed that the traffic vehicle split by direction is approximately 50:50 over 24-hours.

Table 5.19 Rural Mid-block Accident Prediction Equations

Accident Type	LTSA Codes	Equation (accidents per approach)
Head-on	B	$A = b_0*((Q_T/2)^2)^{b1}$
Overtaking	A	$A = b_0*((Q_T/2)^2)^{b1}$
Rear-end (both straight)	FA to FF	$A = b_0*Q_T^{\ b1}$
Rear-end (one turning right)	GC to GE	$A = b_0*Q_T^{\ b1}$
Loss-of-control	C & D	$A = b_0*Q_T^{\ b1}$
Manoeuvring & Hit Object	M & E	$A = b_0*Q_T^{\ b1}$
Other		$A = b_0*Q_T^{\ b1}$

The accident prediction model parameters for the major accident types are given for rural highways and motorways/expressways in Tables 5.20 and 5.21. Insufficient data was available for rural local roads.

Table 5.20 Rural Highway Accident Prediction Equations

	Level		Rolling		K values
Accident Type	b_0	b_1	b_0	b_1	
Head-on	$9.54E^{-4}$	0.33	$1.24E^{-3}$	0.33	3.0
Overtaking	$5.15E^{-6}$	0.65	$1.58E^{-6}$	0.65	2.2
Rear-end (both straight)	$1.09E^{-7}$	1.72	$9.89E^{-9}$	1.72	1.7
Rear-end (one turning right)	$4.25E^{-4}$	0.78	$6.27E^{-5}$	0.78	1.4
Loss-of-control	$2.83E^{-2}$	0.48	$1.82E^{-2}$	0.48	1.2
Manoeuvring & Hit Object	$4.00E^{-3}$	0.52	$1.07E^{-3}$	0.52	3.0
Other	$1.68E^{-4}$	0.84	$1.22E^{-5}$	0.84	3.0

Table 5.21 Motorways and Expressways

Accident Type	b_0	b_1	K values
Rear-end	$5.91E^{-9}$	1.88	3.0
Loss-of-control	$2.81E^{-5}$	1.11	3.0
Overtaking	$1.25E^{-5}$	1.10	1.6
Other	$2.65E^{-2}$	0.41	0.5

Crash Codings

	TYPE	A	B	C	D	E	F	G	O
A	OVERTAKING AND LANE CHANGE	PULLING OUT OR CHANGING LANE TO RIGHT	HEAD ON	CUTTING IN OR CHANGING LANE TO LEFT	LOST CONTROL (OVERTAKING VEHICLE)	SIDE ROAD	LOST CONTROL (OVERTAKEN VEHICLE)	WEAVING IN HEAVY TRAFFIC	OTHER
B	HEAD ON	ON STRAIGHT	CUTTING CORNER	SWINGING WIDE	BOTH OR UNKNOWN	LOST CONTROL ON STRAIGHT	LOST CONTROL ON CURVE		OTHER
C	LOST CONTROL OR OFF ROAD (STRAIGHT ROADS)	OUT OF CONTROL ON ROADWAY	OFF ROADWAY TO LEFT	OFF ROADWAY TO RIGHT					OTHER
D	CORNERING	LOST CONTROL TURNING RIGHT	LOST CONTROL TURNING LEFT	MISSED INTERSECTION OR END OF ROAD					OTHER
E	COLLISION WITH OBSTRUCTION	PARKED VEHICLE	CRASH OR BROKEN DOWN	NON VEHICULAR OBSTRUCTIONS (INCLUDING ANIMALS)	WORKMANS VEHICLE	OPENING DOOR			OTHER
F	REAR END	SLOW VEHICLE	CROSS TRAFFIC	PEDESTRIAN	QUEUE	SIGNALS	OTHER		OTHER

G	TURNING VERSUS SAME DIRECTION	REAR OF LEFT TURNING VEHICLE	LEFT TURN SIDE SIDE SWIPE	STOPPED OR TURNING FROM LEFT SIDE	NEAR CENTRE LINE	OVERTAKING VEHICLE	TWO TURNING		OTHER
H	CROSSING (NO TURNS)	RIGHT ANGLE (70° TO 110°)							OTHER
J	CROSSING (VEHICLE TURNING)	RIGHT TURN RIGHT SIDE	OBSOLETE	TWO TURNING					OTHER
K	MERGING	LEFT TURN IN	RIGHT TURN IN	TWO TURNING					OTHER
L	RIGHT TURN AGAINST	STOPPED WAITING TO TURN	MAKING TURN						OTHER
M	MANOEUVRING	PARKING OR LEAVING	"U" TURN	"U" TURN	DRIVEWAY MANOEUVRE	PARKING OPPOSITE	ANGLE PARKING	REVERSING ALONG ROAD	OTHER
N	PEDESTRIANS CROSSING ROAD	LEFT SIDE	RIGHT SIDE	LEFT TURN LEFT SIDE	RIGHT TURN RIGHT SIDE	LEFT TURN RIGHT SIDE	RIGHT TURN LEFT SIDE	MANOEUVRING VEHICLE	OTHER
P	PEDESTRIANS OTHER	WALKING WITH TRAFFIC	WALKING FACING TRAFFIC	WALKING ON FOOTPATH	CHILD PLAYING (TRICYCLE)	ATTENDING TO VEHICLE	ENTERING OR LEAVING VEHICLE		OTHER
Q	MISCELLANEOUS	FELL WHILE BOARDING OR ALIGHTING	FELL FROM MOVING VEHICLE	TRAIN	PARKED VEHICLE RAN AWAY	EQUESTRIAN	FELL INSIDE VEHICLE	TRAILER OR LOAD	OTHER