TRIPP BULLETIN
VOL 12 NO.2 MONSOON 2015
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
INDIAN INSTITUTE OF TECHNOLOGY DELHI

Ph.D. Scholars *Current*

Naturalistic driving behaviour study
Scholar: Abhaya Jha

Study of the effect of geometric design features on capacity of hill roads
Scholar: Achyut Das

Multi objective optimization in construction project management
Scholar: Amit Chandra

Urban landuse and transport modeling
Scholar: Amit Sharma

Accident reconstruction based study on motorcycle crashes
Scholar: Amrit Lal

Design and optimization of air ventilation system for improved heat transfer characteristics in helmet
Scholar: Bhagwat Singh Shishodia

Methodology for low carbon mobility plan for indian cities
Scholar: Deepty Jain

Safety issues in project management
Scholar: Dilip A Patel

Modelling and risk assessment of heterogeneous traffic
Scholar: Gaurav Pandey

Methodology for design of vehicle front of an urban car for safety of vulnerable road users
Scholar: Hariharan S

Analysis of travel behaviour and impact of demand management interventions on non-captive bus users
Scholar: Hemant Kumar suman

Establishing relationship between elements of highway engineering on crashes on national highways in India
Scholar: H.M. Naqvi

Issues in human body FE modelling
Scholar: Kanhaiya Lal Mishra

Human body model (thorax modelling and its validation)
Scholar: Khyati Verma

Characterisation of long bones bending under impact
Scholar:Mike Winifred Jimbry Arun

Private participation in metro rail projects in India: challenges and way forward
Scholar: Mukund Kumar Sinha

Road safety risk assessments of modern toll plazas and standardization of its geometric design
Scholar: Navdeep Kumar Asija

Urban freight studies
Scholar: Nilanjana De Bakshi

Thorax model building and validation – diaphragm and aorta
Scholar: Piyush Gaur

Pavement materials
Scholar: Priyansh Singh

Finite element human body modelling direction
Scholar: P Devendra Kumar

Effect of traffic characteristics on vehicle emissions
Scholar: P.V. Pradeep Kumar

Human body finite element modelling
Scholar: Rajesh Kumar

Measuring public health effects of urban transportation in Delhi
Scholar: Rahul Goel

Mode choice initiators in public transport demand modelling
Scholar: Sandeep Gandhi

Ph.D. Scholars *Continued*

Finite element human body modelling direction
Scholar: Sanyam Sharma

Vehicle and crew scheduling optimisation of city bus systems
Scholar: S B Ravi Gadepalli

Estimation of perceived and actual risk faced by pedestrians: case study delhi, india
Scholar: Shalini Rankavat

Service level benchmarks for urban transport systems
Scholar: S.K. Lohia

A methodology for simultaneous route network design and frequency setting problem in small and medium sized cities
Scholar: S.M. Hassan Mahdavi M.

Framework to determine the level of service of urban bus systems - Case study: Delhi
Scholar: Sneha Lakhotia

Impact of traffic control measures on speed and driver behavior in highway work zones
Scholar: Sumeet Gupta

Human body modelling requirements for vulnerable road users
Scholar: Wondwosen Ayelework Lakew

Ph.D. Scholars *Completed*

Statistical modelling to estimate pedestrians' risk and risk taking behaviour on urban crosswalks
Scholar: Mariya Khatoon

Estimating traffic crash risk to road users in urban areas and its impact on travel mode choice: case study Vadodara city, India
Scholar: Pankaj Shankarlal Prajapati

M.Tech. Projects *Completed*

Development of homogeneous temperature zones based on climatological geographic data using advanced statistical techniques
Student: Aayush Kumar

Macroscopic modelling of the heterogeneous traffic characteristics
Student: Anjaneyulu Chinthi Reddy

Tolerance and distribution criteria for legal axle load: A case study in Ethopia
Student: Biswajit Mallik

Incorporating uncertainty and viscoelastic effects in fatigue damage modelling of asphalt concrete
Student: Himanshu Sharma

Urban freight parking practices: the cases of Gothenburg (Sweden) and Delhi (India)
Student: Leeza Malik

Effect of lime stabilization on mechanical properties of subgrade material
Student: Mahesh Chand Chaudhary

Risk analysis of highways
Student: Manali Telang

Cellular automata modelling of traffic characteristics in work zones
Student: Mohit Kumar Singh

Estimating cost of congestion: a case study in Delhi
Student: Mohsin Manzoor Janwar

Continued on page 4

The **Transportation Research and Injury Prevention Programme (TRIPP)** at the Indian Institute of Technology Delhi, is an interdisciplinary programme focussing on the reduction of adverse health effects of road transport. TRIPP attempts to integrate all issues concerned with transportation in order to promote safety, cleaner air, and energy conservation. Faculty members are involved in planning safer urban and inter-city transportation systems, and developing designs for vehicles, safety equipment and infrastructure for the future. Activities include applied research projects, special courses and workshops, and supervision of student projects at postgraduate and undergraduate levels. Projects are done in collaboration with associated departments and centres at IIT Delhi, government departments, industry and international agencies.

TRIPP BULLETIN
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
VOL 12. NO.2 MONSOON 20155

URBAN TRAFFIC SAFETY ASSESSMENT: CASE STUDY OF SIX INDIAN CITIES

Excerpts from the study done by
Dinesh Mohan, Geetam Tiwari, Sudipto Mukherjee

This study reports the results of fatal road traffic fatal crash data from six mid sized cities in India: Agra, Amritsar, Bhopal, Ludhiana, Vadodara and Vishakhapatnam. The total number of vulnerable road user deaths in all the six cities range between 84% and 93%, car occupant fatalities between 2% and 4%, and TST occupants less than 5%. The largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars, however the proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The data indicate that the 0-14 age group is under represented in proportion to their share in the population including children riding motorcycles. Occupant fatality rates per hundred thousand vehicles for MTW and TST occupants are 2-3 and 3-5 times higher that for cars respectively. However, estimates of association with fatal crashes shows that MTWs and cars pose a similar risk to society and TSTs little less. More detailed data are needed to confirm some of these results

1n 1990 road traffic injuries (RTI) ranked 10th in global years of life lost. In 2013 the global situation became worse with RTI moving up to 5th position after ischaemic heart disease, lower respiratory infections, cerebrovascular disease, and diarrhoeal diseases. While the years of life lost due to RTI have increased globally, the situation has improved in many of the OECD countries but not in most of the low and middle-income countries. Among the low and middle-income countries India accounts for a large share of the deaths and disabilities contributed by RTI partly owing to its large share of the world population and also because appropriate road safety measures have not been instituted in the country. In 2014 RTI resulted in 141,526 fatalities in India accounting for a rate of 11 deaths per 100,000 population as compared to rates of 3-4 prevailing in some of the most successful countries in the world.

The high rate of RTI in India is also reflected in its cities where the fatality rates can vary between 3-35 per 100,000 population. It is interesting that the lowest rates compare well with some of the safest cities in the world and the highest with some of the worst. Over the past decade the fatality rate in some of these cities has increased by a factor or 4 or more. However, it is difficult to ascribe reliable reasons for these differences and the increases in fatalities over time as details of RTI and crashes are not available in the public domain for most of the cities.

Official road traffic crash data for cities do not include fatalities by road user category in India. Such data are only available from a few cities and research studies done on selected locations on rural highways. These data show that car occupants were a small proportion of the total fatalities, 4 and 3 per cent in Mumbai and Delhi and 15 percent on rural highways. Vulnerable road users (pedestrians, bicyclists, and motorized two-wheeler riders) accounted for 89 and 83 per cent deaths in Mumbai and Delhi, and 47-76 per cent on highways. This pattern is very different from that obtained in all high-income countries.

The high incidence of vulnerable road user fatalities has negative influences on many issues in urban life including freedom of children and the elderly to use the street and use of public transport. Safety on public transport access trips emerges as an important issue. Unless the walking trip is safe from accidents, harassment, and crime, people avoid using public transport. Therefore, safety emerges as a precondition for promoting public transport and active travel. However, it would be difficult to promote effective road safety countrmeasures all over the country in the absence of RTI details from more cities in India. The present study is an effort to understand road traffic carsh details in mid size cities of India and presents the results of data collected from 6 cities with populations in the rnage of 1.0-2.0 million persons.

Six cities with populations between 1.0-2.0 million were selected from different locations in India and different RTI fatality rates: Agra, Amritsar, Bhopal, Ludhiana, Vadodara, and Vishakhapatnam. These cities represent the growing urban agglomerations of India where high growth rates are expected in the next decade.

Research assistants were sent to Agra, Amritsar, Bhopal, Ludhiana, Vadodara and Vishakhapatnam to obtain primary data on vehicle registration and road traffic fatality cases and other data available in the city from secondary sources (e.g.: transportation and city development plan studies commissioned by respective city governments). Different police stations in each city were visited and a request placed for obtaining copies of First Information Reports (FIRs) of fatal road traffic crashes for the period 2008-2011. The data from the records so obtained were coded on to an accident recording form designed for this project. The data from these forms were then entered in spread-sheets for computer analysis. The following variables were used for analysis:

- Sex of victims
- Month, day and time of crashes
- Road user type and type of associated crash vehicles
- Type of road where crash occurred
- Vehicles registered in the city
- Brief description of the crash as recorded by the police

These were the only variables in the police files that were considered reliable. The data coders were also asked to note details of crashes that had any special characteristics and those reports were children were involved. Fatality data could not be obtained for a full period of four years from all cities.

The numbers for personal vehicles (cars and motorised two-wheelers) are estimated as 60% of the official number for cars and 50% for motorised two-wheelers). These adjustments have been made because the official numbers of personal vehicles are overestimated because in India owners pay a lifetime registration tax at purchase of the vehicle and most owners do not de-register their vehicles when the vehicles are junked. The estimate of actual number of vehicles are based on studies done to determine the number of vehicles on the road by surveys in three Indian studies.

In proportions of vehicles, all the cities have similar vehicle populations. However, Ludhiana has the highest number of cars and MTW and Vadodara and Vishakhapatnam a much higher proportion of TST.

The total number of vulnerable road user deaths in all the six cities range between 84% and 93%, car occupant fatalities between 2% and 4%, and TST occupants less than 5% per cent, except in Vishakhapatnam where the proportion for the latter is 8%. These total proportions are similar to those in the megacities Mumbai and Delhi. However, the relative proportions of pedestrian fatalities are smaller in these cities and MTW fatalities greater than those in the megacities. This may be because the proportion of MTW ownership is higher in these smaller cities than that in the megacities. Helmet use by MTW riders is not enforced in any of these cities though the use is mandated by the Motor Vehicles Act 1988 of India. The high rate of MTW fatalities can be reduced significantly if the existing mandatory helmet laws are enforced in all the cities and laws introduced for compulsory daytime running lights for MTWs.

Ludhiana and Amritsar have a higher rate for bicyclists than the other cities. Anecdotal evidence suggests that these cities have higher bicycle use than the other cities surveyed, but we cannot confirm this. The reasons for a higher rate of MTW fatalities in Vishakhapatnam cannot be ascertained at present.

Two cities Agra and Bhopal are representative of the patterns in all the six cities and have been selected as the fatality rates per 100,000 persons are different with Vishakhapatnam at 24 and Bhopal at 14 in 2011. In both the cities the largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars. This is true for the other four cities also. The most interesting feature emerging from this analysis is the involvement of motorised two-wheelers as impacting vehicles for pedestrian fatalities in all the six cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The highest proportion was observed in Bhopal. The involvement of MTWs as impacting vehicles in VRU fatalities may be due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders.

The cities Agra and Ludhiana have been selected as they have different fatality rates and traffic characteristics were studied in greater details in these two cities. Pedestrian and bicycle fatalities have high rates earlier in the morning. This may be because this class of road users start for work earlier than those using motorised transport. The total fatality rate remains somewhat similar between the hours of 10:00 and 18:00 and a strong bimodal distribution is not observed. This could be because school and working timings are reasonably staggered. Schools start around 08:00 in the morning and close at 14:00 and some of them have a second shift, private offices open between 08:00-09:00, government offices between 09:00-10:00 and shops around 11:00. Most shops stay open up to 21:00 and restaurants up to 23:00. The data also show that MTW and pedestrian deaths are relatively high at 20:00-23:00 when we would expect traffic volumes to be low. The details of risk factors for high rate of vulnerable road user fatalities at night are not available for all cities but surveys done in Agra and Ludhiana suggest that due to lower volumes vehicle velocities can be higher at night, adequate street lighting is not present, and there is very limited checking of drivers under the influence of alcohol. The situation would be similar in the other four cities except in Vadodara where there is prohibition of alcohol use by law.

Age of victims was not recorded in the First Information Reports (FIR) made available to us for a vast majority of the cases. These data indicate that the 0-14 age group is under represented in proportion to their share in the population. The data coders marked out the cases where 'children' were mentioned as victims in the text in the police reports. In general these would be persons younger than 4 years. For Agra, Amritsar, Bhopal and Vishakhapatnam (total fatal cases in sample: 2,788) a total of 78 cases (2.8%) were identified of which 13 were MTW occupants (0.5%) and 53 were pedestrians (1.9%). This is less than the national rate of 7% for persons 0-14 years. This may be partly because some of those below 14 years may not have been classified as children. Lower exposure rates for children may account for this, however, this explanation does not seem to be adequate enough to explain these very low rates, especially children on motorcycles. This phenomenon needs further study.

The ratio between males and females is roughly 4:1 in all the six studies. This difference in males and females can be partly explained by the fact that women have lower participation rate in employment than men in the country.

Risk of fatality has been calculated using different indices to understand the role of different motor vehicles, personal risk per trip by different modes and the risk different vehicles present to society.

It has been found that the number of motor vehicle occupant fatalities per 100,000 vehicles for four cities where the vehicle data were relatively reliable. This has been obtained by dividing the total number of occupant fatalities for each vehicle type estimated for 2011 divided by the number of that vehicle type estimated for the city (corrected for overestimates). These data show that occupant fatalities per vehicle decrease in the following order – TST:MTW:Car. Occupant fatality rates for MTW and TST occupants are 2-3 and 3-5 times higher that for cars respectively. The high rates per vehicle for TSTs would also be because they carry a much larger number of passengers in the day as compared to MTWs and cars. The MTW fatality rate is not more than 5 times the fatality rate for cars in any of the four cities. For Europe and USA this ratio is reported to be in the range of 10-20. We do not have detailed data to explain with certainty why this risk ratio for MTW riders should be lower in Indian cities where the helmet law is not being enforced. The possible reason could be that the majority of motorcycles sold are of low power (<150 cc), the riders are not enthusiasts but regular commuters, and also the effect of numbers.

The personal fatality risk has been calculated by dividing the vehicle specific occupant fatality rate by estimates of average number of occupants carried by each vehicle per day. The numbers assumed are (based on 3 trips per day for MTW and cars with occupancy of 1.3 and 2.3 per trip respectively): MTW – 4, TST – 60, Car – 7. It is clear that given the present trip lengths for each vehicle type, the MTW rider is 3-6 times more at risk than a car occupant. The MTW fatality rates per trip in Agra and Vishakhapatnam are much higher than the other three cities. The reasons for this are not known at present. At a personal level, risk per trip seems to be lowest for TST occupants in all the cities for the assumed occupancy rates and number of trips per day.

All the fatalities that each vehicle type is associated with per 100,000-vehicle km per day. The following values have been assumed for distances travelled per day.

•Bus: 150 km

•Car: 50 km

•TST: 150 km

•MTW: 25 km

This includes occupant fatalities and those of road users other than the vehicle occupant. For example, if a motorcycle hits a pedestrian and the pedestrian dies, then the pedestrian death will also be associated with the motorcycle. This index gives a rough idea of the total number of fatalities you can expect for each vehicle type given the present traffic conditions and mode shares. These figures basically indicate that the relative low rate for TSTs as compared to cars is due to the higher exposure of TSTs per day. These indices appear to indicate that per km of travel TSTs, MTWs and cars are very roughly equally harmful for society under present conditions. Out of these three vehicles it is very important to improve the safety performance the MTW for its occupants (helmet use and daytime running lights). TSTs need improvement for safety of occupants as well as the VRUs it impacts.

The total number of vulnerable road user deaths in all the six cities range between 84% and 93%, car occupant fatalities between 2% and 4%, and TST occupants less than 5%, except in Vishakhapatnam where the proportion for the latter is 8%. These total proportions are similar to those in the megacities Mumbai and Delhi. Helmet use by MTW riders is not enforced in any of these cities though the use is mandated by the Motor Vehicles Act 1988 of India. The high rate of MTW fatalities can be reduced significantly if the existing mandatory helmet laws are enforced in all the cities and laws introduced for compulsory daytime running lights for MTW.

The largest proportion of fatalities for all road user categories (especially vulnerable road users) are associated with impacts with buses and trucks and then cars. This is true for the other four cities also. The most interesting feature emerging from this analysis is the involvement of motorised two-wheelers as impacting vehicles for pedestrian fatalities in all the six cities. The proportion of pedestrian fatalities associated with MTW impacts ranges from 8 to 25 per cent of the total. The involvement of MTWs as impacting vehicles in VRU fatalities may be due to the fact that pedestrians and bicyclists do not have adequate facilities on arterial roads of these cities and they have to share the road space (the curb side lane) with MTW riders. Provision of separate and adequate pedestrian and bicycle lanes in all cities is a prerequisite for RTI control.

MTW and pedestrian deaths are relatively high at 20:00-23:00 when we would expect traffic volumes to be low. Surveys done in Agra and Ludhiana suggest that due to lower volumes vehicle velocities can be higher at night, adequate street lighting is not present, and there is very limited checking of drivers under the influence of alcohol. This suggests that traffic calming methods, better street lighting and alcohol control would be necessary to control RTI during night time.

Involvement of young children in fatal crashes appears to be low and the reasons for this are not clear need to be studied. Relative risk of occupants of MTW is the highest but not as high in the high-income countries. However, the estimated risk to society posed by cars as estimated from total involvement in fatal crashes seems to be greater than that posed by motorcycles and thee-wheeled scooter taxis. Further research is necessary to determine the veracity of these findings.

TRIPP BULLETIN
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
VOL 12 NO.2 MONSOON 2015

M.Tech. Projects

Continued from page 1

Pedestrianization of heritage core of Indian cities: case study of old Delhi (Chandni Chowk)
Student: Nikhil Soni

Estimation of capacity of horizontal curves
Student: Pradeep Kumar

Characteristics and unsustainable impacts of urban freight in Gothenburg and Delhi
Student: Saubhagya Dixit

Determination of field dry density using dynamic cone penetration method and comparison of destructive test results
Student: Subrat Patnaik

Effects of chemical stabilization on mechanical properties of subgrade material
Student: Yohannes Legesse

Estimation of capacity of roundabouts
Student: Ramu Arroju

NEWS

Secondary Behavior of Drivers on Cell Phones

The objective of this study was to determine whether cell phone use by drivers leads to changes in the frequency of other types of potentially distracting behavior. There were 2 main questions of interest: (1) As each driver changes cell phone use, does he or she change the amount of driving time spent on other distracting behavior? (2) As each driver changes cell phone use, does he or she change the amount of driving time spent looking away from the driving task?

Day-to-day driving behavior of 105 volunteer subjects was monitored over a period of 1 year. The amount of driving time during each trip spent on tasks secondary to driving (or looking away from the driving task) was correlated to the amount of time on a cell phone, taking into account the relationships among trips taken by the same driver.

Drivers spent 42% of the time engaging in at least one secondary activity. Drivers were talking on a cell phone 7% of the time, interacting in some other way with a cell phone 5% of the time, and engaging in some other secondary activity (sometimes in conjunction with cell phone use) 33% of the time. Other than cell phone use, the most common secondary activities were interacting with a passenger (12% of driving time), holding but not otherwise interacting with an object (6%), and talking/singing/dancing to oneself (5%).

Although using a cell phone can be distracting from the driving task, other secondary activities can be equally or more distracting, at least as measured by eye glances away from the road ahead and mirrors. In this group of drivers, dialing, reaching for, and answering the cell phone were associated with increased eyes off driving task, as opposed to the decrease in eyes off driving task associated with talking on the phone. Predictions about the effect of cell phone usage on driver distraction need to consider what other behavior is being displaced by the time spent on the phone. A focus by researchers, policy-makers, and the media on the distraction of using cell phones while driving may lead drivers to disregard the risk of other secondary behavior that is even more distracting.

Secondary Behavior of Drivers on Cell Phones(2015). Charles M. Farmer, Sheila G. Klauer, Julie A. Mcclafferty, and Feng Guo. Traffic Injury Prevention (2015) 16, 801–808

Policy Solutions To Reduce Vehicle Exhaust Emissions Under Real-World Driving Conditions

Policymakers worldwide are looking for ways to address the challenge of controlling real-world emissions brought to forefront by the Volkswagen case. In this position brief, we propose a rapid and comprehensive policy response not only to deal with defeat devices but also to identify vehicle models with high real-world emissions relative to their test-cycle performance and to improve current compliance and enforcement programs. The ultimate goal of these suggested changes is to ensure that the policy objectives of reducing air pollutant and greenhouse gas emissions from vehicles are met not only in the laboratory during certification/type-approval testing but throughout the full useful life of vehicles across a wide range of operating conditions.

The VW defeat device scandal is among other things a reminder of the importance of strong in-use compliance and enforcement programs. Even though the defeat device in this case went unnoticed for several years in the United States, the regulatory agencies acted swiftly and decisively once the problem was brought to their attention. This was only possible because their compliance divisions have both strong technical teams and adequate legal authority and resources to enforce vehicle emission regulations. Governments that wish to reduce real-world vehicle emissions must allocate sufficient resources and authority to compliance and enforcement programs to improve the effectiveness of traditional efforts through adoption of more robust test cycles, effective in-use testing, and appropriate enforcement actions, including financial penalties and recall programs. The value of strong compliance programs in creating a level playing field for industry and earning consumer trust cannot be overstated.

Policy Solutions To Reduce Vehicle Exhaust Emissions Under Real-World Driving Conditions (2015). Position Brief, The International Council on Clean Transportation, October 2015. http://www.theicct.org/sites/default/files/publications/PosBrief_DefDev_sept2015_v4.pdf

Establishment funds have been received from
Ministry of Industry, Government of India
Asian Institute of Transport Development, India
Tata Motors, India
Volvo Research and Educational Foundations(VREF), Sweden

Endowments for perpetual Chairs
CONFER, India: TRIPP Chair for Transportation Planning
Ministry of Urban Development, India: MoUD Chair for Urban Transport & Traffic Planning
VREF: Volvo Chair for Transportation Planning for Control of Accident and Pollution

Transportation Research and Injury Prevention Programme
Room MS 808 (Main Building)
Indian Institute of Technology
Hauz Khas,
New Delhi 110016, India
Phone: 91-11-26596361, 26858703
Fax: 91-11-26858703, 26851169
Email: ird8541@cbme.iitd.ernet.in
http://tripp.iitd.ernet.in

TRIPP BULLETIN
VOL 12 NO.2 MONSOON 2015
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
INDIAN INSTITUTE OF TECHNOLOGY DELHI

Excerpts from a Ph.D. Dissertation : A TRIPP BULLETIN INSERT

Title: Estimating Traffic Crash Risk to Users in Urban Areas and its Impact on Mode Choice: Case Study Vadodara City, India

Scholar: Prajapati Pankaj Shankarlal

Supervisors: Geetam Tiwari

Department: Department of Civil Engineering

In this study traffic crash risk to different road users in Vadodara city has been estimated. Traffic police data shows that the proportion of vulnerable road users (pedestrian, bicyclists and motorised two-wheeler riders) observed as a victim in fatal crashes is 41%, 13% and 33% for M2W riders, bicyclists and pedestrians respectively. Safety Performance Functions (SPFs) have been developed to predict number of fatal crashes per year on different road locations, which identified factors affecting these crashes. The important factors includes traffic volume, presence of heavy vehicle on urban roads, land use type, length of road segment, street intersection density, volume to capacity ratio, type of road and presence of median. Separate models have been developed to predict number of fatal crashes per year for pedestrian, bicyclists, and motorised two-wheeler riders. These findings have important bearing on the design of urban arterial roads. In the absence of facilities for pedestrians and bicyclists, arterial roads with wider carriageway and higher number of lanes increase the risk of fatal crash for pedestrians and bicyclists.

This study quantifies real and perceived traffic crash risk to urban road users of medium size city. An average fatality per million persons is 84 for the urban area of Vadodara city. Truck as impacting vehicle is involved in 35% of the fatal crashes which shows the high risk imposed by heavy vehicles to vulnerable road users. High number of crashes with M2W and pedestrian at roundabouts shows the need to improve geometric design of roundabouts. Real fatal crash risks to common travel modes on different road facilities have been quantified using real fatal crash data and exposure level. Different road facilities on order of real crash risk level from highest to lowest are mid-block, signalised intersection, roundabout and un-signalised intersection. Pedestrians have highest real crash risk on mid-block followed by M2W riders and bicyclists. M2W riders have highest risk on signalised intersection followed by pedestrians and bicyclists. Roundabouts impose highest risk to M2W riders, followed by bicyclists and pedestrians.

Self-reported perceived crash risks to road users on different road locations have been compared to real crash risk. The ranking correlation by Spearman's rho has established that there is no correlation between real and perceived crash risk.

The influence of perceived traffic risk on different modes at mid-block, signalised intersection, un-signalised intersection and roundabout has been assessed by two multinomial logitmode choice models; one for people of ages up to 25 years and other for above 25 years. The impact of perceived crash risk for age below 25 years is insignificant for all modes. The probability of choosing auto-rickshaw, car, bus and bicycle mode is less for the road users who perceive high trafficcrash risk at signalised intersection with respect to road users who perceive no crash risk. On the other hand, probability of choosing these modes is high at un-signalised intersection even if the perceived crash risk is high.The perceived crash risk at roundabout is not significant for any mode.

An attempt has been made for the first time to evaluate and quantify the perceived risk on different road locations like mid-block, signalised intersection, un-signalised intersection and roundabout of urban area for all modes available; walk, cycling, motorised two-wheeler, auto-rickshaw, car, and bus.The relation between real and perceived traffic crash risk to different modes on above road locations has been established.

As the travel behaviour is governed by perceived crash risk, the influence of perceived crash risk on different modes has been modeled in this study. The mode choice depends on perception about crash risk associated with particular mode and not based on real risk. In order to address the road safety issue, the real risk should be addressed. Thus, both the risks; real and perceived crash risks are very important in policy framework.

Four-arm arterial intersections have more fatal crashes than other types of intersections. Compared to arterial intersections with more than four arms, three-arm intersections have higher expected number of fatal crashes. The signalised intersections have higher risk of fatal crash compared to roundabouts. The intersections of arterial roads with another arterial road have higher risk of fatal crash compared to intersections of arterial road with non-arterial road. As the traffic level increases, the risk of fatal crash also increases on the intersections. Similar results have been reported by Poch & Mannering that as traffic volume increases, the number of crashes also increases at intersection.

An attempt has been made for the first time to evaluate and quantify the perceived risk on different locations like mid-block, signalised intersection, un-signalised intersection and roundabout of urban area for all modes available; walk, cycling, motorised two-wheeler, auto-rickshaw, car, and bus.

Different road locations (mid-block, signalised intersection, un-signalised intersection and roundabout) have been compared for crash risk and location specific risk has been calculated. The locations with high risk can be identified and treated for the safety improvements.

The relation between real risk and perceived risk to different modes and all the above locations has been established.

The crash prediction models are developed to predict fatal crashes on urban arterial mid-block and arterial intersections. These findings have important bearing on the design of urban arterial roads. The fatality of vulnerable road users on signalised intersections should be taken care of. The traffic signals must be followed by all road users and traffic rules should be enforced by traffic police strictly to reduce fatal crashes. As arterial roads with less street intersection density on mid-blocks have predicted higher fatal crashes. The arterial roads with longer segment length and higher traffic have more fatal crashes. This information should be considered by the planning authorities. In the absence of facilities for pedestrians and bicyclists, arterial roads with wider carriageway and higher number of lanes increase the risk of fatal crash for pedestrians and bicyclists.Many single-vehicle motorised two-wheeler fatal crashes indicate probable high speed driving by M2W riders. The over speeding should be monitored. Those M2W riders do not prefer to use M2W when they perceive high crash risk on signalised intersection. The MNL models predicts that young bicyclist prefer bicycling when they perceive somewhat crash risk on mid-block as compared to higher risk while elder bicyclist prefer when they do not perceive any crash risk on mid-block and un-signalised intersection. The elder auto-rickshaw users perceive high crash risk on mid-block though use auto-rickshaw. It is likely that these auto-rickshaw users like door-to-door mobility of this mode and may not afford other mode as many users are sharing the auto-rickshaw with other people.

The present study has presented crash prediction models for urban areas based on traffic level and other road network features like intersection type, intersection density, and segment length. The traffic volume data for the city can be collected by actual traffic survey. Other explanatory variables like speed and built environment may be included along with other geometric features.

TRIPP BULLETIN
VOL 12 NO.2 MONSOON 2015
TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME
INDIAN INSTITUTE OF TECHNOLOGY DELHI

Excerpts from a Ph.D. Dissertation : A TRIPP BULLETIN INSERT

Title: Statistical modelling to estimate pedestrians' risk and risk taking behaviour on urban crosswalks

Scholar: Mariya Khatoon

Supervisors: Niladri Chatterjee and Geetam Tiwari

Department: Department of Mathematics

Dodge, stated that "The field of statistics is concerned with the collection, organization, analysis, interpretation and presentation of data. It deals with all aspects of data including the planning of data collection in terms of the design of surveys and experiments". In this work, the analysis of data has been done by both the statistics methodologies: descriptive statistics and inferential statistics.

Transportation Studies have inspired many important developments in statistical modelling, which contributed to important breakthroughs. Statistical modelling has been widely used in the application of transportation studies to learn the patterns and trends from the data points. In particular often it is used to predict the outcome variables from a set of predictor variables. The present research is focussed on the application of the statistical modelling techniques to analyse the road crossing behaviour of pedestrians at different traffic and road environments, and to quantify statistically the risk faced by them.

In depth analysis of pedestrian behaviour is important because walking is the most sustainable and most used mode of transportation in Indian cities. However, pedestrians are often exposed to high risks on Indian roads. As per the accident data, among all road users in Delhi, the ones who are most exposed to risk are the pedestrians. The share of pedestrian fatalities in Delhi from 2001 to 2012 indicates that pedestrians have the largest share in total fatalities and the share remains the same over the years, which is about 45.50% of the total fatalities.

One of the important reasons for this may be the basic needs of pedestrians are not recognized as a part of the urban transport infrastructure improvements projects. Gupta et al., observed that pedestrians are the most vulnerable; and the ongoing infrastructure improvement projects in Delhi are making them even more vulnerable. Rather, an ever increasing number of cars and motorized two-wheelers encourage the construction of environment to fatalities the smooth and signal free movements for motorized vehicles, exposing pedestrians to greater risk. A significant investment has been made in Delhi for the construction of free left turn, flyover, and grade separators to increase the speed of motorized vehicles, to reduce their delay, and to make arterial roads in Delhi signal free. With these types of constructions the signalized crossings are converted into signal free crossings, causing more problems for pedestrians.

Although signalized intersections provide pedestrians a protected crossing phase, most pedestrians tend to prefer using the available traffic gaps for crossing. Moreover, pedestrians often cross roads away from signalized crosswalk, such as near bus stops and foot of flyovers/grade separators, to save their travel time or distance. Further, if free let-turns are provided on an intersection then motorists generally do not yield to pedestrians using these turns.

In Delhi, a pedestrian often has the option of crossing the road using the subway/foot-over bridge, yet most often they do not use it. Rather, they prefer to cross the roads on the surface. Globally, very few researchers compared signalized intersection pedestrian crossings to overpass and underpass counterparts such as Rasanen et al. at Ankara, turkey and Tanaboriboon and Jing at Beijing China. They also found that pedestrians preferred signalized at grade crossings to overpass or underpass crossings.

A common Phenomenon in Delhi is that a pedestrian has to fight for space on the road, because of lack of safe and convenient pedestrian paths. Therefore, a significant number of pedestrians often indulge in risky road crossings at all types of crosswalks. It is therefore important to study pedestrian behaviour in order that the risk faced by them can be minimized while the transportation facilities are improved for motorized traffic. The objective of this study is to examine the pedestrian road crossing behaviour exhibited by different types of pedestrians, and their road crossing risk while crossing the roads in an urban area, such as Delhi.

The present research is aimed at the development of statistical models to analyse the pedestrians' road crossing behaviour and quantify their risk on urban roads. We have considered Delhi as a case city for the study. Modelling of pedestrians' road crossing behaviour and the associated risk has to be treated as an integral and basic component of any comprehensive city development plan. The existing models on this topic reveal a lack of detailed consideration of pedestrian behaviour in urban areas. They focused primarily on one or two potential parameters such as, gender or age of pedestrian while crossing whether they are alone or in a group, location of zebra crossings, speed or type of the conflicting vehicles etc.

Statistical modelling has been widely used in the application of transportation studies to learn the patterns and trends from the data points. In particular, often it is used to predict the outcome variable from a set of predictor variables. In the present research we explored the utility of the binary probabilistic modelling and its performance measures in analysing the pedestrian road crossing behaviour exhibited by different types of pedestrians and the associated risk at different traffic and road environments. The models are developed on the hypothesis that each pedestrian intends to cross roads safety, but their perceptions about the chances of safe crossing are related to their individual characteristics, and also to the road and traffic environments.

In this work we aimed at estimating the subjective probabilities in unsafe crossing behaviour or pedestrians. We have considered cases of pedestrians' road crossing in an unsafe conditions i.e. when they cross a road on the green phase of vehicles, or not using underpass/foot over bridge which have been constructed for safe road crossing of pedestrians.

In the present study, the risk to a pedestrian at crosswalks is defined as a function of "accepted gaps size" which is the measure of time to collision. Risk to a pedestrian is taken as inversely proportional to the gap size accepted by a pedestrian.

For the study we have collected data at six different types of pedestrian crosswalks in Delhi. At the selected signalized crosswalks, pedestrians have the option to cross the road safely (at the red phase for vehicles), although some pedestrians still commit an unsafe crossing (at the green phase of vehicles). At the selected non-signalized crosswalks, such as near bus stops and foot of flyovers/grade separators, many pedestrians cross the road straight ahead with moving traffic to reduce their travel time and distance. At the selected free left turn no pedestrian crossing facilities are provided and they are forced to cross in between the moving traffic.

Since a significant number of pedestrians do cross roads in unsafe conditions at all types of crosswalks, an analysis of their crossing behaviour is important from the safety perspective.

In this work, the analysis of pedestrian behaviour and their associated risk has been done broadly for the two scenarios: (1) impact of change in infrastructure: Before and after the construction of grade separator; and (2) related to infrastructure type: at signalized crosswalk, non-signalized crosswalk, free left turn and foot of flyover.