WINTER
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WHO COLLABORATING CENTRE
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T R I P - CENTRE **BULLETIN**
TRANSPORTATION RESEARCH & INJURY PREVENTION CENTRE
VOL 1 NO. 3

## RESEARCH & CONSULTANCY PROJECTS

**Centre of Excellence for Advance Data Management System for Highways (ADMS Highways)**
Sponsor: National Highway Authority of India
Project Team (IITD): *GeetamTiwari, K.R.Rao, K.N. Jha, A.K. Swamy, Manoj M., Anoop Krishnan, Naduvath Mana, Maya Ramanath, N. Chatterjee and Chetan Arora*
From NHAI: *P.K. Mohapatra*
Background:
National Highways Authority of India signed a Memorandum of Understanding (MoU) with IIT, Delhi to set up a Centre of Excellence (CoE) at IIT Delhi, for Advanced Data Management System for Highways, which will focus on advance analytics, modelling, simulations and predictions based on Artificial Intelligence (AI) and Machine Learning (ML) on project Management work flows and alerts; advance alerts on possible litigations and disputes; traffic and tolling revenue growth, road safety and incident management, etc. using huge data from NHAI Data Lake.
The CoE activities will be supported by NHAI for five years in phase-I. Currently following research projects are ongoing:
1. Machine learning assisted incident analysis and prediction using structured and unstructured NHAI data.
2. A system for organising and searching all digitised data at
3. An approach towards creating a safe traffic work zone environment on National Highways.
4. Empirical assessment of schedule and cost performances of various contracts of NHAI and development of a decision support framework to improve the performances.
5. Multi-objective optimization of highway projects using machine learning and data-driven modelling.
6. Development of crash database for national highways.
7. Developing a comprehensive repository of national highway infrastructure.
Work Progress
- Conducted an exhausted review and documented all the different streams of information related to highway design characteristics available in Data Lake.
- Identified a common set of attributes that are available across all the projects.
- Information for the following design specifications are commonly available across different projects: e.g. shoulders, curbs, number of lanes, guard rails
- These data attributes are of critical importance for conducting road safety analyses, and for building safety performance functions (SPFs). However, there are some variables that are not available across all the projects.

Future Work
- Developing a data structure to facilitate access to roadway details of a specific location or a highway section
- A prototype database to be shared with NHAI for review by October 2022. This will need modifying certain data reporting procedures by project directors.
- Developing a comprehensive relational dataset of the existing projects in Data Lake

**Road Safety Inspection and Discussion of Identified Blackspots**
Sponsor: Uttar Pradesh Public Works Department
Project Team: *G.Tiwari, D.Mohan, K.R. Rao, K.N. Jha and S. Mukherjee*
Objective: Uttar Pradesh government has been working to reduce traffic crashes on all roads. In this context the UPPWD has identified 583 blackspots in selected districts. Methodology for safety inspection and audit of these spots for preparing site specific observations and recommendations will be finalised.
Field audit will be conducted on selected stretches of the highway corridor

**Consulting Services to audit the implementation by the States of the directions issued by the Supreme Court Committee on Road Safety ( Group B, C & D)**
Sponsor: Delhi Integrated Multi-Modal Transport Solution, Ministry of Road Transport and Highways
Project Team: *Geetam Tiwari, Kalaga Ramachandra Rao, K Neeraj Jha*
Objective:
• Evaluate the level of compliance (quantify) of the Supreme Court recommendations
• Identify problems in complying with the Supreme Court recommendations
• Evaluate impact of various recommendations on safety outcomes
• Identify the most effective recommendations in impacting traffic safety outcomes

**Pedestrian Safety and Sustainable Mobility in NCT, Delhi**
Sponsor: Office of the Principal Scientific Adviser, Govt of India
Project team: *Geetam Tiwari*
Objective:
* Improve Operational Efficiency of Bus Systems
* Promote Pedestrian safety (Development of Pedestrian Safety Dashboard)

**Traffic Performance Evaluation and Optimisation of Highways in Delhi Using Simulation Analysis - for Delhi PWD Roads**
Sponsor: Medulla Soft Technologies Pvt. Ltd.
Project Team: *Sai Chand*
Objective:
* Check and quantify the travel demand data
* Data analysis of crowdsourced travel time data
* Check and review the simulation model for calibration and validation

**Development and Validation of an Electric Rickshaw Passenger Safety Scale**
Sponsor: Science & Engineering Research Board (SERB)
Project Team: *Manoj M., G.Tiwari and Nezamuddin*
Abstract:
This project aims to develop and validate an electric rickshaw passenger safety scale. The study develops a methodology that combines machine learning algorithms and standard econometric approaches to develop and validate the proposed scale and prioritize safety improvement actions based on user perceptions. The project is the first attempt to present an electric rickshaw safety assessment scale from the passengers viewpoint.

**Identification of keyp performance indicators for ITMS of Delhi using simulation**
Sponsor: Gaia Smart Cities Pvt. Ltd.
Project Team: *Sai Chand*
Objectives:
- Identify KPIs for Delhi ITMS using a simulation model.
- Calibrate the travel demand data required for the simulation model.
- Data analysis of crowdsourced travel time data from TomTom.
- Check and review the simulation model for calibration and validation.

**Improving gender equality and safety of cycling use in an Indian city**
Sponsor: Urban Land Transport, Urban Development Department, Govt. of Karnataka
Project Team: Rahul Goel, Avinash Chanchal, Ruchi Varma, Sandeep Gandhi
Objectives:
- To evaluate the mobility impact of free bicycle distribution among low-income women workers in Bengaluru.
- To measure a) livelihood of women to take up cycling to work and b) mobility among women (e.g. total daily distance, number of destinations).
- To identify various factors that mediate the impact of receiving a free bicycle

**Reducing road traffic injuries in LMICs by using in-vehicle telematics and behavioral feedback**
Sponsor: National Institutes of Health, USA
Project Team: *Rahul Goel, Geetam Tiwari, Rijurekha Sen*
Objective:
- Develop and adapt telematics technology for use in commercial trucks in India.
- Strengthen research capacity and build collaborations to support use of telematics.
- Conduct a small-scale randomized control trial of a telematics-based intervention to reduce aggressive driving.
- Assess how speed cameras affect speeding behavior.

**Research to Support Large Scale Investments in Bicycling in the Cities of Low- and Middle-Income Countries**
Sponsor: Susan and Richard Kiphart, Centre for Global Health and Social Development, USA
Project Team: *Rahul Goel, Geetam Tiwari*
Objectives:
Large investments in bicycling can help LMICs make progress toward climate goals by decarbonizing transport. They can also help meet several Sustainable Development Goals (SDGs) due to reduced road traffic injuries, and the cardiovascular benefits of lower vehicular emissions and increased physical activity.
- To assess the current state of bicycling in the cities
- Describe the political economy of investments in bicycling infrastructure.

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## Excerpts from the abstracts presented at : THE DINESH MOHAN MEMORIAL

**Safe engineering: an example of application of a recent accident model to automated driving**
*Yves Page*

Safe roads and roadsides, safe vehicles, safe speed, safe road use, post-crash care: these are a summary of the safe system paradigm which has been popular for a few decades. Explicitly, this is safety by design. As for vehicles, concrete applications are technical regulations, standards, norms, car assessment programs, codes of practices, guidelines, statements of principles, external and internal safety standards and verification/validation plans, etc.

Obviously, safety by design starts by understanding and ends by proposing countermeasures to prevent/mitigate the hazards and their consequences.

The paper describes the STAMP approach (Systems-Theoretic Accident Model and Processes), an accident causality model based on control theory and systems theory (Leveson, 2011). STAMP integrates into engineering safety analysis the causal factors such as software, human factors, new technologies, social and organization structures, and safety culture. It is designed to address complex systems. The method behind the approach is STPA (Systems-Theoretic Process Analysis), the hazard operational analysis technique (Leveson and Thomas, 2013, 2018). STAMP and STPA now receive more and more attention and interest, especially when new technologies and complex systems are considered.

**Dinesh Mohan – A tribute**
*Brian O Neal*

Dinesh Mohan had recently completed his PhD in Biomechanics when he joined the then small research group at the Insurance Institute for Highway Safety (IIHS). William Haddon Jr. was the President of IIHS at the time , and was one of the most important of the early highway safety pioneers. From the beginning Haddon took Dinesh under his wing and broadened his perspectives, not only in science and research but also in politics.

At IIHS Dinesh was involved in a number of research projects including some that were directly involved in the then current political issues. For example, seat belt laws were being considered in many states and some people were advocating that mothers should be allowed hold their young children (clearly an unsafe way for young children to travel). Using his biomechanics background Dinesh was able to develop test procedures that demonstrated that mothers were not strong enough to safely hold a child during a crash. As a result this was no longer considered a “safe” way for children to travel. He also did research on the early crash experience of airbags, which at the time were extremely controversial and strongly opposed by much of the auto industry.

Dinesh’s tenure at IIHS was relatively short; when he was hired IIHS had agreed to sponsor him for a green card (which would have allowed him to become a permanent US resident). However, when his green card was approved he decided that he didn’t want to be seduced by it, and so in 1979 he left the US and returned to India without collecting his card.

Dinesh’s time at IIHS, and in particular his interactions with Haddon, was very important in broadening his perspectives so that when he returned to India he was much more than an expert in biomechanics as his subsequent career demonstrated.

**Children and traffic safety**
*Karin Brolin*

The protection of children in motor vehicle crashes has improved since the introduction of child restraint systems. However, motor vehicle crashes remain one of the top leading causes of death for children. Safe design of vehicles should provide protection for the whole population in case of an accident. However, children are not small adults. As the body grows and matures the biomechanical response changes.

The development of head, neck, thorax, and pelvis changes the biomechanics of child bodies. Children under 4 years of age have a proportionally large head and an anthropometry of the neck that have led to crash fatalities for forward facing children. The rear facing child seat distributes the crash load over a large area of the body and supports the mass of the head, which has proved to be a very efficient protection for young children.

By providing child adaptability of the vehicle the protection of child passengers can be further optimized. An example of this is the significant reduction of lap belt misuse when using integrated boosters. The review of human whole-body models covers both multi body and finite element models developed for crash simulations. The European project PIPER developed an open-source scalable child model and pre-processing tools. Child safety should not be an expensive add-on option, rather it should be standard in all vehicles. For low- and middle-income countries and families, affordable child restraint systems can be developed based on the basic principles of child biomechanics.

**Sustainable urbanization?**
*Hermann Knoflacher*

The concept of sustainability is focused on the future and addresses the challenges for cities. The sustainability principle means enduring a certain level of resource use without any collateral damage; this was first applied in forestry. It arose from the experience that the economic methods practiced for centuries led to the destruction of this resource, which was an existential resource at that time. This leads to irreversible consequences. Unfortunately, we have no sense of irreversibility, and only after millennia have we learned from mistakes that the long-term consequences of our actions are dangerous.

Because needs are unlimited, they are used as an engine of growth for corporate economies. Not so much in developing countries, but in rich countries and their urban populations, demands for convenience and energy consumption have exceeded all historical limits and are also expressed in enormous motorization and related infrastructures.

Corporations, like cities, are a human intellectual artifact, but oriented toward unlimited growth and short-term profit. Along with the exploitation of natural resources, cities have become the target of their profit maximization at the expense of the population and the future. They are therefore trying to use information technology to gain access to and control the data not only of cities, but also of each individual citizen. "Smart cities" are a corresponding business model of the corporations.

While the material aspiration level of the population has risen, population, politics and car-oriented urban planning have moved further away from sustainable development.

**Future Cities and Vision Zero**
*Mark Stevenson*

Faced with ageing and insufficient transport infrastructure, growing inequities particularly on the urban fringe, increasing air pollution and increasing rates of road injury and non-communicable disease, 21st century cities need to urgently

implement strategies that lead to sustainable agglomerations if globally, we are going to limit global warming to within 1.5 degrees Celsius. On a pathway to limiting global warming, we need to focus attention on the road transport system which contributes more than 20% of greenhouse gas emissions (GHG); sustainable urban transport systems must, therefore, be an urgent priority for policymakers across the globe.

Recent research not only highlights the effect of road transport emissions on air quality in cities but also the role a city's typology contributes to a resident's access to sustainable transport systems. To ensure our transport system is sustainable, we need to consider both transport adaptation and mitigation strategies, strategies that range from technology for sustainable transport to land-use planning.

*Dunu Roy*

Prof. Dinesh Mohan was concerned about the 'vulnerable' road user. His work focused on how to design the road to protect this particular user. His fundamental belief was that the design must be based on the lived experience of the user.

This paper builds upon the same basic concepts to argue that this specific road user is also a city dweller. So her vulnerabilities extend beyond the road to residence and work spaces, as well as to all services and utilities that the city has to offer.

Hence the design of the city has to encompass all these multiple factors of the lived experience of vulnerability. Furthermore, if the principles of participatory research are adopted to bring this lived experience to the core of design then the vulnerable citizen evolves into an active designer.

With examples from habitation layout to waste disposal, from optimum use of resources to climate mitigation, from creation of value to sustaining the value of creation, the paper offers the concept of 'cellularity' through which the vulnerable citizen reclaims her agency to protect the city.

**Data Requirements and Data Resources to Understand Road Transport Emissions**
*Sarath Guttikunda*

Building an emissions inventory for road transport in Indian cities is a challenging exercise. While the basic equation is simple: multiplying three numbers – number of vehicles (supply), vehicle usage (demand), and an emission factor (technology), collating the necessary information from number of vehicles registered or on the road, their usage, to knowing prevalent vehicle technology and their maintenance levels requires not only some analytical prowess but also some practical and logical understanding. The process itself involves compiling information from disparate sources and modelling to infer emissions with a reasonable understanding of uncertainty in various information sources. Dinesh loved the idea of exploring these sources, their uncertainties, and ways to guesstimate these numbers for broader applications

Promoting Active Travel: Lessons from Europe and North America
Ralph Buehler

International organizations, as well as governments at national, regional, and local levels have identified the promotion of walking and cycling to reduce car travel. It summarizes successful policies and measures implemented to promote walking and cycling and reduce car dependence in Europe and North America. These policies include measures that make walking and cycling more attractive like traffic calming to reduce car travel speeds and volumes; connected bicycle and pedestrian infrastructure to increase safety and convenience; integration of walking and cycling with public transport to facilitate longer trip distances; enforcement to improve walking and cycling safety; and programs to promote walking and cycling. The manuscript will also highlight policies that decrease the convenience of driving and increase its cost, such as taxes on motor vehicle use and ownership; restrictions on and reductions of car parking; or the imposition of speed limits. The manuscript will end with potential lessons for Indian cities on how to promote walking and cycling.

**Promoting active transport for health and the environment, including climate change.**
*Francesca Racioppi*

On World Bicycle Day 2022, WHO launched a new publication summarizing the evidence that underpins its key message that cycling and walking can reduce physical inactivity and air pollution, saving lives and mitigating climate change. Regular cycling and walking greatly reduces the risk of non-communicable diseases, which are responsible for more than 70 % of deaths worldwide and help to maintain a healthy body weight reducing the risk of obesity, which kills over 4 million people each year. Active transport can play a major role in achieving the minimum level of physical activity recommended by the WHO, reducing physical inactivity, which causes some 5 million premature deaths per year. The importance of active mobility in the package of effective measures to mitigate climate change has been underlined also in the most recent report of the Intergovernmental Panel on Climate Change .

Working in partnership with scientists from across the world and other UN Agencies, WHO supports Member States in this necessary transition through the provision of evidence, guidance, and tools to improve the safety of cyclists and pedestrians ; to integrate health in urban and territorial planning, including in relation to promoting active mobility ; to estimate the net health effects and carbon emissions from walking and cycling ; to develop national policies for walking and cycling.

**The importance of advancing road safety governance research**
*Meleckidzedeck Khayesi*

Institutions, organizations, politics and power matter in road safety policy and planning. However, are road safety researchers dedicated to examining these governance issues and designing solutions for them? This paper examines the status of road safety governance research, presents findings of a literature review on this topic and results of a global study on road safety lead agencies as governance mechanisms. Compared to research on risk factors and interventions, road safety governance has received limited attention. This topic deserves deep research investment to gain insights into the context of road safety policy, planning and implementation in different countries. Results of the road safety lead agency study identify several governance gaps related to coordination, funding, implementation and accountability that need to be addressed if the well-researched evidence-based solutions are to be meaningfully translated in tangible outcomes in countries. The paper proposes a road safety governance conceptual model to not only inform research on governance per se but also embed governance into existing road safety research.

**Identifying and Establishing a Road Safety Lead Agency**
*Matts-ake Belin*

In the World Health Organization and World Bank first world report on road traffic injury preventions the first recommendation was to set up a lead agency for road safety. According to the world report on road traffic injury prevention, each country needs a lead agency on road safety with the authority and responsibility to make decisions, control resources and coordinate efforts by all sectors of government.

## NEWS

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**The Dinesh Mohan Memorial Symposium was held on 7-9 September 2022**

*The main themes:*

*Road traffic Injuries and Unintentional Injuries*
The philosophy of "safety by design" was core to Professor Mohan's lifelong work on this topic, which he applied to many areas of unintentional injuries including traffic injuries.

*Institutions, organizations and governance*
Institutions have a played a very important role in promoting traffic safety as a science in most high-income countries. They improve road safety through formulation of multiple interventions, and it's the latter that are evaluated in road safety studies.

*Active Transport*
Increasing use of walking and cycling is now recognised as an important behavioral intervention to mitigate climate change. Active travel also contributes to population health through physical activity.

*Public Transport*
Bus based public transport continues to be the backbone of a sustainable city. All public transport systems are dependent on access and egress trips, primarily walking trips. What are the challenges and opportunities for ensuring a vibrant, inclusive and clean bus system in Indian cities?

*Environment Pollution and Public Health*
In low-income and middle-income countries, urbanisation is associated with an increased health burden from non-communicable diseases. Largest health gains would be from reductions in the prevalence of ischemic heart disease, cerebrovascular disease, depression, dementia, and diabetes. Are the current policies addressing these issues? Do we have enough data and evidence to support the current policies?

*Sustainable Urbanization*
Most cities in the world are grappling with issues concerning sustainable urban systems including transportation and safety on the streets. Most Indian cities have evolved organically mostly by defying formal plans and growing around informal sector-housing, business and work. How does this address the 21st century challenges for ensuring sustainable urban patterns?

*Human Rights*
The concept of human rights is relatively new. It came into everyday parlance only after the Second World War, the founding of the United Nations in 1945, and the adoption by the UN General Assembly of the Universal Declaration of Human Rights in 1948. The theoretical justification of human rights is based on a wide range of values that enhance human agency and protect human interests. The debate reflects the struggle for power between economic and social classes on the conceptions of the "good society".

*Pre Hospital Care*
The processes and the science of emergency care of the injured are still evolving. The lack of empirical data on the benefit of many pre-hospital care interventions remains a serious problem. Patient transfer to a definitive care facility has been a widely discussed area for pre hospital care. One of the dilemmas of pre-hospital care has been 'are we doing too little for a damage which seems too much?'

## COURSES

**Title: Certification Course On Road Safety Audit For Border Road Organisation Officers**
Date: 12 - 27 July 2022
A total of 24 participants attended the course nominated by the Border Roads Organisation

**Title: Two Separate 15- Days Certification Courses On Road Safety Audit For National Highway Authority Of India Officers**
Date: 19 April – 4 May, 2022
A total 20 officers attended the course out of 25 nominated by NHAI.

Date: 12-26 September, 2022
Total 14 officers attended the course out of 15 nominated by NHAI

**Title: Transformation of the Transport System and Cities for a Sustainable Future**
*Course taught by Prof. Hermann Knoflacher, Honorary Professor, from University of Vienna, Austria.*
Date: 01-03 December 2022
31 students have attended the course.

**Title: International Course on Road Safety, Road Safety Audit and Vehicle Safety Technology**
Date: 05 - 19 December 2022
The course was conducted in three different modules. 1) Road Safety (05-16 December 2022); 2) Road Safety Audit (5-19 December 2022); 3) Vehicle Safety Technology (10-14 December 2022). 63 participants have attended the course. 23 students completed the Road Safety Module, 13 students completed Road Safety Audit module and 27 students completed the Vehicle Safety Technology module.

**Uttar Pradesh Public Works Department Capacity Building Workshops for UPPWD Officers**
Under the objective of the project "Road Safety Inspection and discussion of Identified Blackspots and Travelling Workshop". The following workshops have been conducted for the officers of the Uttar Pradesh Public Works Department.

Date: 25th July 2019 (Lucknow workshop)
No. of participants: 80

Date: 12th January 2020
No. of participants: 25 (Meeting with SEs)

Date: 5th November 2020 (Webinar)
No. of participants: 100 (participants from all districts)

Date: 6th November 2020 (Webinar)
No. of participants: 60

Date: 7th January 2022 (Online)
No. of participants: 120

## SAFETY 2024

15th World Conference on Injury Prevention and Safety Promotion, 2-4 September 2024, Delhi, India

web: safety2024@georgeinstitute.org
twitter @Conf_Safety

The Transportation Research and Injury Prevention Programme has been operational for two decades. On May 21st 2021 it was established as TRIP Centre. It is based at the Indian Institute of Technology (Delhi) and is an interdisciplinary academic unit focusing on the reduction of adverse health effects of road transportation. Researchers at TRIP Centre seek to integrate all issues concerned with transportation to promote safety, active mobility, cleaner air, and energy conservation. They are involved in planning safer urban and inter-city transportation systems and developing designs for vehicles and safety equipment.

**Endowments for perpetual Chairs**
CONFER, India: TRIPP Chair for Transportation Planning
Ford Motor Co., USA: Ford Chair for Biomechanics and Transportation Safety
Ministry of Urban Development India: MoUD Chair for Urban Transport & Traffic Planning
MoUD Chair for Urban Transport and Environment
MoUD Chair for Urban Traffic Safety
VREF: Volvo Chair for Transportation Planning for Control of Accident and Pollution

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## Excerpts from two recent projects

### DEVELOPMENT AND VALIDATION OF AN ELECTRIC RICKSHAW PASSENGER SAFETY SCALE

*Sponsor: Science & Engineering Research Board (SERB)*

*Project Team: Manoj M., G.Tiwari and Nezamuddin*

Paratransit modes are an essential component of the urban transport systems of Indian cities. These modes mainly contribute to last-mile connectivity in megacities. In small cities, paratransit is also the primary travel mode providing access to work, school, recreation, etc. Additionally, paratransit modes also cater to the urban poor's mobility needs (Mani and Pant, 2012, Harding et al., 2016). Interestingly, the paratransit index of the megacities like Delhi, Mumbai, and Bangalore is nearly 90. The values indicate the relevance of paratransit to the daily mobility of urbanites. Despite these virtues, paratransit modes have been criticized for their contributions to air and noise pollutions (Harding et al., 2016; Mani et al., 2012) and undesirable fare structures, and social impacts (Baviskar 2011; Sood 2012). In light of this, the National Transport Development Committee (NTDC, 2012) suggested the need for technological overhaul and pragmatic changes in the provision of paratransit services.

One of the reforms proposed in paratransit services is the promotion of green mobility. Paratransit modes are found to have the possibility to promote low carbon mobility (Kumar et al., 2016). The "Smart Cities Mission" of the Indian government emphasizes promoting sustainable and green last-mile connectivity through paratransit modes (Smart Cities Mission, 2018). The national (DHI, 2012)-and state-level policies (e.g., Government of NCT of Delhi, 2018) regarding electric vehicles encompass paratransit services. These policies and reforms have led to the evolution of battery-powered rickshaws (Electric Rickshaws) in Indian cities and towns. These rickshaws generate power from lead-acid batteries (Majumdar and Jash, 2015) and are touted to reduce carbon emissions (Majumdar et al., 2015). With the Motor Vehicles (Amendment) Bill (2015), the electric rickshaw operations have been legitimated. Noteworthy, Indian cities have seen the growth of electric rickshaws at a greater rate than the adoption rates of electric cars and two-wheelers (Dhar et al., 2017). Electric rickshaws are present in most Indian cities and towns, ensuring first- and last-mile connectivity (Harding and Kandlikar, 2017) and addressing the public transport's supply deficit in small-sized cities (Priye and Manoj, 2020a). Electric rickshaws emit zero pollutants as compared to petroleum-based auto-rickshaws (Majumdar and Jash, 2015) and provide higher driver comfort than manual rickshaws (Rana et al., 2008). Also, the drivers of electric rickshaws are benefitted from more income than those gained from their previous jobs (Saxena, 2019).

Notwithstanding these positive impacts, electric rickshaws are found to have adverse effects. Safety has been an issue associated with electric rickshaws. As per the Indian Government, nearly 400 fatal accidents involving electric rickshaws were registered in 2016 (MoRTH, 2017). There have been discussions regarding the banning of these vehicles (Marwah and Bawa, 2016), and there is a restriction on transporting children to school on electric rickshaws (Government of Bihar, 2016). The static and dynamic aspects of electric rickshaws seem to impact other vehicles' movements and traffic stream safety (Mondal and Saha, 2020). Recent studies have shown that passengers are concerned about electric rickshaws' safety (Priye and Manoj, 2020b). Riders' future riding intentions concerning electric rickshaws are also improved if there are safety improvements (Priye and Manoj, 2020a). These findings clearly show that passengers' safety evaluation can be a reference for electric rickshaw safety modifications. From a policy standpoint, it is relevant to clearly understand what the electric rickshaw passengers consider when assessing personal safety before riding the rickshaws. The economic viability of a (public) transport system demands a thorough understanding of users' expectations. However, the scientific literature lacks scales to measure passengers' expectations regarding the safety of electric rickshaws. This project aims to develop and validate an electric rickshaw passenger safety scale. The study develops a methodology that combines machine learning algorithms and standard econometric approaches to develop and validate the proposed scale and prioritize safety improvement actions based on user perceptions. The project is the first attempt to present an electric rickshaw safety assessment scale from the passengers' viewpoint.

### ROAD SAFETY INSPECTION AND DISCUSSION OF IDENTIFIED BLACKSPOTS

*Sponsor: Uttar Pradesh Public Works Department*

*Project Team: Geetam Tiwari, Late Dinesh Mohan, Kalga Ramachandra Rao, K. N. Jha*

Among the states of India, Uttar Pradesh (UP) has reported the highest number of fatalities. In India, thirty percent of RTCs and thirty-six percent of RTC fatalities occurred on NHs, respectively. Reduction in RTC injuries and fatalities has become a priority for all stakeholders. Research has proved that highway designs (geometric characteristics-alignment, shoulder width, median design, roadside furniture, markings, and signage) play an important role in reducing RTCs. In India, various Indian roads congress (IRC) codes are available to guide the site engineer in adopting safe road designs. However, given the complexity of mixed traffic prevailing on Indian roads and highways passing through towns and villages, maintaining the safety of the roads becomes challenging. Therefore, standards and international best practices must be adapted to the local context to enhance the safety of the roads. The UP government has continually worked to reduce traffic crashes on all roads under its jurisdiction. In continuation of this effort, the Uttar Pradesh Public Works Department (UPPWD) identified black spots on their road network from 2015 to 2020. TRIP Centre (TRIPC), IIT Delhi was tasked with auditing those identified blackspots and proposing low-cost measures.

This study was divided into two phases. In phase one, 288 blackspots in 32 districts of the UP were audited. These blackspots were identified based on the crash data from the year 2015 to 2017. In phase two, 417 identified blackspots were audited. These blackspots were identified based on the crash data from 2018 to 2020. Before initiating the audit, a project inception meeting was held in the TRIPC in January 2020 with UPPWD superintending engineers to discuss the methodology and audit plan.

Under phase 1, the site visit was done in February 2020 and November 2020 to December 2020 for the audit. The audit was done by a team of three road safety auditors. In parallel, audit reports district-wise were prepared. A two-day online workshop on 5th and 6th November 2020 was conducted with the UPPWD engineer to get feedback.

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In phase 2, 417 blackspots were audited from March 2022 to June 2022. Two audit teams were deployed for the audit. Multiple trips were made for the audit. District-wise audit reports were prepared for each district.

The blackspot (BS) typologies were decided based on the area type, junction type, highway section passing through the settlement or not, and curve section. The BSs were segregated based on the location typology, area type characteristics, road category and junction typology. The location typologies considered are whether BS was a junction or a midblock section (non-junction). The BS locations were further subcategorized based on whether the audited BS is passing through the settlement. The junction typologies considered were the 4-leg intersection, T-type, Y-type, staggered, and multi-leg. The BS area typology is used whether the audited BS is in an urban or rural area. The major and minor road categories were NH, SH, MDR, ODR, and VR. Therefore, a total of eighteen types were identified based on the criteria mentioned above. The identified typologies were the representative of the audited BS on UPPWD roads.

In this study, checklists were developed for (a) midblock road sections, (b) junctions, (c) road sections passing through a settlement, and (d) road sections passing through a school. These checklists were further subdivided based on the major and minor road characteristics. In addition, separate speed and traffic volume data collection forms were also used. Speed was measured based on a hand-held laser speed gun. Traffic volume data was collected manually, and mode-wise volume was recorded in a format.

Next, district-wise reports of the audit were prepared. In the report, first a summary of all blackspots for the district was provided. Next, the summary and recommendation for each audited blackspot in the district was done. For each blackspot location, the following details were provided in the report (a) blackspot location summary, (b) crash details, (c) activity summary, (d) audit observation summary and (e) recommendations. For each blackspot location, three figures were also provided. In the first figure location details were provided. The second figure explained all types of activities happening in the vicinity of the blackspot. The third figure elaborates on the proposed recommendations based on the audit findings. For some of the locations optional recommendations were also provided. The audit observation summary and recommendations were made for both major and minor roads. And, in case of a junction for all legs of the junction. The recommendations were made based on the relevant IRC codes and international best practices in case information in the IRC codes was unavailable.

The audited blackspot (BS) Awadh Chauraha (BS-8) was in the Lucknow district on NH 230. It was at a four-lane divided ODR (VIP Road) and a six-lane divided ODR (Towards Alambagh) met the six-lane divided NH. At BS-8, a total of 11 fatal crashes and 40 grievous crashes have been recorded in the last three years. These crashes resulted in 11 fatalities and 40 grievous injuries and 5 minor injuries, respectively. The BS-8 Awadh chauraha is primarily located in the urban area where the predominant land use in the vicinity of this blackspot is commercial and residential. Pedestrians were crossing and walking along the road. There is a canal across the road. Buses were boarding and deboarding the passengers at informal stops. Vehicles were over speeding at the location. Therefore, this blackspot location belongs to type 14 of the blackspot typologies. The probable hazardous situations observed at the audited blackspot (BS-8) are as follows:

- Shoulders are occupied by parked vehicles thus hindering pedestrian movement.
- The risk of collision with median could result in hit-median crashes.
- Passengers of bus and paratransit transport could face the risk of getting hit by other vehicles while boarding and deboarding at the informal stop.
- Risk crash due to unregulated and haphazard vehicle's movement on major roads.

Next, a summary of the audit observations for major and minor roads was prepared and presented as follows:

Major road observations:

Mandatory and Cautionary signages were present.

Informatory (halt and go) signage was present.

- The pedestrian crossing marking was faded.
- Pavement marking was not present.
- Speed control measures were not present near the junction.
- TBM marking was not present near the junction.
- Mandatory (No Stop) marking was not maintained.
- Road studs were not provided adequately.

Minor road observations:

- OHM signage was present.
- The pedestrian crossing marking was faded.
- A gantry sign was present.
- The pavement marking was faded.
- Retroreflectors treatment was not given to the road median.
- Bar marking was not present.
- Speed control measures were not present.
- Cautionary (One way) signage was present.
- Delineators were present on the road median.

Based on the audit finding, recommendations were proposed. The recommendations aimed to bring the vehicular speed down to 30 kmph in the road junction passing through the settlement as per IRC:99-2018. The recommendations were primarily made to control speed, provide adequate road signages, improve markings and traffic-calming measures. The recommendations are made for the intersection area, major road, and minor road sections. The following measures are recommended for the road category other than the village road category.

➢ Speed control and driver alerting measures

➢ Road signages as per IRC:67-2021

➢ Road markings as per IRC:35-2015

➢ Speed control and driver alerting measures IRC:99-2018

➢ Road signages as per IRC:67-2021

➢ Option 2: Recommendations for the junction area: