



Report | Road Safety in India. Joint Working Group Recommendations.

February 14, 2020

Autoliv

The **Road Safety Knowledge** Sharing Platform was launched late 2018 through the initiative of the Autoliv Group. All participating stakeholders in the platform share a common goal to reduce road traffic fatalities in India. A review and evaluation of the current situation of road traffic safety in India was completed 2019. The result is a set of recommendations on how to address the number of fatalities on Indian roads. This report presents issues and recommendations with the ambition to support Indian governmental bodies, at both national and state level, in the formation of future policies and implementation of strategies.

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1. Executive summary

The official national statistics in India show that around 150,000 fatalities occur on the roads each year. Based on this, Autoliv initiated the "Road Safety Knowledge Sharing Platform" in late 2018. The initiative was inspired by the Swedish "Vision Zero" approach. A Joint Working Group (JWG) was thereafter launched in early 2019 including representatives from governmental bodies in India (ARAI, and NATRIP, including ICAT), industry associations (ACMA and SIAM), university (IIT Delhi) and the Autoliv Group. The work within the JWG has resulted in a set of recommendations supporting key road safety areas. These areas and recommendations are:

1. On Infrastructure:
   a. A Road Safety Authority should be installed both at national and state level. Note that the government in India has taken first steps with the Draft GSR 902 dated December 10, 2019.
   b. An appropriate policy and framework based on the Safe System approach should be adopted to guide safe road infrastructure design.
   c. The Indian Roads Congress (IRC) Codes of practice need to be updated regularly, based on local research. Application of the IRC Codes should be mandatory. Safety of vulnerable road users must be prioritized on all roads, i.e. must be reflected in the IRC Codes.
   d. Installation of road signages must be done in accordance with the IRC Codes.
   e. Safety performance of roads and their design standards should be evaluated continually.
   f. Road safety consultants should be independent, which is common practice internationally.
   g. A pool of safety auditors should be created both at a national and a state level.
   h. Rating of road safety auditors and contractors should be conducted in regards to their level of experience and expertise.

i. A government recognized in-depth road accident database should be established.

j. Road safety inspection and management through a blackspot approach across India may be used as one measure, a risk-based approach is recommended in the long term as a global best practice.

2. On Vehicle Technology:

a. Harmonization of vehicle regulations with the UN ECE Regulations should be pursued while the process must take in consideration the road traffic situation of India.

b. The opportunities to develop enhanced regulations for buses, commercial vehicles, and motorcycles, should be reviewed and understood.

c. It should be possible, by the appropriate assigned body, to cancel vehicle registrations should the vehicle not meet applicable safety regulations.

d. A vehicle rating program should be finally defined, i.e. rating programs should be scientifically examined to benefit the Indian market, and get support from all stakeholders, with an aim to help buyers of vehicles to make informed purchase decisions.

e. Incentives to promote safety beyond basic regulations should be considered.

3. On Human Behaviour:

a. Training programs for driving of commercial vehicles should be improved and affordable.

b. Graduated driving license schemes for young and new drivers are important.

c. Evaluation of programs for young road users on how to behave on the roads and how to handle emergency situations should be done to improve effectiveness of these programs.

d. Implementation of a reward and recognition program on road safety, which would encourage people to assist in emergency situations during road accidents, provided these programs can be assessed for effectiveness.

e. Nationwide campaigns should be run with the goal to achieve 100 percent seat belt use in front and rear seat in cars and helmet wearing of two-wheeler riders and pillions.

4. On Monitoring:

a. Installation of monitoring systems, e.g. Closed-Circuit TV (CCTV), at appropriate junctions and blackspots.

b. A digital platform should be created for the public to easily report any road accidents through phones or mobile applications which will support faster rescue and medical care/attention.

2. Background

One of the leading road safety researchers in recent years, Dr Leonard Evans, states in the introduction to his textbook 'Traffic Safety and the Driver' that no one who lives in a motorized society can fail to be concerned about the enormous human cost of traffic crashes.

The UN World Health Organization, WHO, states the following on its website: "The Global status report on road safety 2018, launched by WHO in December 2018, highlights that the number of annual road traffic deaths has reached 1.35 million". Road traffic injuries are now the leading killer of people aged 5-29 years. The burden is disproportionately borne by pedestrians, cyclists and motorcyclists, in particular those living in developing countries. The report suggests that the price paid for mobility is too high, especially because proven measures exist. Drastic action is needed to put these measures in place to meet any future global target that might be set and save lives.

WHO estimates in the same report that more than one fifth of all global road fatalities occurred in India, i.e. around 300,000 fatalities. However, the official national statistics in India indicate that around 150,000 fatalities occur on the roads each year. More precisely 151,467 people died on the roads in India in 2018, as reported by the Ministry of Road Transport and Highways, Government of India, in its 'Road accidents in India 2018'. Whether looking at the WHO estimation or national statistics, road traffic injuries continue to be one of the leading causes of death, disabilities and serious injuries in India. The number of those who sustain severe injuries, including disabling injuries, is three to four times higher than the number of fatalities, as reported by the Ministry of Road Transport and Highways (Road accidents in India 2018), yet the estimated numbers are in general even higher. The number of crashes with severe injuries is often 10 to 20 times higher than the number of fatal crashes according to current estimations in many other countries.

The UN Sustainable Development Goal (SDG) No 3 stipulates that ensuring healthy lives and promoting the well-being at all ages is essential to sustainable development. Each goal has several targets. The target 3.6 is to halve the number of global deaths and injuries from road traffic accidents by 2020.

India signed the Brasilia Declaration in 2015, thereby committing to reduce road accidents and fatalities by half from year 2011 through 2020, and by that also committing to the UN SDG 3.6. The declaration does include high level recommendations further to the target on reduction of fatalities and was the outcome of the 2nd Global High-Level Conference on Road Safety, which was hosted by Brazil in 2015 in Brasilia. This 2nd conference did continue the UN initiative that was launched by the first Global Ministerial Conference on Road Safety, held in Moscow in 2009, which culminated a little later in the UN decision to declare a decade of action for road safety in the world. Unfortunately, at the current rate of road accidents and fatalities, India will not be able to achieve the UN SDG target 3.6 by 2020.

Road fatalities in India have simply not yet shown any significant decrease. The decrease was for instance less than 2% from 2016 to 2017 and the trend in 2018 seems to be a small increase. The total number of road accidents in India decreased slightly in 2017, but on the other hand the overall accident severity increased somewhat. India's overall official accident death rate (as well as death per 100,000 population – almost 12 according to national statistics or 23 according to the WHO estimate) is one of the highest in the world. About 35% of the fatalities are pedestrians as per Global Burden of Disease report. However, government reports in India indicate that 13% of the fatalities are pedestrians and 40% are riders of two- or three-wheelers. The road safety challenges are momentous, as are the opportunities to save lives in India.

Sweden is to host the 3rd Global Ministerial Conference on Road Safety 19–20 February 2020. The conference theme is 'Achieving Global Goals 2030' and minister-led delegations from more than 80 countries are expected to attend. Representatives from industry, academia, and international organizations will also participate. The Conference will be an opportunity for delegates to share best practices and experiences based on implementing the Global Plan for the Decade of Action for Road Safety 2011–2020. Moreover, it is an opportunity to define future strategic directions for global road safety in 2030 and beyond and define ways to accelerate action on proven strategies to save lives. The Conference will also provide an opportunity to link road safety to other sustainability challenges.

3. Introduction

India is the world's largest democracy and is among the world's ten largest economies, according to Business Sweden. India is expected to be ranked as the world's third largest economy, after China and the US, by 2030. India has today around 1.3 billion inhabitants and is the second most populous country after China, according to US Census July 2019. India is expected to overtake China by 2025 regarding population when both will have around 1.4 billion inhabitants. 15% of the population in India is expected to be older than 65 in 2050, whereas EU and China will have almost 30% older than 65. The GDP of India was approximately 2.6 trillion USD in 2017. In EU and the USA respectively, GDP's were approximately 19 trillion USD. China had a little more than 12 trillion USD in 2017.

Sweden and India have for many years had a strong and stable relationship in both the fields of politics and business. Sweden's first technology export to India took place already in the early 20th century, consisting of telecom equipment from Ericsson through the establishment of a subsidiary. Other Swedish business establishments in India include large corporations such as Alfa Laval, Tetra Pak, Sandvik, Atlas Copco, Volvo, Scania, Perstorp, IKEA and H&M but also many smaller companies. India and Sweden had a bilateral trade turnover of 3.37 billion USD in 2018. Almost 200 Swedish companies have today subsidiaries in India, jointly employing directly almost 200,000 people and 600,000 indirectly, and with 2,200,000 employment opportunities created through the supply chain, distribution network and auxiliary services (all according to the Swedish Chamber, 2019).

The Swedish economy has been a front-runner within the area of sustainability, e.g. climate change measures, renewable resources, waste management, energy production and safety. The social aspects of safety in society have been encouraged and enforced by the Swedish government for many years. Sweden has had a focus on workplace health and safety, child safety with

regards to playgrounds and toys, safety legislation setting standards for equipment within the area of sportswear, and other safety aspects in society. Hence, the Vision Zero approach regarding road safety was a natural step for Sweden in the late 1990's. Statistics verify that the efforts have paid off. Swedish roads are among the safest in the world. Since the year 2000, the number of traffic fatalities has been reduced by 50% in Sweden. The Swedish road fatality rate per 100,000 population is one of the lowest in the world (2.5) and is still decreasing. This positive development did not come by itself. It was imperative that the government developed and pursued a strategy regarding policy development and enforcement, whether through legislation or voluntary measures, regarding infrastructure and vehicles. The more support and involvement of concerned stakeholders there is, the faster and more efficient effects will be seen.

The Swedish Parliament adopted the Vision Zero in 1997. It was a non-conventional approach aiming to reduce the number of road fatalities down to zero and it was adopted by the EU 14 years later, when the EU for the first time defined a European Vision Zero regarding road fatalities. This ambition was defined in the statement "By 2050, move close to zero fatalities in road transport and make sure that the EU is a world leader in safety and security of transport in all modes of transport". As an intermediate step, Europe did decide through the EU Commission's Road Safety Programme 2011-2020, to set a target of reducing the number of road deaths by 50% by 2020 and the ambition to reduce the severity of injuries resulting from road accidents.

Vision Zero is founded on a system approach and stakeholder responsibility, known among road traffic researchers as the Safe System Approach. Road traffic must in this perspective be a process within a system made up of several sub-systems, i.e. the roads, vehicles and road users of all kinds. To prevent serious accidents and injuries, the roads and the vehicles must be adapted to match the capabilities of the people that use them, both regarding the aspects of biomechanical tolerances and the whole spectrum of Human Factors.

In most countries around the world the road systems are far from perfect. The significant day-to-day road safety issues seems to be related to

alcohol, speeding and poor usage of seat belts or other safety equipment, such as helmets and child restraints. Distraction, fatigue and the poor interaction between motorized vehicles and vulnerable road users are other prominent road safety issues. Such system defects are predominantly related to poor road user behaviour and had to some degree become accepted by society until the Vision Zero discussion started. India and any country must certainly aim to achieve the safest possible road user behaviour, but the safe system approach is also about creating a more mature system, a resilient system, so that the system can deliver the overarching functionality (mobility) without killing people. A system is an aggregation of cooperating subsystems. System integration is about adding value to the system. Capabilities that are possible thanks to the interactions between multiple subsystems. Mobility and safety do not contradict each other in this perspective. They can work in concert.

Autoliv India is one of the Autoliv Group's major foreign subsidiaries, which provides global technical and scientific support from its innovation centre in Bangalore including road traffic safety research. Autoliv India does also produce safetybelts, airbags and steering wheels controls in several manufacturing plants across India. The Autoliv mission is to "Provide World Class Life-Saving Solutions for Mobility and Society" under the vision of "Saving More Lives". Autoliv's long-term Corporate Social Responsibility program is founded on its global independent road traffic safety research, which Autoliv has conducted systematically since the start of the Vision Zero policy work in Sweden in the early 1990's.

Taking in account the high road fatality and injury rate in India and considering the UN goals, Autoliv initiated the "Road Safety Knowledge Sharing Platform" in late 2018. The initiative is inspired by the Swedish Vision Zero and Safe System approach. The platform aims to provide an opportunity for the relevant stakeholders to influence the road safety development in India in a positive way. To enable the platform to come to relevant and realistic recommendations, a Joint Working Group (JWG) based on the triple helix approach, i.e. collaboration between government, industry and academia with the objective to provide knowledge and conduct research, was set up soon after the launch of the platform. In 2019 the JWG had the following participating organizations:

- Automotive Research Association of India (ARAI),
- National Automotive Testing and R&D Infrastructure Project (NATRiP),
- Society of Indian Automobile Manufacturers (SIAM),
- Automotive Component Manufacturers Association of India (ACMA),
- Indian Institute of Technology Delhi (IIT-Delhi),
- Autoliv India and Autoliv Global Research.

Special invitees:

- International Centre for Automotive Technology (ICAT),
- Institute of road traffic education in India (IRTE),
- Ministry of Road Transport and Highways (MoRTH),
- National Highways Authority of India (NHAI),
- The Swedish Transport Administration (Trafikverket).

The JWG has reviewed the road traffic safety issues in India using the complete Haddon Matrix, whereas the deliberations of the JWG have been grouped into the categories of Human, Vehicle and Infrastructure only, without making the distinction between phases of accidents. Five workshops have to date been conducted with the following themes:

1) JWG #1 on 11 December 2018 – Kick-off, Trafikverket presented Vision Zero.
2) JWG #2 on 21 February 2019 – Road safety for Vulnerable Road Users.
3) JWG #3 on 4 June 2019 – Road Infrastructure and Vehicle Technology.
4) JWG #4 on 25 September 2019 – Shared Road User Responsibility.
5) JWG #5 on 11 December 2019 – A final workshop to finalize the recommendations

4. Discussion

The level of road safety does affect all citizens and organizations. Acting on road safety is about improving the lives of people and communities, and about reducing the significant social and economic burden of deaths and injuries caused by traffic accidents. Speed management, safe road design, higher vehicle safety standards, improved post-crash care, more efficient laws and improved enforcement, and the encouragement of key safety behaviours such as the use of seat belts and an end to drink driving are all part of the solution. The evidence on how to achieve this, as well as the benefits, are already available as several actions and metrics related to Vision Zero have been studied for quite many years.

Without doubt, road safety is recognized as a key well-being parameter in India but reducing fatalities and negative effects will demand that many stakeholders do take joint action. The stakeholders that have been involved in the Platform/JWG do all play an important role in the process of both definition and implementation of road safety measures that will make a difference. The ambition is to share the discussions and deliberations by the JWG and the conclusions thereof of learnings from global best practices, to find their alignment to Indian preconditions and drive conclusions that could support in building a safer mobility solution for India and escalate the Indian government's ambition to reduce deaths by road accidents and incidence of accidents. There seems to be a strong interest and need for a reform of the road safety policy in India, including the regulatory framework with traffic rules, codes for infrastructure design, vehicle regulations and traffic management guidelines. The discussions and deliberations of the Joint Working Group are now summarized into recommendations to encourage decision-makers to define an upgraded policy and regulations.

The automotive industry has for many years importantly supported an increased focus on road safety around the world, and for instance in Europe in May 2018, the ACEA (European Automobile

Manufacturers' Association) and CLEPA (European Association of Automotive Suppliers) signed a "Road Safety Pledge" together with FIA (Fédération International d l'Automobile), which is a full support of the European Vision Zero Approach in EU. The International Organisation of Motor Vehicle Manufacturers (OICA) did publish a Global Road Safety Manifesto in late October 2019, which is a commitment to support the implementation of the basic vehicle safety regulations around the world. OICA did already in 2015 express support for such a global development and not least are the UN activities under WP29 regarded as the preferred way to adopt by emerging countries. Hence, the automotive industry in India (represented by SIAM and ACMA in the JWG) has counterparts in other countries around the world that are in the same position in regards to the implementation of basic safety regulations. In addition, the automotive industry in India has an opportunity to participate in the further development of vehicle safety standards also on a global level.

India has mandated with the new amendment to the Motor vehicle act 2019, a good level of needed basic safety regulations and the automobile industry has supported the implementation of these requirements. With the basic requirements in place and with a view to further develop technology based on global best practices the JWG has focused the attention on the additional development of road safety requirements in India. The related issue of a vehicle rating program has been addressed and it can be concluded that although the JWG stakeholders have different views upon the best way forward for India, all participants agree that Bharat NCAP or BNVSAP has an important role to play in promoting vehicle safety further. While there are different measures that should be evaluated to improve the road safety situation, and the BNVSAP is not the only panacea for the road safety situation in India, the JWG concluded that a vehicle rating program that will fit India is one important initiative. A swift investigation should be performed, which is to say that the pending BNVSAP should be revisited and scientifically examined to ensure it will benefit India and get support from all stakeholders. It is worth to note that the counterparts of SIAM and ACMA in Europe (ACEA and CLEPA, respectively) are both actively involved in the process of developing the protocols of the European rating program Euro NCAP.

Finally, it should be highlighted that there has been a development of road safety policies in India during 2019 while the work of the JWG has been conducted. In other words, some of the recommendations that the JWG are proposing have already been or are being addressed.

Note that further discussions on the specific topics in the workshop series during 2019 are found in the Appendix of this report.

5. Recommendations

It is recommended that India in the long term should implement the safe system approach like Sweden and the EU where all the rules, road safety management processes, vehicles and the infrastructure are increasingly designed for resilience, i.e. prepared for human errors and sustainability, yet to deliver the desired mobility. In other words, the JWG recommends India to adopt the Vision Zero validated for the Indian preconditions as the long-term goal for future mobility.

The concerned legislative authorities in India are requested to consider the listed recommendations in the following when formulating future strategies, regulations and policies on road safety, including vehicle safety. The JWG is confident that these recommendations will support India in achieving the goal and milestones of reduced road fatalities, making its roads safer for all while preventing social and economic loss to the country.

The recommendations cover the following four road safety fields:

- Infrastructure
- Vehicle technology
- Human behaviour
- Monitoring

Further detailed road safety gaps are part of the discussion that are described in the Appendixas well as in the previous chapter (Discussion, Chapter 4).

RECOMMENDATIONS ON INFRASTRUCTURE

Roads and road furniture

a. A Road Safety Authority should be installed with an appropriate governance and structure, both at national and state level. Note that the government in India has taken first steps with the Draft GSR 902 dated December 10, 2019.

b. An appropriate policy and framework based on the safe system approach should be adopted to guide safe infrastructure design and development.

c. The Indian Roads Congress (IRC) codes of practice need to be updated regularly, based on local research studies. Application of the codes should be mandatory. Safety of vulnerable road users must be prioritized on all roads.

d. Road design must drive the development of practical solutions regarding vulnerable road users, for example pedestrian zones or lanes and other measures to protect vulnerable road users, i.e. all categories of VRU should be regarded in reality.

e. Installation of uniform road signages must be done in accordance with the IRC codes introduced and should be based on behavioural science.

f. Roads should use relevant and proper barriers, medians, audio-tactile markings, and roundabouts, always considering interaction between motorized and non-motorized road users.

Road evaluation

g. The safety performance of roads should continuously be evaluated by competent institutions.

h. Roads should be rated based on an appropriate rating standard. A road assessment program should be drafted based on international best practices and considering the specific needs for Indian roads and traffic.

i. Road safety consultants should be independent, in line with international best practice.

j. A pool of independent safety auditors should be created both on national and state level.

k. Rating of road safety auditors and contractors should be done in regards to their level of experience and expertise.

l. In addition to past and ongoing activities, a road safety inspection and management through a blackspot approach across India may be used as a measure, a risk-based approach is recommended in the longer term in line with global best practices.

Road accident data

m. In addition to existing databases a well qualified government recognized in-depth road accident database should be established to support the identification of contributory factors of accidents and taking relevant steps in mitigating accidents, injuries and fatalities in India. The databases should be capable of storing data from in-vehicle crash and event recorders. The data should be open for research.

n. A medical database that is relevant to road accidents should be established. Reclassifying or regrouping cases caused by road accidents to be properly accounted for.

o. Reporting of road accident data in the National Crime Record Bureau report, and the Ministry of Roads and Highways reports from police case files, should be improved for identifying type of victims and impacting vehicles.

p. A specific national database for fatal accidents should be established on the lines of FARS (Fatal Accident Recording System, USA) in collaboration with the states.

RECOMMENDATIONS ON VEHICLE TECHNOLOGY

Vehicle safety regulations

q. Harmonization of vehicle regulations with the UN ECE Regulations should be pursued with a defined and industry approved timeline.

r. The opportunity for enhanced regulations for buses, commercial vehicles (both light and heavy duty), scooters and motorcycles, should be reviewed and understood in detail.

s. It should be possible, by the appropriate governmental body, to cancel any vehicle registration in case the vehicle does not meet applicable safety norms.

t. An event recorder (black box) for commercial and private vehicles can act as a data gathering source and thus used for post-accident research, insurance providers, OEM's and other automotive related research & industries.

Vehicle rating programs

u. A vehicle rating program should be finally defined, the pending proposal on BNVSAP should be scientifically examined together with other industry recommended programs to ensure there is a relevant program that will benefit India, and get support from all stakeholders, with an aim to help buyers of vehicles to make informed purchase decisions. A process taking in account for conditions specific to India regarding the implementation of the vehicle rating program should be considered.

Other measures

v. Subsidies and other financial incentives to promote safe vehicles beyond basic regulations and requirements are encouraged and should be explored.

RECOMMENDATIONS ON HUMAN BEHAVIOUR

Education and tests

w. A regular evaluation of education and learning programs related to the driving of vehicles should be carried out and aim for improved programs.

x. A graduated driving license scheme is needed for young and new drivers.

y. An upskilling program on road safety norms for all parts of the ecosystem and digital solutions to be introduced and implemented.

z. Evaluation of the effectiveness of education programs for young road users on how to behave on Indian roads and how to handle trauma or emergency situations during accidents should be carried out.

Reward and recognition

aa. Implementation of a reward and recognition program regarding road safety, which would encourage people and students to actively assist in emergency situations during road accidents.

Focus on drunk driving, speeding and other dangerous traffic behaviour

bb. Additional campaigns and radar control, and evaluation of their effectiveness.

cc. Technologies for monitoring and reacting to drivers who are fatigued or driving under the influence of alcohol.

Use of safety devices

dd. Find ways to encourage and ensure use of helmets, seat belts, child restraints, reflective tape, etc.

ee. Nudging with tailored communication, education at work, campaigns, etc.

RECOMMENDATIONS ON MONITORING

Monitoring

ff. Installation of monitoring systems, e.g. Closed-Circuit TV (CCTV), at appropriate

junctions and blackspots, with the aim for more efficient emergency care as well as traffic management and road improvements.

gg. A digital platform should be created for the public to easily report any road accidents through phones or mobile applications which will support faster rescue and medical care.

hh. A connectivity solution together with an event recorder (black box) for commercial and private vehicles can act as a prevention mechanism and a data gathering source to be used for post-accident research, insurance providers, OEM's and other automotive related research & industries.

FURTHER RECOMMENDATIONS

A number of additional action points and recommendations were discussed in the JWG resulting in the following suggestions:

- Establish interdisciplinary Centres of Excellence in selected academic institutes (possibly IIT's, and NITs) to support research required for safer roads, vehicles, evaluation and management practices, and to assist the National Road Safety Agency in defining practical road safety targets.
- A need to upgrade the Inspection and Certification system to reduce the number of road fatalities. To address, scientific and quantitative measurement of health status of vehicle, support in reduced traffic congestion caused by the vehicle breakdown and accidents. The test data can be computerized and a national database with linkages to "vahan" and "sarathi" could be created.
- Prioritize research areas (electrification, mobility of vulnerable road users and digitalization to mention three important areas) in order to define and launch long-term research programs.
- Prioritize research areas for the shorter term in order to support existing research programs.
- Evaluation of current standards in practice, IRC codes that need immediate revisions, evaluation of current regulatory measures, licensing schemes, safety campaigns and educational programs.
- Establish a national road safety agency to develop specific targets in consultation with road traffic experts in India to start a management by objectives, as in Sweden and EU, with clear targets on road safety performance indicators.
- Assign responsibility to respective concerned organizations to develop action plans required for implementing the road safety recommendations and to work with MBO (Management By Objectives).
- Collaboration with the appropriate institute in Sweden on training of auditors and safety counsultants.

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9. Appendix – JWG Road Safety Discussions

An introduction to the JWG workshops and their discussions can be found in chapters 3, 4 and 5; a more detailed review and explanations of specific topics are found in this Appendix.

All discussions are based on the current situation in India with evidence from reports, surveys, technical papers, newspaper articles, etc. The deliberations are based on theoretical knowledge and experiences from countries that have applied these in practice. The conclusions are based on scientific work and driven by data, enabling relevant and cost-effective road safety related plans and policies. The Haddon Matrix was used to give structure to the discussion in the JWG. This structure was chosen because it is still the most common concept in the road traffic injury prevention field. It was developed by William Haddon in 1970. The matrix looks at elements related to the categories of Human, Vehicle and Infrastructure connected to the three phases of accidents, namely pre-crash, crash and post-crash, in an arrangement of the elements into rows and columns.

INFRASTRUCTURE

Observations and discussions

Safe roads play an important role in reducing road fatalities. Roads that are designed and built well with appropriate guardrails and other barriers at dangerous stretches, signs, visibility, surface, bends, bridges, crossings, lane separations, markings, speed limits, maintenance, monitoring, etc. can prevent and mitigate crashes significantly.

- There is a lot of continual work to improve road infrastructure in Sweden to increase road safety.
- Efforts in clearing roadside fixed objects like trees, etc. and installing roadside barriers, guardrails, have shown positive results in reducing road fatalities.

- By installing the median barrier on roads, the proportion of traffic flow went from 21% to 41%.
- Audio Tactile Lane Markings have been installed in the middle of the roads on 4,000 kilometres of rural roads.
- In urban areas roundabouts have replaced intersections.

MoRTH (Ministry of Road Transport and High- ways, 2017) statistics reveal that India has about 5.6 million kilometres of road networks making it among the largest road networks in the world. The road network compound had an annual growth rate of 3.7% from 2006 to 2016. India's road network consists of National Highways (NH), State Highways (SH), Districts roads, Rural and Village roads. Over the years, the road network has been improved significantly across the country through the construction of new roads and upgraded existing roads.

India has a road density of 1.7km/km2 which is higher than many developed countries. However, surfaced or paved road constitutes only 62.5% of the total road length which is lower than in developed countries. NH and SH constituted 1.80% and 3.1% of the total road length of the country in 2016, respectively. While remaining is shared by district roads (10.0%), rural roads (70.2%), urban roads (9.1%) and project roads (5.7%) (Ministry of Road Transport and Highways, 2017). However, 63% of total road traffic fatalities are on NH and SH during 2017.

The challenges are momentous for India as well as the opportunities. Some of the observations by the JWG members were:

- The Indian Road Congress (IRC) codes of practices for specifications and standards are not optimal or followed rigorously in the existing infrastructure or while building new infrastructure related to road, highway, and expressway.
- Road safety consultants and auditors are not independent, and the competence of road safety consultants and auditors can be optimized.
- There is also the dearth of Road Safety Auditors in India. Institutional capacity of training of auditors is limited.
- Design guidelines with respect to the safety of Vulnerable Road Users need more details for implementation.
- Roundabouts are being replaced by intersections in India, which is contrary to the current best practices in countries like Sweden. The approach needs to be looked at with evidence and justification.

Roundabouts do make road traffic safer and more efficient. Modern roundabouts follow various design rules to increase safety. Compared to stop signs, traffic signals, and earlier forms of roundabouts, modern roundabouts reduce the likelihood and severity of collisions greatly by reducing traffic speeds and minimizing side collisions as well as head-on collisions, as per Wikipedia 2019.

Traffic exiting the roundabout comes from one direction, rather than three, simplifying the vulnerable road users' visual environment. Traffic moves slowly enough to allow visual engagement with vulnerable road users, in deference to them. Other benefits include reduced driver confusion associated with perpendicular junctions and reduced queuing associated with traffic lights. They allow U-turns within the normal flow of traffic, which often are not possible at other forms of the junction. Moreover, since vehicles on average spend less time idling at roundabouts than at signalled intersections, using a roundabout potentially leads to less pollution. When entering,

vehicles only need to give way, they do not always perform a full stop; as a result, by keeping a part of their momentum, the engine will produce less work to regain the initial speed, resulting in lower emissions. Research has also shown that slow-moving traffic in roundabouts makes less noise than traffic that must stop and start, speed up and brake

Vulnerable road users are very important to incorporate in designing roundabouts. Basic principle of yield is by design, earlier roundabouts were called rotaries, modern roundabouts are called roundabouts since the geometry is done in such a way that the approach is deflected, you don't straight go into the roundabout, the minute they approach traffic slowdowns the running roundabout traffic gets right of way, which is by design - flare the traffic and deflect the approach. Example: On Lodhi road, they closed the roundabout, used cones to manage the approach and then reworked and opened the roundabout. Roundabout in Chandigarh with correct geometry is controlled by traffic lights which give you the control to fatalities. These are small roundabouts.

Sweden has a high number of roundabouts. Even then, two-wheelers are hard to manage in roundabouts under Vision Zero in Sweden. Fresh learnings and study for roundabouts to be designed in the Indian context, a fresh outlook to be derived, as engineering system has prescribed roundabouts which are embedded in the system since the 1950s and 1960s. Roundabouts to be designed with meeting the criteria of saving cyclists and pedestrians who are most vulnerable. Roundabouts can slow down vehicles so when a crash does occur, the speed will be lower, and the crash angle will result in less severe injuries compared to a right-angle crash at an intersection.

Guardrails are an important feature (or tool) that could be used more in infrastructure. Guardrails aim to keep cars in the roadway during the critical event i.e. it would prevent cars to run-off the road which could later impact any road-side object such as a tree, or pole, or lose control and initiate a rollover. Also, if guardrails are used in medians in an undivided road would avoid head-on collisions.

Roads in India do often not have proper lane markings, nor display of signboards, nor traffic signals, and so on, which creates limitations in introducing state-of-the-art systems such as lane keep assist systems, intelligent speed adaptation systems, etc.

Studies assessing Road Infrastructure Safety in India

Studies based on RASSI crash data at specific locations have been published in the public domain. These annual reports provide summary details of the road accidents investigated under the RASSI initiative and list the contributing factors – Human, Vehicle and Infrastructure – based on a descending order of influence on road accidents and injuries to help readers and decision-makers prioritize road safety action plans.

Coimbatore Rural Road Accident Study

This report analyses the data of 218 road accidents in Coimbatore Rural District that were scientifically examined by JP Research (JP Research India Pvt Ltd, 2017a) during the period of January 2016 to December 2016. The contributing infrastructure factors influencing the occurrence of the 218 road traffic accidents were undivided roads (35%), poor street-lighting (10%), poor pedestrian infrastructure (8%) and poor intersections (6%). Roadside objects (6%) and roadside steep slopes (3%) were the main contributing infrastructure factors resulting in fatalities and serious injuries.

Kolkata City Road Accident Study

This report analyses the data of 125 road accidents in Kolkata City that were scientifically examined by JP Research (JP Research India Pvt Ltd, 2019) during the period of January 2018 to December 2018. The contributing infrastructure factors influencing the occurrence of the 125 road traffic accidents were poor pedestrian infrastructure (8%), poor road marking and signage (18%), poor intersection design (14%) and undivided roads (12%). Roadside objects (9%) were the main contributing infrastructure factors resulting in fatalities and serious injuries.

Delhi Jaipur National Highway Study

A project was conducted in 2014-15 by Accident Data Analysis Centre (ADAC) in collaboration with IIT-Delhi on "In-depth Study of Serious Road Accidents" on the Delhi-Jaipur National Highway – 8 covering 190 km. Detailed Data from more than 240 motor vehicle accidents were collected and analysed. There were 17 contributing factors related to road attribute were found such as U-turn without signboards, hazardous roadside objects, open under construction roads, etc. The study identified 15 blackspots of which 11 were corrected. The impact was observed in the number of accidents which declined from 3,361 in 2015 to 2,221 in 2017 (member of JWG, n.d.).

Yamuna Expressway Study

A safety audit was performed on Yamuna Expressway by analysing 553 accidents. The study reported, 28% of accidents as first event type were due to infrastructure-related issues

such as hitting median, culvert (or wall), pedestrians, and bicyclists. Some of the observations related to infrastructure were the unprotected concrete pillar, deformed (or unrepaired) guardrails, raised medians, missing lane markings, etc. (member of JWG, n.d.).

Based on the observations in the study, it was clear that the high-speed roads were not made as per the IRC codes available in India. IRC has given clear guidelines for the design and construction of roads but the following of the same by contractors is the issue. Another issue was no action for a faulty design or deformed infrastructure.

Insufficient auditors for Safety audits

National Highway Authority of India (NHAI) struggles to identify well-qualified auditors for safety audits of roads. Currently, two auditors are assigned on a project. However, each auditor operates on multiple projects. Thus, it reflects on the competences and quality of auditing the roads. Design consultants and executing agencies do not emphasize on safety aspects. NHAI had conducted training in which 30 teams of auditors participated. However, after 15 days of training, only four teams managed to qualify the requirements (member of JWG, n.d.).

Some examples of poor safety audits were: incorrect placement of signboards which leads to poor indication to drivers, insufficient paved shoulders, etc. The authorities aim to have two auditors per project while each auditor shall have a maximum of four projects at a time. Further authorities aim to hire contractors based on their technical knowledge and not on commercial terms. MoRTH has kickstarted the work with AITD (Amity institute for training and development), academia needs to take the initiative to create supply and a new employment opportunity in the area of safety auditors.

Road Traffic Accident Data Collection and Analysis

There is a broad diversity in the Indian traffic landscape when compared to other landscapes, stressing the importance of accurate data. It can be questioned how available data is being analysed – and setting a strategy for addressing road safety hinges on credible data and analysing it thoroughly. Data today stems from police "First Information Reports (FIRs)" on the site of an accident, received by Police as a cognizable offence. The problem lies in interpretation. FIRs need to be standardized with relevant questions. What the police see, ask and note should be standardised through a set of basic, uniform questions.

A private firm – JP Research India (JPRI), funded by a consortium of OEMs, suppliers and research organizations initiated the activity of collecting road traffic accident data using established methodologies practised in developed countries such as scene investigation: collision point, final rest-position, marks on roads, etc.; injury correlation: injured body region, and source for the injury; reconstruction: travelling and collision speeds, delta-v, deformations, under the project called RASSI (Road Accident Sampling System- India).

Vehicle safety technologies are primarily developed and implemented in high-income countries. Many active safety technologies depend upon infrastructure like proper lane markings, traffic signals, which are well developed in high-income countries, but not to the same extent in India. There is also a big difference in the share of road users when comparing India to high-income countries (World Health Organization, 2018). All these factors may have a substantial effect on the performance of active safety technology performance in real-life traffic. It is, therefore, a limitation to assume that all the active safety technologies have the same performance in India as in high-income countries. Accident database would provide a platform to carry out multiple studies evaluating the effectiveness of any safety technologies in India.

Recommendations

The early phase of road designs shall involve a thorough understanding of the psychology of the driver, and VRU behaviour. Improved infrastructure provides solid and well-understood crash and injury reduction outcomes and is critical for the long term and sustainable trauma reduction. For example, in Sweden clearance for removal of roadside objects and trees is done at the design stage. The discussed recommendations in the JWG are:

- Require separation of pedestrians, bicyclists, and motorized two-wheeler
- Safer speed limits (slower speeds more forgiving of human error)
- More usage of roundabouts
- Guardrails as per correct specifications
- Adequate paved-shoulders on either side of the road
- Proper placement of signboards, lane markings, and road-side furniture
- Ban on road-side vendors
- Consideration of post-crash care in the design

Studies assessing Road Safety in India

This sub-section provides some evidence on the effect of improving road infrastructure on road safety. There are more studies addressing factors that need to be looked before designing of any roads, for example, UK and Sweden have applied 30 km/h speed zones in high pedestrian areas so if a crash was to occur, a person would have a much higher chance of survival. In Sweden under non-pedestrian zones, i.e. motorways, speeds are restricted to a maximum of 120 km/h. and a minimum of 50 km/h. No pedestrians, cyclists, towing of cars or crossings are allowed in those zones.

Determination of crash barrier runout lengths for expressways in India based on crash data analysis

Anecdotal results indicate that the following IRC codes for crash barriers on the expressway would reduce crashes by 50% perhaps up to 85% if the run-out length of crash barriers will be enough.

Mumbai – Pune Expressway Road Accident Study

The report highlights some factors influencing accidents on Mumbai-Pune expressway which include narrow or absence of shoulders, sharp curvatures, inadequate warning for parked or accident involved vehicle. Addressing these factors would reduce the number of accidents on the expressway (JP Research India Pvt Ltd, 2017b).

Education to create a pool of auditors

The current practice of an independent consultant is also responsible for safety has a conflict of interest. We need to adopt the international best practice of a separate safety consultant who would not only oversee the road safety aspects at the design stage but would also need to sign off at completion stage including road safety, the safety of workers, pedestrians, etc. during construction. Introduction and implementation of learnings and findings from Vision Zero to contribute to the safe roads in India. Some of the recommendations from JWG members are:

- The gap in resources for consultants and auditors could be covered by setting up a group of exclusive road safety specialists that are only focused on road safety audits. These resources should be specifically trained for the safety audits and regularly rated and recognized.
- Safety consultants for each project should be independent and not a part of the project consultant team. The consultants' approval should be mandatory from the design and through the implementation and construction stages, as in respect of world bank-funded projects.
- To reduce the risk of potential corruption on road safety, it may have three independent units: auditors from government, a private firm, and students from universities. Each unit should provide an independent report which could later be summarized into one with an appendix containing each unit's report for reference.
- Each state should nominate one research institute which would be the nodal institute to calibrate all training models and be Centre for Excellence on Road Safety for Quality Safety auditors.
- The training program should be run by engineering institutes like IITs, NITs or Civil Engineering Institutes.

In addition, international exchange programs would support in an understanding of global best practices and then implement relevant practices in India.

Road Traffic Accident Data Collection and Analysis

Collaborating and using scientific data, with the inclusion of event-recorder in vehicles and CCTV footages would support in making decisions for upcoming regulations and BNVSAP. Usage of accident database such as RASSI (currently used by many OEMs, and suppliers) and the upcoming database of ADAC-ICAT would also provide certain estimates which could be foreseen before any implementations. Thus, the government would know what range of benefits could be expected, and after implementation, the same can be measured. If there is any difference in expected results and in actual results, then that could be studied as well over time. Another benefit of government collaborating with these databases would be helping in scaling databases to the national level, making it representative of the country. This could be achieved through cooperation between government and industry.

The use of new technologies in data collection should be legalized. For example, event-recorder shall be enforced in every vehicle in India and its use shall be open for researchers. This will allow researchers to measure actual events just before the crash and plan their countermeasures for the given kind of crashes accordingly. Another possible way is to install closed-circuit television (CCTVs) at various black spots, and intersections. Also, its access shall be made open for the researcher. This will help to correlate reconstructed cases with CCTV footage.

VEHICLE TECHNOLOGY

Observations and discussions

Safe vehicles of all kinds play an important role in reducing road fatalities. Vehicles that are designed well with appropriate body structures and safety technologies can mitigate crashes significantly.

The positive trend in making cars safer continues in Sweden and Europe. Compared to the 1980s, the risk of disability has decreased by 75 percent and the risk of being killed in a car accident has decreased by almost 90 percent according to Anders Kullgren, vehicle safety research director of Folksam Research. (Hur säker är bilen? 2019). The risk of death is several times higher in the least safe cars than the safest cars. In real-life accidents, it is above all the crash safety characteristics and weight of the cars that determine how seriously passengers and drivers are injured in a collision between two cars, which is encouraging in the way that crashworthiness and occupant protection can be improved relatively cost effective if you design the vehicle against appropriate safety standards from the start.

Newer cars usually have a significantly higher safety standard and thus become less damaged. This means that a new, small car can be just as safe, or safer, than an old, large car. If every vehicle can be upgraded to the safest in its class, road trauma & fatalities could be reduced by a third. It is worth to note that this reasoning applies also to protection of vulnerable road users

The safe system approach will require appropriate speed limits. They must be guided by the knowledge of the human body's tolerance to external forces and ensuring compliance with the set limits. Appropriate speed limit setting, and compliance, will enhance the effectiveness of initiatives implemented in the road or vehicle space. Thus, speed limits must be considered both when defining codes for road design and vehicle safety regulations. To a large extent, this relation is considered since many years depending on country. As an example, modern cars in EU and USA are designed to protect people well in urban crashes as they occur at speeds which have been considered manageable. The outcome of a crash on a rural road will depend on how road furniture, etc. interact with the vehicle, i.e.

the outcome will depend as much on the road as the vehicle design.

Automotive regulations that are in place in India generally follow the UN regulatory framework for vehicle safety already. The UN regulatory framework for road and vehicle safety is well evolved and scientifically based, moreover based on an extensive consultative international process. It is recommended that the UN should continue to be basis for automotive regulations in India. There could be an adoption in India with a delay of a few years depending on regulation and depending on roads and traffic management situation, during the phase of development of a thorough road and vehicle safety approach in India.

The JWG has also discussed a "Road Safety Agency"; that it should be created to facilitate early adoption and to ensure that the Indian preconditions and legislatures are in line with all other conditions set within the market. A mandate from parliament is important and funds from the national level to the state level to be made available for use. There is a need for a holistic approach at the national level which

requires setting challenging goals and working towards achieving it.

Vehicle regulations

Automotive regulations in general are requirements that vehicles must meet to be sold. They are mandated by legislation and administered by a governmental body. The regulations concern primarily the aspects of safety and environmental protection. It will be positive for world trade if all automotive regulations could be harmonized as much as possible. The scope of the UN regulatory framework does cover all types of motorized vehicles, e.g. passenger cars, motorcycles, buses and goods vehicles of different weight classes.

The passive safety regulations for vehicles are developed in the Working Party on Passive Safety (GRSP), which is the subsidiary body of the world forum for harmonization of vehicle regulations (WP.29). This group of experts (GRSP) reviews available and published research results to develop passive safety requirements for vehicles. There is a similar working party for active safety and automation (GRVA) and other working parties for other fields, such as GRSG for general safety and GRE for lighting and lighting signalling.

The Automotive Industry Standards Committee (AISC) in India was initiated under the Central Motor Vehicles Rules -Technical Standing Committee (CMVR - TSC) by MoRTH in the year 1997 to review the safety in the design, construction, operation and maintenance of motor vehicles in India.

As a proposal, a draft notification by the UN should automatically trigger the start of a national consultative process in India, thereby giving adequate notice to all stakeholders regarding the coming change. Similarly, the final regulatory notification by the UN could be the trigger for the issue of the draft notification under the Indian framework, specifying the lag by stipulating the sunset clause. Wherever required, the India specific amendments should be incorporated at both the draft and final notification stages. This process would provide enough time for all stakeholders to plan for regulatory implementation and compliance.

After the 65th GRSP UN meeting on 13–17 May 2019, india GRSP presented harmonisation status of UN GTRs and UNECE regulations in the field of passive safety to AISC crash panel. Same will be deliberated in AISC for preparing road map for future alignment.

For passenger vehicles specifically,

- The full-frontal crash test (AIS-096), crash dummy injury assessment is not mandated.

For buses and commercial vehicles specifically,

- Bus body code (AIS 052) is already a published standard. However, it is not in force for non-OEM buses.
- For non–OEM buses, critical safety requirements such as rollover strength are not applied [GSR 368 E].

- School Bus Safety Standard AIS063 is published. Its enforcement is questionable.
- The JWG makes recommendation for "uniform and full implementation of bus body code" at all manufacturing units including aftermarket and specially for school buses.

For motorcycles specifically,

- Anti-lock braking system is mandatory for motorcycle above 125cc (UN R78) [IS 14664/2010].
- Combined braking system is mandatory for motorcycle less than or equals 125cc [IS 14664/2010].

Vehicle rating programs

For EU, it continues to be important to promote safer vehicles in European countries with high fatality and injury rates. The EU Commission has launched performance indicators that shall be monitored in each European state. One indicator will be to monitor how big part of the respective states' vehicle fleet has scored high in Euro NCAP. Europe has had Euro NCAP since 1996. The effects of high NCAP scores compared to low can imply up to 70% in fatality risk reduction (Svensson, n.d.). The difference between very safe cars and not safe cars is in other words significant. The main explanation is difference in crash safety according to for instance the Swedish insurance firm Folksam. Modern cars have a lower risk to be involved in crashes compared to older cars (Kahane, 2019), but the difference between cars that are the least prone to be involved and the cars that are most prone is relatively small (with a few exceptions). Hence, the crashworthiness of vehicles will determine whether people will survive or not in a crash.

The reputation of a vehicle rating program is everything. For car buyers and authorities to trust a rating program, information must be transparent, objective and consistent. The rating has at least two goals; the first is to objectively inform car buyers about the safety performance and the second is to promote safe cars. There is no imbedded contradiction, on the contrary, objectively informing and promoting go hand in hand. The reputation of an NCAP is most important and must be maintained; otherwise both car buyers and car makers will lose interest.

Good relations with both industry and other NCAP organizations are extremely important for any NCAP. There should not really be any differences between the various NCAP test methods if not justified by different road infrastructures, different driving cultures, different behaviour of vulnerable road users, and different vehicle fleets. There are big road system differences between India and Europe, and for this reason the BNVSAP should be tailored differently. In any case, the governance of BNVSAP should be founded on respect for all stakeholders and a deep understanding of the road traffic in India.

In order to introduce the most effective regulation in the Indian market, a thorough analysis of the road accident data should be carried out, followed by a cost benefit analysis of their introduction. This would also ensure that the most effective regulations in terms of significantly reducing accidents in Indian driving conditions are introduced but would also help vehicle manufacturers focus on technologies that are relevant in the Indian context and bring together all stakeholders.

Government in India should together with industry, university and other stakeholders, assess which basic vehicle safety performance aspects must be evaluated and rated. The fundamental performance of crash protection will likely be the most important quality to rate for many years in India, but a swift assessment of the specific needs of India should be done.

A draft of a rating system Bharat New Vehicle Safety assessment program or BNSVAP (personal communication) has already been submitted to MoRTH. It is in line with global practices and all testing facilities are now available in India. The mandate for implementation is pending.

To put India, on the global map of automotive countries and ensure that the consumers get a safer vehicle, a swift assessment of the specific needs of India should be done, basis a relevant rating system with all stakeholders on board should be put in place.

Aftermarket

The aftermarket supply chain is impregnated with multiple issues. The key challenge to quality is the lack of regulations and surveillance on manufacturing / production, import and sale of auto-components in the aftermarket.

Major chunk of supplies in aftermarket happens through Imports. Hence a complete ecosystem needs to be developed to control sale of automotive components in aftermarket.

Recommendations

While the Motor Vehicle Amendment Act 2019 has a clause that restricts selling of non-standard components (Safety Critical Ones) and has a provision to levy penalty , it was proposed that uniform standards be mandated across the country i.e. same standards for aftermarket as well, by single nodal agency i.e. Ministry of Road Transport and Highways.

Further, stringent checks could be introduced at Customs to keep a check on rising imports. For enforcement of regulations on ground, dedicated agencies should be enrolled for market surveillance under the supervision of MoRTH.

For effective control of automotive components sold in the aftermarket, the government must create a whole ecosystem which works towards development of regulations as well as takes care of ground implementation.

Inspection and maintenance of vehicles

The Motor Vehicle Act (Ministry of Road Transport and Highways, 1988) states that a transport vehicle shall not be deemed to be validly registered unless it carries a certificate of fitness containing such particulars and information as may be prescribed by the Central Government, issued by the prescribed authority, or by an authorized testing station. The Motor Vehicles (Amendment) Act (Ministry of Road Transport and Highways, 2019), a provision is included which states "no certificate of fitness shall be granted to a vehicle, after such date as may be notified by the Central Government, unless such vehicle has been tested at an automated testing station." The "authorized testing station" referred to means any facility, including automated testing facilities, authorized by the State Government, where fitness testing may be conducted in accordance with the rules made by the Central Government.

Currently, for inspection, every year a fitness certificate is issued by the Regional Transport Office (RTO) based on the Visual Inspection only as per Rule 62 of CMVR, which are subjective in

nature. Therefore, to eliminate the subjectivity in the existing practice and to bring in more objective practice, Inspection & Certification (I&C) Program is required to be implemented which includes a combination of both Visual (having pre-defined guidelines) and Automated tests for Brakes, Suspension, Speedometer, Emissions, etc.

Every state in India has its own regulations for vehicle inspection. This must, however, be standardized as vehicles are free to travel everywhere in the country. An item that is non-mandatory in one state may be mandatory in other states, so it results in ambiguities and is a hazard for safety. Also, for Inspection & Certification centres, every state defined its own Rules e.g. Skipping- headlight test, emission test, speedometer test, visual test, etc. Currently, there is no mechanism to handle day-to-day issues of inspection and certification centres.

Vehicle occupant safety

Vehicle occupant safety plays an exceptionally important role in saving lives during accidents. One research study (Puthan, Thalya, & Lubbe, 2018) shows that passive safety technologies in passenger cars alone have about 13% to 16% effectiveness in saving lives in India. Further, combining Advanced Driver Assistance Systems (ADAS) and passive safety technologies increases the effectiveness of up to 25% (see figure 1). Results from the Global New Car Assessment Program (NCAP) tests on Indian passenger cars show potential for improving road safety in India by introducing well-known vehicle safety technologies as well as improving crashworthiness (Ministry of Road Transport and Highways, 2019).

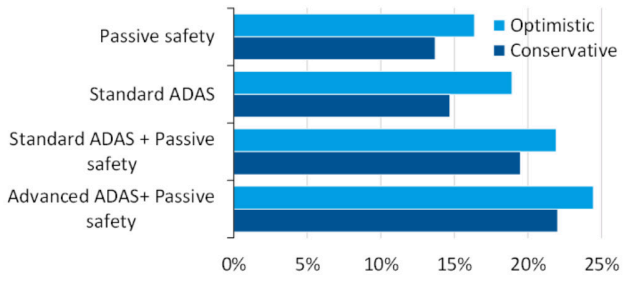


Figure 1. Optimistic and conservative estimates for the effectiveness of different technology groups in reducing fatalities in India.

In addition, the study (Puthan et al., 2018) also shows individual (standalone effect of a particular technology) and marginal (effect of all technologies except the given technology) effectiveness of safety (active and passive) technologies. The most effective (25%) technology would be seat belt reminders. ESC was estimated to have about 15% effectiveness, but there were other technologies that could potentially prevent those accidents, reducing marginal effectiveness close to 3%.

Effectiveness results highlight the importance of introducing passive and active safety technologies together to maximize the reduction of road traffic fatalities. However, focusing on passenger car safety technologies alone may not be enough for a significant overall reduction of fatalities on Indian roads. Another opportunity to reduce fatalities would be improving infrastructure and enforcing the traffic rules such as usage of seat belts and helmets.

Automotive Industry Standard (AIS) such as AIS 100 and AIS 098/ AIS 099/ AIS 096 will ensure that new vehicles will have improved crashworthiness and thus improved safety for occupants. The new AIS 145 standard ensures that all light vehicles will be equipped with a driver's airbag.

Seat belts

In 2017, 26,896 people died due to non-usage of seat belts in India, an exponential increase of over 377 per cent year-over-year. The year also saw around 16,876 passengers killed, and 61,942 passengers injured due to the non-use of seat belts (SaveLIFE Foundation, 2019). Many of them have been rear seat passengers. A quantitative research to survey children and adults including parents, cab drivers and school bus/van drivers in 11 cities across India conducted by SaveLIFE Foundation revealed that although India has a law on the seat belt usage, its implementation remains a challenge due to lack of awareness and weak enforcement of the law (SaveLIFE Foundation, 2019). In India, rear seat belt usage is appallingly low when compared to the front row. The same study revealed that ~38% of the survey respondents thought that it is not mandatory to wear seat belts in rear seats and about ~24% of them were not aware of the presence of seat belts in rear rows of the car (SaveLIFE Foundation, 2019).

Child Restraint Systems

The road safety of children in India is an issue that needs to be addressed. A survey conducted in multiple Indian cities revealed that 75.7% surveyed parents were not aware of the Child Restraint System (CRS) and of those who were aware, only 3.5% have used CRS including Booster Seats at some point (SaveLIFE Foundation, 2019). Even though some cars are now coming with features like ISO FIX, ignorance and lack of knowledge results in poor usage of CRS. Also, there is less awareness about the safety hazard of placing a child in the front seat. Other modes of child transportation such as school buses also lack safety features such as seat belts.

Anti-lock Braking System (ABS) and Electronic Stability Control (ESC)

Handling a vehicle in an emergency can lead to an accident. Anti-lock Braking System (ABS) and Electronic Stability Control (ESC) are two technologies that can enhance stability and improve vehicle handling in critical events. Electronic stability control which is currently fitted in over 70% of new passenger cars worldwide but to less than 10% of new cars in India (World Health Organization, 2018). Moennich et al. (Moennich, Lich, Kumaresh, & Georgi, 2019) highlighted around 9,000 fatalities and 14,000 seriously injured occupants could be prevented with ESC.

Vulnerable Road Users

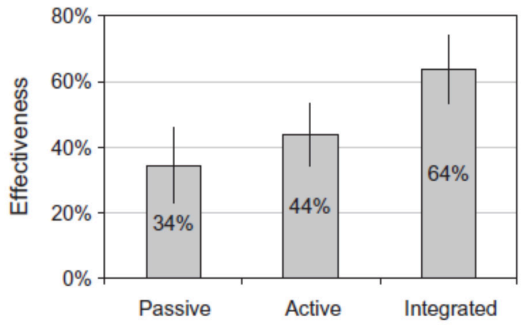
Vulnerable Road Users (VRUs) are the users of motorized two-wheelers, pedestrians and bicyclists. VRUs constituted 54% of the overall road traffic deaths in 2017 (Ministry of Road Transport and Highways, 2017); 33% were riders of motorized two-wheelers; 14% pedestrians and 2% bicyclists. However, Global Burden of Disease (GBD) data estimated in 2017 VRUs constituted 73 % of the road traffic deaths: 31% riders on motorized two-wheelers; 35% pedestrians; and 7% bicyclists. In general, VRU fatalities are more than half of the total road traffic fatalities in India. Discrepancies in data lead to incorrect decision making related to traffic safety policies and regulations. This further, effect on a larger scale in reducing road traffic deaths by providing wrong estimations.

Pedestrians

A German study (see figure 2-left) shows passive safety technologies were 34 % effective in reducing severe head injuries to pedestrians whereas active safety technologies were 44 % effective, and combined (active and passive) technologies increase the effectiveness to 64% (Fredriksson & Rosén, 2012).

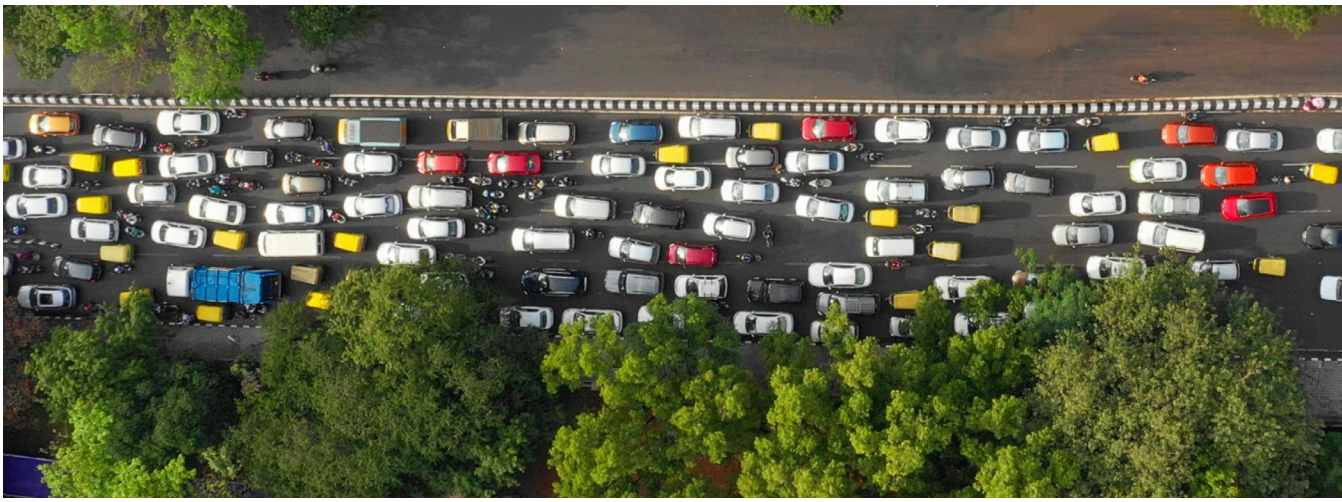
A similar trend in figure 2-right while analysing the pedestrian total injury cost. The base case analysed is without any technology like autonomous emergency braking (AEB) or airbag. In the average scenario, the cost reduces by 16% with AEB; 42% with an airbag; and 50% with AEB and airbag (Edwards et al., 2015).

A recent study in India showed that safety features such as hood lifters and pedestrian protection airbag would be effective in reducing AIS3+ head injury for 27% (95% CI: 12 - 42%) of VRUs. Further, safety features would also help in reducing total injury severity from AIS3+ to lower



	Passive		
	good	average	poor
Base	99%	100%	141%
AEB 'current'	84%	84%	119%
Airbag	56%	58%	99%
Airbag & AEB	49%	50%	84%

Figure 2. Effectiveness of safety systems in reducing pedestrians' severe head injuries (left); and injury cost (right).



levels for 12% (95% CI: 3 - 21%) of VRUs (Shaikh & Lubbe, 2018). The study also reports that the improved head impact protection could be increased by increasing the protected zone on the vehicle and reducing speed. Improving head impact protection of passenger cars to levels achievable with hood lifters and VRU airbags has the potential to substantially and significantly reduce serious injuries for VRUs in India.

Pedestrian impacts with heavy vehicles, under rides and run overs are the other type of accidents were more detailed research need to be done to understand the detailed cause of accidents.

Motorized two-wheelers

Lich et al. (Lich, Kumaresh, & Moennich, 2015) found that if all of the powered two-wheelers on Indian roads were fitted with ABS, every 3rd accident with injuries involving a motorcyclist on Indian highways can be avoided [9]. ABS (or CBS) is now mandatory for new models of two-wheelers depending on the engine capacity (Dutta, 2016).

India has notified standard in place for "Protective Helmets for Two-Wheeler Rider Specification" as IS 4151:2015. It is aligned to the latest UN regulation UN R-22.05. It is mandatory for the vehicle manufacturer to provide the Helmet to the buyer at the time of sale of the vehicle as per CMVR 138, sub-rule 4, cl. F. However, implementation of Helmet usage enforcement is left to the State Government for its effectiveness. It is compulsory for two-wheeler riders to wear safety helmets under Section 129 of the Motor Vehicles Act, 1988. The rule also says that a helmet should have a foam thickness of 20-25 mm. It should also have an ISI mark and follow the Bureau of Indian Standards.

The survey performed by private insurance reveals that around 57% of riders and 74% of pillion riders ride without a helmet (Exide Life Insurance, 2017). According to the survey, the rider's decision to not wear a helmet while riding is due to various reasons: 13% due to high cost; 16% thinks not required by the law; 22% due to habit; and 30% due to comfort reason. Similarly, a pillion rider's safety is also of utmost importance and requires attention.

Bicyclists

Bicyclists are also at great risk while riding on the India roads. There are serious concerns about the visibility of bicycles and the riders, especially during the dark. To make the bicycles visible on road, retro-reflective means are used to make the bicycle more visible which includes retro-reflective devices, retro-reflective spokes, and retro-reflective tires. There are standard "IS/ISO 6742 -2: 2015 Cycles – Retro-Reflective" for the above purpose.

It is mandatory from 1st July 2016, to install a set of 10 reflectors with ISO 6742-2 on the bicycle: four on pedals; two on front and rear wheel each; one on lamp bracket; and one on the rear mud-guard. However, this is not being followed as a normal process. It was recommended that these reflectors are provided together with the bicycle parts kits for assembling by the cycle retailers, so they are pre-installed for the consumer.

Recommendations

Harmonization of Vehicle Regulations,

- The initiative and work to Harmonize the Automotive Industry Standards (AIS) and Indian Standards (IS) with the global technical regulations (GTR) and the UN Regulations is a continuous process. The gaps between them have to be identified periodically and same need to adopted in the standards amending them after examining the relevance in Indian context.
- Some important gaps have been given below as examples which needs to be examined for early adoptions these should become part of a step-wise Adoption of Road Map.
  - Full Frontal Impact regulation needs to be implemented with reference to the UN R137
  - In offset frontal impact the Thorax compression criterion (Thcc) should be reduced from 50 mm to 42 mm as per UN R94 to address safety of aged occupants.
  - Side pole test to be implemented with reference to the UN R135

For passenger vehicles specifically,

- Indian regulations on occupant safety are aligned with requirements in UN Regulations which mainly focus the front row seat occupants. However, in the Indian scenario, rear seat occupancy is significant. Hence, the focus on Rear Seat safety is required and Rear Seat Assessment needs to be considered.

For buses and commercial vehicles specifically,

- Rollover protection for buses should be made mandatory for buses and commercial vehicles made at the OEMs and bus body builders, specially for school buses.
- Uniform and full implementation of bus body code will lead to enhanced safety for bus passengers. Proposed Timeline ASAP
- Implementation of P-marking systems to verify and rate the fire-detection-and-suppression system.
- Fitment of the appropriate safety belt system for intercity buses.
- Under-run protection device (UPD) are not being replaced after an accident or damage. This will affect the safety of colliding vehicles and other road users in case of any repeated under-run crashes. Thus, close monitoring is required during issuing periodical fitness checks or otherwise to ensure right UPD are always available on the vehicles.

For motorcycles specifically,

- Indian government should consider initiating crash-test with defined load cases for motorcycles.

Bharat New Vehicle Safety Assessment Program (BNVSAP)

A rating system to create awareness of vehicle safety among Indian consumers and setting vehicle insured amount based on safety ratings, the Global NCAP has been the best practice and India has had the BNVSAP now called the BNVSAP in consideration in line with other NCAPs like US NCAP, Euro NCAP, ASEAN NCAP, C-NCAP, Global NCAP, etc. These NCAPs provide awareness to consumers about vehicle safety levels. Also, the star-rating of vehicles in these NCAPs helps in deciding vehicle insurance-related policies. Thus, enforcing consumers to demand and buy much safer vehicles. A draft of the same is already handed over to the government and all testing facilities are in place.

In order to introduce the most effective regulation in the Indian market, a thorough analysis of the road accident data should be carried out, followed by a cost benefit analysis of their introduction. This would not only ensure that the most effective regulations in terms of significantly reducing accidents in Indian driving conditions are introduced but would also help vehicle manufacturers focus on technologies that are relevant in the Indian context. After an evaluation of various solutions on ratings and a final decision on the way forward, a roadmap shall be designed. The Technical (or steering) committee could comprise government officials, Teting agencies, OEMs, suppliers, and universities. This will allow to get multiple opinions and help in making qualitative decisions.

Vehicle Inspection and Maintenance

The Inspection and Certification Program will ensure safer and environment-friendly movement of vehicles on road. Also, it will help in bringing the concept of "End of Life" of a vehicle on the road which is currently absent in India.

Vehicle Occupant Safety

Vehicle regulations and BNVSAP would address vehicle occupant safety. Driver airbag, seat belt reminders, reverse park assist and speed alert are a few features that have been mandated for all passenger cars. However, best practices around the globe for vehicle occupant safety shall be introduced in India along with a certain roadmap. For example, CRS shall be mandatory when

a child is present in the car. Thus, not promoting seating on lap gesture. Similarly, a different type of airbags under different crash scenarios shall be put forward which will reflect only after having stringent regulations such as pole impact test, thus promoting side or curtain airbags.

Vulnerable Road Users (VRUs)

It is important to separate pedestrians from other road users as they are most vulnerable when it comes to road safety. The infrastructure needs to be designed ensuring VRU safety where they are present (NH, SH, and other roads), and keeping VRU (especially pedestrians) away from where they are restricted (expressways). There should be proper and safe pedestrian access to roads with improved possibilities for crossing as well as walking alongside the roads. There should also be safe places on the roads for easy pick-up and drop-off especially while using public transport within the city as well as on the highways. Infrastructural planning and road construction need to take pedestrian mobility into consideration. One example is to bring public transport companies to the table when a new road is under design to ensure they can influence and by that share responsibility for the safety when the road is built.

Pedestrians

Pedestrians are most vulnerable when exposed to mixed traffic. An ideal way to reduce pedestrian fatalities would be to separate pedestrians from motorized road users or ensure safe speed (maximum 30 km/h) by design of local roads. Infrastructure shall promote pedestrians on roads by providing them with a separate safe path. There shall be pedestrian walk-way along the roadside. While proper crossing at regular intervals. Pedestrian mobility shall be considered while planning, designing, and construction of roads

Motorized two-wheelers

A study highlighted only around 50% of riders or pillion riders in India wear BIS (with ISI mark) approved helmets. Thus, suggesting enforcement of stringent rules which would reduce head and face injuries (Painter, Sonawane, & Patel, 2018). The riders who are price sensitive and not safety-oriented, tend to buy after-market helmets. These helmets put rider's and pillion rider's life in danger.

Helmet manufacturers that abide by the specifications shall only be allowed to produce and retail helmets. Further, some tax benefits should be provided to these manufacturers so that the cost of the helmets could be reduced to its optimum without affecting the quality of helmets or two helmets shall be provided by OEMs as a standard. In addition, there should be a strict ban on after-market helmets.

Bicyclists

Bicycle usage should also be encouraged and facilitated. Most important aspect of encouraging bicyclist is to create a safe network of bicycle lanes and routes in urban areas. Bicycle ownership is high in India and some start-ups are providing rental bicycles with the business model of pay as per usage in key metros. These bicycles can be rented using mobile applications which seems to be user-friendly and secure. However, if bicycle usage shall be increased the government needs to ensure safety on the roads for the bicyclist. Not only do bicycles help in reducing road traffic congestions, but they emit no pollution, making

it an environmentally friendly mode of transport. There should be separate bicycle lanes on the regular roads, as an alternative to specific bicycle road network, to ensure bicyclist safety and promoting the usage of more bicycles.

Only 20.1% parent owns child helmets even though 92.8% were aware of the safety benefits of the helmets (SaveLIFE Foundation, 2019). Helmet usage shall be mandatory for children and adults riding bicycles. Usage of helmets shall be promoted at the school level, by providing free or reduced-price genuine helmets to students coming to school on bicycles. It could be also a part of corporate social responsibility (CSR) activity to provide a genuine helmet to students coming on bicycles to school. This would create safety awareness from a young age.

Vehicle Technology:

a. Harmonization of vehicle regulations in Indian with the United Nations Economic Commission for Europe regulations should continue to be performed. Regulations should be not only stringent for passenger cars but also for buses, heavy commercial vehicles, and other body types
b. Process to implement Bharat NCAP needs to be fast-tracked with an incentive to OEM, which enables improved safety beyond regulatory norms
c. The assessing agency can have the authority to cancel the vehicle registration in case of the vehicle does not meet safety assessment norms.
d. More specifically, the Indian government could initiate motorcycle regulations having reference form ISO13232, GBT33438-2016 or similar.
e. Indian government should promote manufacturers to build highly safe vehicle by initiating incentives or providing differential excise duty on achieving safety norms above the mandated regulations.

HUMAN BEHAVIOUR

Observations and discussions

While implementing Vision Zero in Sweden, a large amount of time was spent on training and education particularly on using seat belts and helmets. In addition, people were educated on related fatalities and injuries that may occur when seat belts are not used as specified. Note that the

Vison zero is based on the principle of recognizing human frailty and humans' natural tendency to make errors from time to time (Belin, 2016).

India could learn from Vision Zero in Sweden and implement the modules tuned to Indian conditions. In India, many organizations like Driver Training Schools, Corporations and NGO's are already using some safety education and awareness tools to train people and children on road safety. Safety awareness and education should be part of the school curriculum at middle and senior levels, stressing the importance of road safety amongst the children.

Several projects have been done across India to address the safety issues. For example, in Jaipur, a pilot project was done to install an ambulance every 20 km on the highway to provide critical support in case of any accidents. However, the pilot did not really work but could be useful and successful if done with some changes incorporated. A similar project was done in Kerala where Emergency Global Positioning System (GPS) was installed on the Buses to automatically detect crash situations. The project went well but to be successful at the national scale it requires proper technology infrastructure to address crash situations and critical medical support in crash accidents.

Recommendations

Most of the driving licenses were provided without the driving test (Dash, 2017). Thus, driving education and learning system should be made stringent. This should be followed by a strict driving test for providing the driving license to the drivers. Further, health check-up of drivers should be done on a regular basis to ensure safe and healthy people are driving on roads.

Road safety topics shall be introduced in the school curriculum. Safety measures shall be promoted such as the usage of helmets by all the people commuting on bicycles to schools, colleges, and workplaces. Awareness shall be created for safe-road usage by VRUs.

A training program should be enforced for police officials, trauma centres, volunteers for care in the event of the road accident. Reward and recognition program towards road safety should be encouraged which would promote people to actively participate in emergency situations during road accidents.

Human Behaviour:

a. Proper education and learning system related to driving vehicles should be incorporated. Implementing more stringent tests for issuing driving license.
b. Education medium should be established for all citizens of India which will guide Indian youth on how to behave on Indian roads, how to handle trauma or emergency situations during accidents.
c. Reward and recognition program towards road safety, which would encourage people and students to actively participate and assist emergency during road accidents.

Monitoring

Observations and discussions

India has 5.6 million kilometres of road length for which it urges to have a monitoring system. CCTVs is one of the most common sources for the monitoring system. Kolkata and Chennai city police recently announced the installation of CCTVs at every 200m (Ghosh, 2017; Mitter, 2017) and 50m (Selvaraj, 2018), respectively. These CCTVs will monitor traffic, law-and-order, and crime. Also, some other cities have also initiated the installation of CCTVs such as Delhi, Mumbai, and Hyderabad. Installation of cameras and sensors along Mumbai-Pune expressway to monitor traffic, vehicle speeds, lane-disciplines, etc. along expressway was a good way of monitoring system (Tanksale, 2018). However, its implementation is unknown.

Currently, in India, many video surveillance systems have been implemented. However, it requires some or other manual interruption. Automatic Number Plate Recognition (ANPR) is one of the smart ways to identify traffic rules violation done by drivers on road. Cities like Mumbai, Delhi, and Hyderabad have initiated usage of ANPR system (Seetharaman, 2019). Also, usage of artificial

intelligence system has been kick-started by cities like Mumbai, Delhi, and Agra (Kar, 2017).

Recommendations

Deployment of traffic police for monitoring traffic or congestion should be waved-off. This would be possible only by using more advanced technologies. Artificial Intelligence (AI) technology should be replaced by personal-interaction such as identifying a violation of traffic rules, recognizing vehicle with false number plates, sending notification of fines against vehicle for disobeying traffic rules, national-level online facility for fine payment, etc.

Safety platforms should be provided to the general public to report any accidents immediately through phones or mobile applications which could help in getting immediate medical aid which is critical for the accident victim in the golden hour of the accident.

Monitoring and Surveillance:

d. Installation of CCTVs (monitoring system) at appropriate junctions, and blackspots.
e. Safety Platform should be created for the public to easily report any road accidents through phones or mobile applications which will help in getting immediate medical assistance at their pin-point location.

Autoliv