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2023R07EN

ROAD SAFETY IN LMICs: IDENTIFICATION AND ANALYSIS OF SPECIFIC ISSUES

A PIARC LITERATURE REVIEW

TECHNICAL COMMITTEE 3.1 *ROAD SAFETY*

PIARC

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020– 2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

This report is available from the internet site of the World Road Association (PIARC): http://www.piarc.org

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International Standard Book Number: 978-2-84060-749-6

Front cover © Authors

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TECHNICAL COMMITTEE 3.1 *ROAD SAFETY*

AUTHORS/ ACKNOWLEDGEMENTS

The literature review as described in this report has been prepared by the Working Group 3.1.1. Specific road safety issues for LMICs, which is part of the TC 3.1. Road safety. (2019 – 2023).

The working group performed its activities at about the starting moment of the second United Nations Decade of Action for Road Safety 2021 - 2030. The first Decade of Action brought us a series of valuable problem analyses and overview articles prepared by a variety of institutions and institutes. We did not repeat this effort, but used it as a starting point to indicate which specific issues do need further attention in LMICs in the coming period up to 2030. For these specific issues we give a summary of the state of the art and a selection of focus areas that require special attention in LMICs in the coming period up to 2030.

The state of the art sections for the issues were described by the following members of the WG:

I. SDG's: integral approach	Ahmed Ksentini, Tunisia
II. Safety culture	Steven Robertson, South Africa
III. Road safety management and leadership	Paulin Kouassi, Ivory Coast
IV. Building road safety expertise and science	Hans Godthelp, The Netherlands
V. The transportation system as a whole	Hans Godthelp, The Netherlands
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VII. Cost effectiveness	Stephanie Davy, Australia
VIII. Legislation and enforcement	Andrew Burbridge, Australia
IX. Speed	Ahmed Ksentini, Tunisia
X. Sustainable safe roads	Leszek Kania, Poland, Hans Godthelp
XI. Vehicles as a safe system component	Hans Godthelp, The Netherlands
XII. Post crash health care	Gael Italiano, Canada

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EXECUTIVE SUMMARY

2023R07EN

ROAD SAFETY IN LMICs:
IDENTIFICATION AND ANALYSIS OF SPECIFIC ISSUES
A PIARC LITERATURE REVIEW

This report is a deliverable of PIARC working group 3.1.1 Specific road safety issues for LMICs. The working group performed its activities in the period 2019 – 2023. We prepared two deliverables: a) a literature review and b) an overview of case studies.

The present report gives the literature review. The review starts from the notion that road safety is a multifaceted problem which requires a multi-disciplinary approach. The safe system approach is generally considered as the central concept for this purpose and this starting point is also taken in this study. However new directions are needed to make the safe system work in LMICs. The period of the first UN Decade of Action for Road Safety has brought us a series of valuable problem analysis and overview articles prepared by a variety of institutions and institutes. As a PIARC working group we did not repeat this effort, but used it as a starting point to indicate which specific issues do require a boost in LMICs for the coming period up to 2030. We concluded that the following 12 issues deserve special attention:

I. UN Sustainable Development Goals : integral approach
II. Safety culture
III. Road safety management and leadership:
IV. Building road safety expertise and science
V. The transportation system as a whole
VI. City design, architecture, land use, rural planning.
VII. Cost effectiveness
VIII. Legislation and enforcement
IX. Speed
X. Sustainable safe roads
XI. Vehicles as a safe system component
XII. Post crash health care

In order to make clear that the road safety problem is to be approached as a system, we organized these issues in three levels, considering organizational and cultural aspects (strategical), network and traffic system related aspects (tactical) and component related aspects (operational).

For each of these issues we describe a short state of the art, which results in a number of focus areas that need particular attention from the LMIC point of view.

STRATEGICAL

I. Focus areas for LMICs Sustainable Development Goals

- LMICs to integrate road safety strategy as an integrated component of their sustainable development goals
- LMICs to stimulate a multi-sectorial approach with all relevant stakeholders involved.

II. Focus areas for LMICs Safety culture

- LMICs to develop a strategy with traffic rules and design guidelines that are based on knowledge about local behavioral characteristics
- LMICs to develop strong organizations that represent the local community and serve as the eyes and ears regarding traffic problems and solutions.
- LMICs transport companies to develop and/or uses effective incentive systems with the focus on safe driving.

III. Focus areas for LMICs Road safety management

- LMICs to develop a strong lead agency which has full-time expert staff, legally endowed powers, permanent funding, and political support
- LMICs to develop a robust road safety data system
- LMICs to develop a robust set of local guidelines and regulations
- LMICs to develop a center of road safety excellence (see 4.IV, Capacity building)

IV. Focus areas for LMICs. Building road safety expertise and science

- LMICs to develop university road safety programs at bachelor and master level
- LMICs to build research capacity in centers of road safety excellence
- LMICs to connect to regional road safety observatories
- LMICs to connect to international network of universities and centers of excellence.
- PIARC to support this network process.

TACTICAL

V. Focus areas for LMICs. Transportation system

- LMICs to develop a public transport system, with road safety criteria included
- LMICs to promote a Transit Oriented Development with road safety criteria included

VI. Focus areas for LMICs. Rural and urban planning

- LMICs to adopt a systems-oriented approach which puts road safety and public health policies in a broad context of improved transport and health
- LMICs to embrace the compact city approach of shorter distances, lower speeds, higher residential and population densities, and design that promotes walking, cycling, and public transit.
- LMICs to develop evidence-based transportation plans that undergo a participative process

VII. Focus areas for LMICs. Cost effectiveness

- LMICs to develop a road safety strategy based on a selection scheme of cost-effective measures
- LMICs to select low hanging fruit: defining a list of low cost proven countermeasures.

VIII. Focus areas for LMICs. Legislation and enforcement

- LMICs must consider developing and implementing legislation and enforcement strategies to tackle speed, helmet use, seat belt use, drink driving, mobile phone use and regulation of professional drivers.

- LMICs to develop legislation strategies that are both enforceable and enforced to have effect.
- LMICs to adopt strategies that can be easily communicated to and that are accepted by the community.
- LMICs need to be open to considering strategies that are tried and tested in other jurisdictions. This might include adoption of novel technologies such as alcohol interlocks, seat-belt warning systems and speed limitation technology.

OPERATIONAL

IX. Focus areas for LMICs Speed

- LMICs to adopt the 20mph/30kmh speed limit regime in areas with a mix of motorized and VRU traffic
- LMIC to explore new enforcement strategies like section control,
- LMICs to explore the potential benefits of speed control systems like ISA in cars, motorcycles and motor-tricycle

X. Focus areas for LMICs Safe roads

- LMICs to develop road design guidelines and regulation, based on local safety culture, including a clear road categorization scheme.
- LMICs to develop a robust audit and inspection protocol.
- LMICs to make roads in cities and villages safe for pedestrians /bicyclists/vulnerable road users, i.e. based on 30km protocol.

XI. Focus areas for LMICs Safe vehicles

- LMICs to adapt and enforce regulations regarding vehicle safety of new and imported vehicles.
- HICs to regulated the quality of used vehicles exported to LMICs
- Automobile companies and tier suppliers to explore options to implement new technologies like ISA in new and used vehicles to give a boost to road safety in LMICs.

XII. Focus areas for LMICs Post crash health care

- LMICs to improve pre-hospital trauma care
- LMICs to improve quality of trauma centers
- LMICs to improve the training of first responders

Based on the results of this literature review the working group organized an international survey in order to collect one or more LMIC-related case studies for each of the issues. The resulting collection is presented in our second deliverable, noted as ref.2. This second report gives a series of illustrative examples of road safety projects in LMICs. Together the present report and ref. 2 give a) insight in the road safety issues that are of particular relevance for LMICs towards 2030 as well as b) a rich impression of local initiatives, which may be used to build on in the future.

CONTENTS

1. INTRODUCTION

Road crashes continue to be a major cause of death and serious injury for low- and middle-income countries (LMICs). At the global level, ninety percent of traffic deaths occur in these countries. In comparison to higher income countries, where the road deaths per 100,000 inhabitants is 9.2, middle income death rates are double at 18.4 and low-income rates are 24.1[1] . Almost half of these deaths are among the most vulnerable road users, including people who bike, walk and use motorcycles. These rates would suggest that much opportunity exist within these countries to build institutional capacity, with a focus on addressing known safety problems through careful countermeasure selection and adoption of design standards in urban and rural areas. The use of infrastructure road safety audits could be of significant benefit in reducing fatal and severe injury rates.

Given this perspective PIARC installed Working Group 3.1.1 Specific Road Safety issues for LMICs as described in the overall PIARC Workplan 2020 – 2023. The intent of this effort is to assess and identify best practice type road safety activities with a focus on those most applicable to low- and middle-income countries, and to gather specific successful examples of safety management activities with a particular interest on the vulnerable road users. In the period 2020 – 2023 the Working Group delivered three outputs: the present literature review, an overview of case studies[2] and a final summarizing report[3] . At a later stage results will be incorporated in the PIARC Road Safety Manual[4] and in the PIARC Catalogue of case studies[5].

The focus of the present literature review is on determining and analyzing the types of safety related issues that are commonly found in LMIC. Central questions are: what are these road safety issues and what is known about the common approaches in LMICs to address these issues.

The working group performed its activities at about the starting moment of the second Decade of Action. The first UN Decade of Action for Road Safety 2011 – 2020[6] has brought a tremendous series of initiatives and introduced new road safety programs on a variety of areas. During the past decade, a series of studies were initiated all over the world and a number of extensive overviews, problem analyses and visions for the future has been prepared. At the third Global Ministerial Conference On Road Safety, Stockholm, 2020[7] the results of these efforts were presented and evaluated. Many countries made progress through road safety management and better legislation addressing risks such as speeding, drinking and driving, failing to use seatbelts, and infrastructure improvements. However, the intended reduction in casualties strongly lagged behind the original goals. Continuation of programs and new approaches are needed to reach a breakthrough,

[1] World Health Organization; 2018 Global status report on road safety 2018. Geneva. License: CC BYNC-SA 3.0 IGO.
[2] PIARC (2022). Specific road safety issues for LMICs : an overview of case studies. Report to be presented in 2022. World Road association PIARC, France
[3] PIARC (2022). Specific road safety issues for LMICs: an overview and a number of case studies. Report to be presented in 2022. World Road Association PIARC, France
[4] PIARC (2019) Road safety manual. https://roadsafety.piarc.org/en, World Road Association PIARC, France
[5] PIARC (2019) . Catalogue of case studies. Road safety improvements relevant to vulnerable road users, human factors and LMICs. World Road Association PIARC, France
[6] United Nations (2010). Global plan for the Decade of Action for Road Safety. www.who.int/roadsafety/decade_of_action/
[7] Academic Expert Group for the Third Ministerial Conference on Global Road Safety (2020), Saving Lives Beyond 2020 The Next Steps – Recommendations of the Academic Expert Group. Publication number: TRV 2019:209, Stockholm, 2019

particularly in LMICs. The Stockholm declaration[7] gives an important motivation towards new initiatives and makes a plea to connect road safety to the broader set of UN Sustainable Development Goals.

During the same period, 2011 – 2020, the PIARC Technical Committees on Road Safety built their Road Safety Manual[4], which provides an extensive reference document. The RSM intends to support policy makers and practitioners all over the world, both in High Income Countries (HICs) and LMICs, but with a particular focus on the latter. Safety practitioners in LMICs often have limited institutional capacity to develop and implement simple tools, processes, checklist and other methods to begin to address road safety challenges. They also fail to implement several countermeasures due to many restrictions such as in-land use, edge of town development and remaining road width in many urban areas and limited government support or funding. The present work will highlight a number of available implementation aids developed during previous PIARC cycles and combine this with other relevant literature with a particular focus on LMICs.

When preparing this report we experienced a special moment in time that was characterized by the COVID-19 pandemic. Going forward road safety will also be influenced by mobility changes resulting from the pandemic. Many cities have a program of re-allocating road space to pedestrians and bicyclists. At the same time speed of motorists has risen as a result of lower traffic densities, while travel behavior changed due to societal demands on public transport and air transportation. The pandemic effects thus clearly illustrate that our roads are part of a transport system, which in turn serves as a facilitator in the broader societal context. This insight has made us realize again that making roads safe is a matter of making the system safe. The pedestrian killed when crossing a busy urban arterial should be considered as a victim of a chain of policy and design decisions.

The present report therefore starts from the notion that road safety is a multi-faceted problem which requires a multi-disciplinary approach. The safe system concept is considered as the “holy grail” for this purpose and this starting point is also taken in the present study. However, new approaches are needed to make the safe system concept work in LMICs. As indicated previously the period of the Decade of Action has brought us a series of valuable problem analyses and overview articles prepared by a variety of institutions and institutes. We will not repeat this effort, but use it as a starting point to indicate which specific issues do require a boost for LMICs in the coming period up to 2030. For these specific issues we will give a summary of the state of the art and a vision about the strategies and policies that should bring a road safety breakthrough in LMICs.

2. METHOD

This literature review made use of a series of regular data bases:

- Pubmed,
- Scopus,
- TRID,
- DART-Europa and
- TRR Online.

We used search terms such as

- road safety,
- low- and middle-income countries,
- country names,
- vulnerable road users, and the like.

The results of this analysis made clear that the first UN Decade of Action for Road Safety 2011-2020 has brought us a series of problem analysis and overview articles. In order not to repeat this work, we used a two-phase approach. First, we gathered a series of recent overview reports and articles. Chapter III gives an overview and analysis of these documents and the resulting vision on the perspective for future effective road safety measures. Based on this analysis we selected 12 road safety issues which we consider of major potential significance for LMICs. Chapter IV presents phase 2 of our review: for each of the 12 selected issues we give a short state of the art from the LMIC point of view. Based on this we present a vision on what we consider as the future focus areas that need special attention and which may contribute to a road safety breakthrough in LMICs.

The state of the art documens were prepared by members of the Working Group. Their names are mentioned in the Acknowledgement and at the beginning of the chapters 4.1 to 4.12.

3. SPECIFIC ROAD SAFETY ISSUES FOR LMICS

The PIARC Road Safety Manual[4] gives an extensive overview of issues that play a significant role in the process of attacking road safety problems on a worldwide level. In the present study we follow this line of thinking with a particular focus on LMICs. Like in the RSM we will consider road safety as a multi-level, system-oriented problem and describe the issues and case studies from that perspective. This may bring us to broaden the scope of the PIARC catalogue of case studies[5]. In the catalogue most case studies are about infrastructure measures. In the present study we will broaden this perspective and use the different levels of the safe system approach as in the RSM and use that as the format to make an inventory of case studies. This may lead to a re-arrangement of the case study catalogue to align with the specific road safety issues in LMICs.

During the Decade of Action 2011-2020 a number of profound observations were made about the nature of the road safety problem in LMICs. Table I (below) gives an overview of the road safety issues considered as most significant in these analyses. A general look suggests the issues for LMICs and HICs are similar. And indeed, at the macro level the principles behind the issues may be considered as more or less the same. However, the operational approach needed, and implementation of measures may differ strongly. Culture, traffic composition, enforcement strategies, spatial design of urban areas, all of these differ strongly, between or even within countries. The present study starts from this point.

Source Document	Key Issues
2018 Global status report on road safety[1]	Institutional management Legislation and road user behaviour Managing speed Reducing drink-driving Increasing motorcycle helmet use Increasing seat-belt use Increasing child restraint use Reducing distracted driving Reducing drug-driving Safe roads iRAP: separating traffic Safe vehicles: passive safety, stability control
Saving Lives Beyond 2020 The Next Steps – Recommendations of the Academic Expert Group[7]	Recommendation 1: Sustainable Practices and Reporting Recommendation 2: Procurement Recommendation 3: Modal Shift Recommendation 4: Child and Youth Health Recommendation 5: Infrastructure Recommendation 6: Safe Vehicles Across the Globe Recommendation 7: Zero Speeding Recommendation 8: 30 km/h Recommendation 9: Technology
Towards the 12 voluntary global targets for road safety. Guidance for countries on activities and measures to achieve the voluntary global road safety performance targets[8]	Target 1 - National action plan Target 2 - Global alignment Target 3 - New roads Target 4 - Existing roads Target 5 - Vehicle standards Target 6 - Speeding Target 7 - Motorcycle helmets Target 8 - Vehicle occupant protection Target 9 - Driving under the influence Target 10 - Distraction by mobile phone Target 11 - Professional drivers Target 12 - Timely emergency care

[8] Van den Berghe, W., Fleiter, J.J. & Cliff, D. (2020) Towards the 12 voluntary global targets for road safety. Guidance for countries on activities and measures to achieve the voluntary global road safety performance targets. Brussels: Vias institute and Genève: Global Road Safety Partners

Sustainable and safe. A vision and guidance for zero road deaths.[9]	Sustainable and Safe Urban Expansion and Mobility, Safe Rural and Intercity Roads, Safe Vehicles, Safe Conditions for Children, Stronger Economic Development and Reduced Inequality, Guidance on Safe System Strategies 1. Land Use Planning: 2. Street Design and Engineering 3. Improved Mobility Options 4. Speed Management 5. Enforcement of Laws and Regulations 6. Education and Capacity Building 7. Vehicle Design and Technology 8. Post-crash Emergency Response and Care 9. Prioritizing Finances 10. Strengthening Institutions and Frameworks 11. Strengthening laws, regulations, and guidelines
Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System,[10]	1. Think safe roads, not safer roads 2. Provide strong, sustained leadership for the paradigm shift to a Safe System 3. Foster a sense of urgency to drive change 4. Underpin aspirational goals with concrete operational targets 5. Establish shared responsibility for road safety 6. Apply a results-focussed way of working among road safety stakeholders 7. Leverage all parts of a Safe System for greater overall effect and so that if one part fails the other parts will still prevent serious harm
Road Safety in Low-Income Countries: State of Knowledge and Future Directions Sustainability[11]	a. under-reporting; b. global best practices; c. vulnerable groups; d. disabilities; e. road crash costing; f. vehicle safety; g. proactive approaches; h. data challenges; i. social/behavioural aspects; j. capacity building

[9] Ben Welle, Anna Bray Sharpin, Claudia Adriazola -Steil, Soames Job, Marc Shotten, Dipan Bose, Amit Bhatt, Saul Alveano, Marta Obelheiro, Celal Tolga Imamoglu, (2018) Sustainable and safe. A vision and guidance for zero road deaths. World Resource Institute Ross Centre, Global Road Safety Facility

[10] ITF (2016), Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System, OECD Publishing, Paris.

[11] Shahram Heydari 1,*, Adrian Hickford 1 , Rich McIlroy 1, Je_ Turner 2 and Abdulgafoor M. Bachani 3 (2010) Road Safety in Low-Income Countries: State of Knowledge and Future Directions Sustainability, nov. 2019

Guide for Road Safety Opportunities and Challenges: Low- and Middle-Income Countries. Country Profiles.[12]	Pillar approach • Road safety management activity (presence of a lead agency, and development of road safety targets and strategy); • Safe roads and roadsides (road audit and star rating scores and investment potential to improve roads in a cost-effective manner); • Safe speeds (application of speed limits and their enforcement, as well as infrastructure to support compliance with these speeds); • Safe vehicles (vehicle registration, standards, and regulations); • Safe road users (laws relating to seat belt use, helmet wearing, and drink driving); and • Post-crash care (access to care and health coverage).

Table I. Recent overview studies about road safety in LMICs and their resulting focus areas

From Table I, we selected 12 issues that bear the perspective of building successful road safety developments in LMICs. In order to make clear that the road safety problem is to be approached as a system, we organized the issues in three levels, considering organizational and cultural aspects (strategical), network and traffic system related aspects (tactical) and component related aspects (operational):

Strategical

I. SDG's: integral approach
II. Safety culture
III. Road safety management and leadership:
IV. Building road safety expertise

Tactical

V. The transportation system as a whole
VI. City design, architecture, land use, rural planning.
VII. Cost effectiveness
VIII. Legislation and enforcement

Operational

IX. Speed
X. Sustainable safe roads
XI. Vehicles as a safe system component
XII. Post crash health care

Each of these issues is reviewed in more detail in Section 4, subsections 1-12 below

[12] World Bank (2019). Guide for Road Safety Opportunities and Challenges: Low- and Middle-Income Countries. Country Profiles. Washington, DC., USA: World Bank

4. STATE OF THE ART FOR THE ISSUES

Countries differ largely as to their road safety strategy and position. Some will be in the beginning of the process of strategy development, others may be on their way for a longer period. Some may have their focus on building enforcement strategies, others on infrastructure developments. This chapter gives short state of the art descriptions for the 12 issues with the focus on LMICs. As a result a number of focus areas are defined for each issue. These areas will be used to organize the overview of case studies that will be presented in our second report[2].

4.1. SUSTAINABLE DEVELOPMENT GOALS: INTEGRAL APPROACH

Ahmed Ksentini, consultant, University of Sfax.

One of the major accomplishments of the first Decade of Action 2011-2020 was the consideration of road safety as a part of the global development agenda and Sustainable Developments Goals[13] (SDGs,). This was integrated into SDG 3.6:

"By 2020, halve the number of global deaths and injuries from road traffic accidents"

and SDG 11.2:

"By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" .

In the new decade of actions by 2030, it is considered that road safety directly or indirectly influences and interacts with the other 17 SDGs (and many of the 169 respective targets). In this context, it is worth noting that road safety targets ensure better education, employment, less poverty, improve health, trade and better economic development. The efforts and actions that should be deployed for traffic injury reduction should be applied with the same importance as that accorded to natural and man-made disaster risk reduction and climate change impacts mitigation.

Indeed, the Stockholm declaration 2020[14] adopted 18 resolutions which clearly consider a total synergy between SDGs policy areas. Road safety and the safe system approach must be considered in all fields related to public health, development, education, equity and gender, sustainable cities, environment and climate change.

The target of the new Decade of Actions was set to work on reducing fatal and serious injuries by 50% with member states committed to continue their contribution to achieve it. This is to be accomplished by moving from simple actions for strengthening road safety pillars and the safe system approach endorsement into sound road safety actions in all the governments' SDGs daily activities. This is now encouraged by the new regional and global partnerships and the integration of road safety into SDGs. This is made easier when compared with the last decade, during which the road safety targets of SDG 3.6 were considered not met despite the lack of reporting actions.

From the low to middle income countries perspective, these universal considerations should be more motivated though considering the actual global road traffic injuries burden. Those countries

[13] UN Department of Economic and Social Affairs (2019) The Sustainable development Agenda. https://www.un.org/sustainabledevelopment/development-agenda/

[14] Stockholm declaration (2020) Third Global Ministerial Conference on Road Safety: Achieving Global Goals 2030, Stockholm 19-20 February 2020.

are concerned with other major priorities like poverty and low income, diseases and pandemics, wars and conflicts, political instability amongst many others. The lack of actions raised road traffic injuries as one of the 10 major fatal causes during the last 10 years in LMICs[1]. Despite these considerations, many LMICs have become committed to reduce fatal and serious injuries through different actions since 2015. Some countries already adopted national strategies which are defined and maintained by committees linked to the highest political levels. However, the application of these strategies appears to be slow and sometimes efforts are not fully coordinated on local and regional levels. The governments of LMICs are considering road safety as their own responsibility and that actions should be defined only by the politicians. This trend needs to be revised and different stakeholders must collaborate to meet the global targets. They must efficiently involve NGOs, civil society, academia, international donors and corporations, international partners and associations. Road safety must be considered in LMICs for all users, gender, children and youth, vulnerable users, especially in urban areas. This needs to be reflected at highest political level through adequate strategies and action plans using a multi-sectoral approach. Road safety actions must be applied in the land use, street design, transport systems. Institutional capacity, legislation and laws must be revised and consistent with all these considerations to ensure effective law enforcement. Also, post-crash care must be integrated into the strategies and road traffic injury data analyzed and reported.

In order to reach these targets and their synergy through the indivisible SDGs, the Academic Expert Group report for the third global Ministerial Conference in Stockholm on Road safety[15] proposed to adopt 9 clear recommendations summarized as follows:

I. Sustainable practices and reporting of road safety interventions as part of the SDG contributions. This is not limited to governments but includes national and large corporations through their value chain as described in Porter's model.
II. Procurement of public and private sectors across their value chains. This is to be applied by adopting a minimum set of safety and standards for motor vehicles across the globe. Governments and private sectors must adopt safety specifications and approaches in their vehicles, transportation systems and infrastructures. They must also invest in safety of two-wheelers, professional drivers training, road safety monitoring and reporting, low risk roads and vehicles and optimized travel times and paths.
III. Modal shift from personal vehicles toward safer mobility. Cities and urban areas must afford new ways of safe mobility like walking, bicycling, public transit, clean and adequate sidewalks and safer streets.
IV. Mandate a 30km/h speed limit in urban areas. This speed limit should be adopted in all urban areas and minor roads except for roads where safety evidence exists to maintain higher speeds.
V. Improve child and youth health through safer roads and walkways. Frequently adopted routes for children and youth to go to schools and other locations should be examined with regards to road safety and actions to be implemented to develop and maintain safer travel.
VI. Bring technology benefits for vehicles and infrastructures in LMICs. Technology includes sensory devices, connectivity methods and artificial intelligence. This will improve crash

[15] Third Global Ministerial Conference on Road safety (2019) Saving Lives Beyond 2020: The next steps. Recommendations of the Academic Expert Group for the Third Global Ministerial Conference on Road safety (76 p)

prevention, emergency response and trauma care. For LMICs, social, economic and environmental local conditions should be considered.

VII. Design and realize safe infrastructures. This can be accomplished by sufficient budget allocation for road safety consideration in road maintenance projects. This must be done urgently and align with the Safe Systems Approach considerations.

VIII. Eliminate speeding to protect road users. Government vehicles, businesses and other owners' fleet should adopt zero tolerance for speeding. Speeds must be appropriate and align with the safe system approach for all vehicles, infrastructures and enforcement interventions.

IX. Ensure safe vehicles across the globe. Government, manufacturers and vehicles purchasers must ensure adequate safety levels in all vehicles in both public and private sectors, to enhance their safety conditions and performance.

PIARC works on road safety as a development priority. It also supports national and regional initiatives that lead to the appliance of the UN decade of actions and Millennium development goals especially in LMICs. The PIARC Road Safety Manual case[4] gives a list of targets and plans to be adopted at regional and national levels. Key messages for these plans to be adopted are addressed in chapters 2 and 6 of the manual. Focusing on LMICs, PIARC strongly supports the adoption of funding and implementation of a pilot project to build capacity as a first step. This will be followed by large scale projects across the countries. Such pilot projects could be implemented in high-risk corridors through the different agencies to catch the applied policies with regards to SDGs, projects management and outcomes monitoring and reporting. Such pilot projects can then link political actions, improve advocacy, strengthen road safety management, leadership, coordination and extend technical knowledge.

4.1.1. Focus areas for LMICs

The following SDG related issues deserve priority:

- LMICs to integrate road safety strategy as an integrated component of their sustainable development goals.
- LMICs to stimulate a multi-sectorial approach with all relevant stakeholders involved.

4.2. ROAD SAFETY CULTURE

Steven Robertson, South African National Roads Agency

Cultural differences between countries are generally considered one of the major challenges when introducing road safety strategies. Culture may be described as an anthropological item, with mobility behavior as a particular topic. Consequently cultural aspects may result in large differences in traffic behavior. The challenge of developing and enforcing a proper road safety culture among communities and the population at large has proven to be far more difficult than adopting best practices in principle and creating appropriate legislation.

A general review of available literature, as well as first-hand experience, reveals a number of reasons as to why such culture is not entrenched in some countries and societies. These include :

- A pervasive influence of fatalism in certain religious beliefs, leading to a disconnect between behaviour and effect, see also: *Can the traffic safety culture concept be applied to safe road user behaviour in low and middle income countries?* [16].
- Diverse / multi-cultural societies, encompassing many different languages and beliefs, which mitigate the adoption of a common goal. In South Africa, for example, there are 11 official languages.
- Developing infrastructure that caters to increasingly high numbers of private motor vehicles, while failing to develop appropriate safety measures.
- A culture of 'speed is king', where getting to a destination within a certain time is seen as a badge of honour.
- The sale of vehicles without the installation of standard safety features in order to reduce the price, regardless of how marginal this reduction may be.
- A lack of enforcement. In many LMICs, legislation does not equate to compliance. Reductions in blood alcohol limits and posted speed limits have little if any impact when not enforced.
- A culture of 'convenience' resulting with individuals walking directly across a busy highway to the shops, rather than use the pedestrian underpass or overbridge, which entails an additional 100 meter walk.

In order to deal with cultural differences, it is worthwhile to approach this issue with a multi-level perspective: a) authorities, b) community, and c) the private sector.

The ***authorities*** should develop a road safety strategy on the basis of the safe systems principle, i.e. accepting that human errors will occur, and taking the local culture into account. This approach requires knowledge about the relation between local habits and human traffic behavior. When developing legislation, traffic rules and infrastructure guidelines this local culture should be taken into account. This will also influence the nature of educational programs, i.e. school curriculums as well as driver training programs. The introduction of road safety awareness into the school curriculum, as well as outreach programs by road authorities for the education sector, are among the initiatives in LMICs aimed at fostering a road safety culture from an early age[17]. Experience has shown that children can have an influence on parents' behavior in respect with, for example, wearing of seatbelts, stopping at traffic signals, jaywalking, etc. Educational programs and campaigns are a preferable part of broader programs. They may serve as a supporting element of infrastructural measures and enforcement programs. As an example, school programs may contain a mix of traffic calming and education. Campaigns may improve the effectiveness of new rules and enforcement programs, e.g. speed and seatbelt use. The effectiveness of campaigns and education as a stand-alone activity is generally considered to be low.

The effectiveness of campaigns and education as stand-alone activities are generally considered to be low. Enforcement of road traffic rules and legislation is a key element in the reduction of road crashes around the world. Many of the success stories on HIC countries have relied significantly on

[16] King, Mark J. (2018) Can the traffic safety culture concept be applied to safe road user behaviour in low and middle income countries? In 29th International Congress of Applied Psychology (ICAP2018), 2018-06- 26 - 2018-06-30. (Unpublished)

[17] Lianne Malan, Gerda van Dijk & David Fourie (2016) The strategy to align road safety education to the Further Education and Training band curriculum, Africa Education Review, 13:2, 132-146, DOI: 10.1080/18146627.2016.1224557
To link to this article: http://dx.doi.org/10.1080/18146627.2016.1224557

enforcement by the authorities. As an example, data from Spain indicate that between 2004 and 2014, fatalities and casualties in general reduced by approximately two-thirds[1].

Co-ordination between government departments is also considered as a major challenge in some LMIC's. This is equally true at a national level, where different ministries do not interact effectively, including the interactions between national and provincial departments.

The boundaries of national, provincial and municipal responsibility can be blurred, to the extent that no-one takes responsibility for the implementation of long-term strategies. The tendency to allocate funding on the basis of annual budgets, as opposed to long term goals, could be a contributing factor in the lack of co-ordination.

At the ***community*** level, strong organizations are needed to develop a correct understanding of the traffic problems encountered in a particular area[18]. Local working groups (parents, schools) and NGO's may serve as the eyes and ears of the authorities in order to develop effective measures. Advocacy groups founded by road crash victims may play an effective role as well. A strong link between Community teams and Centres of excellence is needed to provide coordination. Funding of community teams should be considered as an important element of a country's road safety leadership. At a more local level, the engagement of communities in the road safety effort is essential. It is a feature of some LMICs that building houses, i.e. so called ribbon development, takes place along national or provincial roads which were originally constructed to rural geometric standards. For various reasons, including a lack of spatial development planning, local communities see the rural highway as the main arterial route. This results in pedestrians and livestock using a road which was not built to cater to these users. Research projects should deliver a clearer understanding of communities' usage of rural roads in order to formulate design features and standards which will improve the overall safety. Engagement and understanding will no doubt encourage acceptance of road safety measures, rather than imposing barriers and restrictions on communities.

Private sector companies under contract to agencies to manage public transport services are important influencers of a proper safety culture in their company. The Bangladesh traffic safety crisis (2018) may serve as an illustrative example. Many of the country's buses are not registered, and often drivers have not been trained or had their eligibility to drive a bus verified. Buses are often rented to drivers who feel they need to drive fast to collect enough fares to pay for the bus[19].

The case illustrates particularly that a multi-level approach is needed. Improving driver training is necessary but not sufficient by itself. The underlying causes of speeding should be considered, .i.e. the incentive to collect as many fares as possible. Drivers should also receive incentives for safe driving.

[18] SSATP (2004) Interventions to improve road safety: community participation. https://www.ssatp.org/sites/ssatp/files/publications/HTML/Gender-RG/Source%20%20documents/Issue%20and%20Strategy%20Papers/Safety/ISSAF1%20CommunityParticipationin%20traffic%20safety-GRSP%20Kvam.pdf

[19] https://www.roadsafetyngos.org/events/citizens-take-action-bangladeshs-road-crisis/

4.2.1. Focus areas for LMICs

Taken together the following traffic safety culture related issues do deserve priority:

- LMICs to develop a strategy with traffic rules and design guidelines that are based on knowledge about local behavioral characteristics
- LMICs to develop strong organizations that represent the local community and serve as the eyes and ears regarding traffic problems and solutions.
- LMIC transport companies to develop and/or uses effective incentive systems with the focus on safe driving.

4.3. ROAD SAFETY MANAGEMENT AND LEADERSHIP:

Paulin Kouassi, Conseiller Technique du DG du LBTP et Président du Comité National AIPCR/AGEPAR

An efficient management system and leadership body are key requirements for the implementation of an effective road safety improvement program[20]. In many LMICs the organizational structure of the management system may suffer from deficiencies, thus weakening the institutional functions across key road safety players. In fact, countries may differ strongly in their starting point[21]. In most cases there is a lack of leadership, a lack of political priority, a lack of funding, a lack of expertise, etc.

According to the World Bank[12], the success and effectiveness of road safety lead agencies (RSLAs) in coordinating preventative road safety interventions in developing countries is dependent on the following key elements:

- Lead agencies with full-time expert staff, legally endowed powers, permanent funding, political support, and access to relevant data;
- Road safety strategies with clear intermediate and final targets and outcomes;
- Funding dedicated to road safety;
- Road crash and other complementary data
- Understanding of the causes and circumstances at road crashes location.

The development of an effective road safety strategy starts from the notion of the Safe System approach. Instead of focusing on human errors, the safe system principle designs a system to prevent fatal and serious injury crashes. Such an approach deals with human behavior in a proactive and integral way by creating an environment for safe human behavior. In developing countries, regions under increasing motorization, place vulnerable road users (pedestrians, cyclists and motor cyclists) at particular risk[22]. Pedestrian crashes are a serious and growing problem in the cities. Poor planning of road networks, poor traffic control and management at intersections, inadequate

[20] Khademi N. and al. (2018). Investigating the road safety management capacity: Toward a lead agency reform, International Association of Traffic and Safety Sciences.

[21] Wegman, F. (2017) The future of road safety,: a worldwide perspective. IATSS Research Volume 40, Issue 2, January 2017, Pages 66-71

[22] Wismans, J. and al (2016). Road safety implications and opportunities for regions under increasing motorization, Proceedings from the 17th International Conference Road Safety on Five Continents (RS5C), Rio de Janeiro, Brazil, 17-19 May 2016

pedestrian facilities and the severe lack of priority and attention given to the pedestrians are the main causes of such dangerous situations.[23]

While some road crashes are predictable and thus preventable, efforts to reduce crashes in developing countries are further hampered by lack of accurate crash and casualty data. Data collection helps governments to more effectively prioritize funding, monitor the impact of investments, and strengthen inter-agency collaboration and efficiency[12].

Bhalla and Shotten[24] analysed the Argentina case, which illustrate that focusing events, like a road safety tragedy, can create an opportunity for legislative reform, with demand for safety and solutions that could be deployed when the opportunity arose.

Their case study emphasizes " the importance of developing institutions with the resources and authority necessary for managing national road safety programs".

The preparation of a road safety strategy in a city highlights the need to ensure high quality analysis of safety issues is integrated with straightforward participatory processes, and the importance of institutional arrangements to ensure plans can follow through and resources can be effectively allocated to the issues that matter most [25].

Identifying black spots based on safety potential can be a suitable approach to accident reduction in developing countries. For Nguyen[26], this approach has the greatest economical effectiveness.

Hoque M[27]also argues that significant safety gains can be achieved by implementing affordable road infrastructure measures targeting priority crash types on such high risk highway sections. Site specific infrastructure improvements through modification of alignments, curvatures, roadside hazards removal and delineation treatments have resulted in marked reduction in crashes and casualties, by up to 70%.

The instruments of Road Safety Audits (RSA) and Road Safety Inspections (RSI) are recommended to be a central part of the road infrastructure safety management[28] (*See also chapter Sustainable safe roads*).

In Egypt for example, the structure of a clear hierarchy of road network is often missed. Most of the developing countries are in the same situation. The long term experiences with RSA and RSI courses and reports figure out that a consequent implementation and use of the benefits of these instruments can help to improve road safety and avoid accidents.

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[23] Pervaz S. and al. (2016). Pedestrian safety at intersections in Dhaka metropolitan city, Proceedings from the 17th International Conference Road Safety on Five Continents (RS5C), Rio de Janeiro, Brazil, 17-19 May 2016

[24] Kavi Bhalla & Marc Shotten (2019) Building Road Safety Institutions in Low and Middle-Income Countries: The Case of Argentina, Health Systems & Reform, 5:2, 121-133, DOI: 10.1080/23288604.2019.1565061 To link to this article: https://doi.org/10.1080/23288604.2019.1565061

[25] Hirpa, J. and al. (2018). Preparation of a road safety strategy for the city of Addis Ababa, Australasian Road Safety Conference, 2018, Sydney, New South Wales, Australia

[26] Nguyen, H and al (2015). Identifying Black Spots Based on Safety Potential - A Suitable Approach to Accident Reduction in Developing Countries, Journal of the Eastern Asia Society for Transportation Studies

[27] Hoque, M (2014)

[28] Gerlach, J. (2016). Experiences with road safety audits and inspections, Road Safety on Five Continents (RS5C): 17th International Conference, Rio de Janeiro , Brazil, 2016

Credible studies in Africa indicate that defective road design, poor driver education, increase in vehicular use, bad road conditions and increased levels of speeding have resulted in high levels of unsafety. [29].

Improving prehospital and emergency response systems in developing countries have had a positive impact on injury and death rates resulting from road traffic crashes [30].

In order to overcome human resource limitation, a Mobile Mapping System (MMS) technology can be applied to collect road asset data such as traffic signs, road markings, bridges and culverts, lighting post, etc. The collected asset data is complemented with geographic information and accuracy within 0.10 meter tolerance.

After risk spots are located, the auditors can review the scene of road section again a system, called "Rural Road Network Management (RM) system" or in field. The developed system a cost effective option for road safety audit and can solve the human resource shortage problem of the Department of Rural Roads[31] .

As a solution, LMICs should invest in local capacity building (See 4.IV) to carry out tasks and create effective road safety communities that involves all players: the public sector (all tiers of government), academia, NGOs, and the private sector. Positive results will develop if lead agencies orchestrate strategy development and the implementation of action plans. Setting and monitoring road safety targets will likely be instrumental, and that process requires good data systems.

4.3.1. Focus areas for LMICs

The following road safety management issues deserve priority:

- LMICs to develop a strong lead agency which has full-time expert staff, legally endowed powers, permanent funding, and political support;
- LMICs to develop a robust road safety data system;
- LMICs to develop a robust set of local guidelines and regulations
- LMICs to develop a center of road safety excellence (see 4.4, Building road safety expertise and science)

4.4. BUILDING ROAD SAFETY EXPERTISE AND SCIENCE

Hans Godthelp, Road safety for all

Although road safety principles, like the safe system approach, may be considered as universal and internationally oriented, they don't give a recipe book for each country. That's why countries should develop a robust level of national road safety expertise. Differences in culture, traffic characteristics and transport history make it necessary for countries to develop their own approach of safe system developments. Building from international noteworthy practices, local authorities and specialists should develop and operationalize guidelines, rules and regulations, based on a national framework

[29] Ojugbana, C. and al. (2010). Investigating Effectiveness of Speed Cameras in Developing Communities. The Nigerian Perspective, Safety 2010. 10th World Conference.
[30] Adeloye, D. and al. (2016). The Burden of Road Traffic Crashes, Injuries and Deaths in Africa: A Systematic Review and Meta-Analysis, Bulletin of the World Health Organization, 2016
[31] Bamrungwong, C. (2017). A Study of Applying Mobile Mapping Result for Road Safety Audit on Rural Roads in Thailand, First International Roadside Safety Conference: Safer Roads, Saving, 2017

of legislation. Guidelines specifying road designs may indicate how the road network is hierarchically divided in a limited number of functional road categories, both in urban and rural areas. They will also describe the design characteristics of the different road types under these categories, see par 4. X. Traffic rules and their underlying legislative notions will guide drivers and give direction to road users on how to behave safely. They will also give a basis to the educational programs at schools and to enforcement strategies undertaken by police. Also vehicle regulations will give requirements that automobiles and other vehicles should satisfy in order to be approved for use in a particular country. Legislation will also involve the prescribed use of data systems, i.e. about traffic characteristics and road crashes.

In order to develop the fundamental building stones of a robust road safety management system countries should develop a strong framework of expertise development. Local universities and Centers of Excellence should play a central role in this process. The system approach also defines the scope of the needed road safety expertise. Although most road safety knowledge is based on a 5 pillar approach, i.e. road safety management, safe roads, safe vehicles, safe road user behavior and adequate post-crash actions, the safe system concept clearly indicates the need to analyze these pillars not as separate entities, but in interaction with each other. Road safety experts are multidisciplinary; their expertise is based on the integration of engineering, social, psychological and policy related disciplines. Of course emphasis may differ, but the system approach should be considered as an expertise on its own.

Building expertise and science should be considered as one of the central issues of a road safety strategy, also in LMICs. This notion has resulted in a number of international initiatives during the last decade. Roughly spoken these initiatives can be divided in the two following lines of approach:

- international courses focusing on the strategic nature of the road safety problem. Examples of this type of programs can be found at Unita [32] , Johns Hopkins/GRSP [33] ,Delft University/FIA Foundation [34]. Each of these programs provide a curriculum with a mixture of leadership and operational road safety principles. Participants are stimulated to translate these principles to their home situation and develop their own strategic plans
- international courses with a more operational character, i.e. dealing with road design and legislation and enforcement. Examples of these types of programs are presented by iRAP[35], IRF[36], WHO[37]. iRAP and IRF provide training on a variety of specific road safety knowledge, most of which intend to support countries in the process of inspecting and auditing their local road network. In the same sense many types of courses are available to support local governments and police officers in their enforcement task. WHO[37] gives just one example of this sort of courses.

[32] Unitar, (2020). Road safety initiative. Road Safety Initiative | UNITAR, Online Road Safety Training in Response to COVID-19 | UNITAR
[33] Johns Hopkins/GRSP (2021), Global Road safety Leadership Course. Global Road Safety Leadership Course - Training Programs - Capacity Development - Education - Johns Hopkins International Injury Research Unit - Centers and Institutes - Johns Hopkins Bloomberg School of Public Health (jhsph.edu)
[34] Delft Road safety Courses/FIA Foundation, (2022). HOME - Delft Road Safety Courses
[35] iRAP Training opportunities. Training - iRAP
[36] IRF (2021) Introduction to road safety audits. Online Course: Introduction to Road Safety Audits - International Road Federation (IRF) (irfnet.ch)
[37] WHO (2014). Strengthening road safety legislation. A toolkit for rad safety legislation workshops. Strengthening road safety legislation: a toolkit for road safety legislation workshops (who.int)

This rich set of international courses, both classroom and online, has brought a great amount of international road safety knowledge to the LMICs. The effect has resulted in more and more countries starting to implement lead agencies, developing road safety strategies and taking their responsibility for road safety legislation and road safety data systems. Also, the knowledge on road safety auditing and inspection has developed. Initiatives taken by the World Bank and Multi Lateral Development Banks like AfDB/ SSATP to build Road Safety Observatories [38] [39] for different continents and Centers of Excellence by Unitar [40]to build Networks of universities, strongly support this work.

Despite this large international effort, countries do differ strongly in their level of national knowledge development and academic programs. For the coming decade, it's of utmost importance to develop such local programs, i.e.

- University programs for bachelor and master education and
- Centers of Excellence (CoE).

4.4.1. Focus areas for LMICs

The development of national knowledge centers both at universities and research institutes is to be considered as one of the major issues in the coming years. PIARC may stimulate this development and support the activities of university networks.

Taken together the following Road safety expertise and science issues do deserve priority:

- LMICs to develop university road safety programs at bachelor and master level
- LMICs to build research capacity in centers of road safety excellence
- LMICs to connect to regional road safety observatories
- LMICs to connect to international network of universities and centers of excellence.
- PIARC to support this network process.

4.5. THE TRANSPORTATION SYSTEM AS A WHOLE

Hans Godthelp. Road safety for all

More and more LMICs take the position to develop a road safety strategy which is connected with their strategic development goals. This policy implies the creation of urban and rural development patterns which stimulate the use of public transport, walking and cycling as primary modes of transport and which support vibrant, diverse, and liveable communities[41].

When developing cities this is achieved by concentrating urban densities, communities, and activities within a 5-10 minute walking distance from mass rapid transit stations (both bus and rail-based), developing quality urban space and providing convenient and efficient access to a diverse

[38] SSATP (2021). Operationalizing the African Road Safety Observatory. 0 African Road Safety Observatory | SSATP
[39] African Development Bank (2019) . https://www.afdb.org/en/news-and-events/african-road-safety-leadership-program-kicks-off-in-abidjan-18960
[40] Unitar (2018) Network of universities on road safety. Network of Universities on Road Safety is Presented at UNITAR's Road Safety Africa Conference | UNITAR
[41] World Bank, (2021) Transit-oriented-development. Implementation and resources and tools. Document prepared for the World Bank by IBI Group and World Resources Institute India. International Bank for Reconstruction and Development / The World Bank 1818 H Street NW, Washington, DC 20433

mix of land uses. Truong and Currie (2019)[42], give a nice overview of the potential positive safety impacts of public transport, based on the Melbourne case.

A policy of improving public transport facilities and making urban and rural areas more attractive for walking and cycling should be based on a road safety strategy that focuses on the protection of these vulnerable road users. Based on the Bogota study of the Bus Rapid Transport system, Bocarejo et al (2012)[43] illustrate the need to give special attention to the improvement of pedestrian facilities and traffic calming measures.

In the period up to 2030 a strong international Transit Orient Development (TOD) movement is made under the umbrella of the World Bank. Owing to the potential benefits, cities around the world – both in HIC and LMICs - are adopting TOD planning practices for smart growth and improving quality of life for their residents[44]. This gives a plea to link TOD with road safety, particularly in LMICs. A five step framework is presented based on the safe system approach. The five steps include:

1. Assess: To evaluate the road safety status of a city by evaluating the existing conditions, focusing on demographics and road crash data assessment; infrastructure conditions and spatial assessment; and policies, regulatory frameworks, and capacity assessments.
2. Enable: To develop an enabling environment that facilitates institutions and stakeholders to be aware of road safety challenges and allows a TOD project to fill gaps identified in the previous step and act as a catalyst for achieving road safety
3. Plan & Design: To plan and design infrastructure that addresses networking challenges within a TOD station area and the elements designed are equitable and equipped to cater to the increased volume of users and their requirements.
4. Finance: To develop innovative financing tools for the local authorities, enabling institution, developers and property owners that help allocate funds and provide incentives for ensuring road safety.
5. Implement: To overcome barriers for implementing road safety within a TOD station area by addressing various gaps as identified and evaluate the effectiveness through key road safety performance indicators.

The World Bank[45] provides examples of cities that were in such a transition phase until 2019 before the pandemic period. Since then, this process has accelerated strongly as a result of the mobility effects of the pandemic.

4.5.1. Focus areas for LMICs

The following Transportation system issues deserve priority:

- LMICs to develop a public transport system, with road safety criteria included
- LMICs to promote a Transit Oriented Development with road safety criteria included

[42] Truong, Long and Currie, Graham, (2019) Macroscopic road safety impacts of public transport: A case study of Melbourne, Australia Article in Accident; Analysis and Prevention · August 2019

[43] Bocarejo, J. P., Velásquez, J.M., Díaz, C.A., , Tafur, L.E. (2012) Impact of Bus Rapid Transit Systems on Road Safety, December 2012, Transportation Research Record Journal of the Transportation Research Board 2317(-1):1-7

[44] World Bank, 2019 Achieving sustainable cities: The link between Transit-Oriented Development (TOD) and road safety (worldbank.org)

[45] World Bank (2017) Can Dar es Salaam become the next global model on transit-oriented development? Can Dar es Salaam become the next global model on transit-oriented development? (worldbank.org)

4.6. CITY DESIGN, ARCHITECTURE, LAND USE, RURAL PLANNING

Andrea Pimentel Rivera (University of Illinois Urbana-Champaign), Michael S. Griffith (Federal Highway Administration)

Planning is a technical process tied to economic and political priorities and considerations. As a country's transportation network is interrelated to its socio-economic system, rapid motorization in LMICs caused by urbanization is responsible for increasing rates of road traffic injuries (Stevenson, 2019[46]).

This societal shift is a significant issue as it can hinder the long-term economic growth of LMICs (Job & Wambulwa, 2020[47]).

Planning for road safety in LMICs is a complex effort that takes place in regions where formal plans and informal developments may conflict with travelers' mobility needs. An example is the growing number of upper- and middle-income earners in LMICs as contributors to sprawl through the increase in private vehicle ownership creating a demand for new high-speed and high-capacity roads (Tiwari, G. 2016[48]). This results in longer trip distances which are difficult to service through either active transportation modes or public transit. Thus, road infrastructure safety in LMICs requires planning interventions through a context-sensitive, systems-oriented approach.

4.6.1. International Framework

The United Nations have led several efforts to tackle the road safety crisis in LMICs. The Stockholm Declaration, prepared in the Third Global Ministerial Conference on Road Safety in 202014, includes a resolution (7) which addresses the need to incorporate the planning process in road safety:

"Include road safety and a safe system approach as an integral element of land use, street design, transport system planning, and governance, especially for vulnerable road users and in urban areas, by strengthening institutional capacity with regard to road safety laws and law enforcement, vehicle safety, infrastructure improvements, public transport, post-crash care, and data."

Additionally, a practice encouraged at the Third Global Ministerial Conference on Road Safety is to provide for the safety of vulnerable road users through reduced motor vehicle speeds. Saving Lives Beyond 2020[49] recommends reducing urban speed limits to 30 km/h based on a systemic review by Cairns, et al[50] of 10 independent studies of measures that show evidence of reduced crashes, injuries, traffic speed, and volume. Based on the Safe System Approach principles, introducing traffic calming road features in urban areas may also be needed to reduce serious crash injuries.

LMICs' efforts towards reducing road traffic injuries and deaths through a systems-oriented approach begin through adequate legislative interventions, as these have been found to be most

[46] Stevenson, M., Thompson, J., Wijnands, J.S., Nice, K., Aschwanden, G., & Zhao, H. (2019). Opportunities to reduce road traffic injury: new insights from the study of urban areas. International Journal of Injury Control and Safety Promotion, 27, 20 - 26.
[47] Job, R., & Wambulwa, W.M. (2020). Features of Low-Income and Middle-Income Countries making Road Safety more Challenging
[48] Tiwari, G. "Land Use-Transportation Planning, Mobility and Safety." In Transport Planning and Traffic Safety: Making Cities, Roads, and Vehicles Safer, 45-57: CRC Press.
[49] Swedish Transport Administration. (2020). Saving Lives Beyond 2020: The Next Steps
[50] Cairns, J. Warren, J. Garthwaite, K. Greig, G. Bambra, (2015). Go slow: an umbrella review of the effects of 20 mph zones and limits on health and health inequalities. Journal of Public Health. Vol. 37, No. 3, pp. 515 –520

effective in reducing road traffic crashes, injuries, and deaths (Staton, C. et al, 2015[51]). Since LMICs are often resource-constrained with limitations in infrastructure, implementation, and funding resources, it is imperative for transportation professionals to recognize the evidence between land use, the transportation network, and road safety as a means to devise interventions that are context-sensitive and cost-effective.

4.6.2. Relationship between land use and road safety

The Transport, Health and Urban Design Research Lab (THUD) at the University of Melbourne explores the gaps in research that address road traffic injury burdens globally with a focus on urban design. Their approach involved processing 1,667 cities' sample maps with populations exceeding 300,000 by classifying them based on urban characteristics of private motor vehicle and public transit networks (Stevenson, et. al., 2019, ref. 46; Thompson, et. al., 2020[52]). This points toward a strong association between urban design and road traffic injury burden.

The research, situated in the Asia-Pacific Region, identified a three-times difference in the burden of road traffic injuries in cities with distinct differences in their road network (those with investments in public transit were considerably safer).

THUD recommends transportation professionals integrate road safety across the entire transportation system. Specifically, they recommend supporting transport policies that embrace the compact city approach of shorter distances, slower speeds, higher residential and population densities, and design that promotes walking, cycling, and public transit.

Further, perspectives from cross-disciplinary assessments between planning and public health assert that the urban form can be optimized through a systems-oriented approach which puts road safety and public health policies in a broad context of improved transport and health (Schepers, Lovegrove, & Helbich, 2019[53]). This is achieved by what the authors consider an ethical vision to transport and health which involves a bottom-up, "human-first" design process.

4.6.3. Public participation in road safety planning

Tackling road safety issues through an holistic approach that places greater emphasis on public participation is critical to ensuring that public needs are addressed (Agarwal, Kumar, & Zimmerman, 2019[54]).

Public participation in the transportation decision-making process should seek to accomplish the following key objectives:

- information exchange,
- education,

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[51] Staton, C., Vissoci, J., Gong, E., Toomey, N., Wafula, R.B., Abdelgadir, J., Zhou, Y., Liu, C., Pei, F., Zick, B., Ratliff, C.D., Rotich, C., Jadue, N., Andrade, L.D., Isenburg, M.V., & Hocker, M. (2016). Road Traffic Injury Prevention Initiatives: A Systematic Review and Metasummary of Effectiveness in Low and Middle Income Countries. PLoS ONE, 11.

[52] Thompson, J., Stevenson, M., Wijnands, J.S., Nice, K., Aschwanden, G., Silver, J., Nieuwenhuijsen, M., Rayner, P., Schofield, R., Hariharan, R., & Morrison, C. (2020). A global analysis of urban design types and road transport injury: an image processing study. The Lancet. Planetary health, 4 1, e32-e42.

[53] Schepers, P., Lovegrove, G., & Helbich, M. "Urban Form and Road Safety: Public and Active Transport Enable High Levels of Road Safety." In Integrating Human Health into Urban and Transport Planning: A Framework, edited by Mark Nieuwenhuijsen and Haneen Khreis, 383-408. Cham: Springer International Publishing.

[54] Agarwal, O.P., Kumar, A., & Zimmerman, S. (2019). Transport Planning and Decision Making in the Age of Social Media: From Exclusivity to Inclusivity. In Emerging Paradigms in Urban Mobility, (pp. 169-197), Elsevier, https://doi.org/10.1016/B978-0-12-811434-6.00009-3.

- support building, and
- input from all sectors of the public.

A case study of governmental policies in Port Louis, Mauritius highlights the gaps between citizen needs and transportation investments (Thondoo, et al, 2020[55]).

The study points toward the poor surveying of residents' needs as a primary reason for the misalignment in technological, institutional, and infrastructure measures that cater to private motor vehicles. Recommendations derived from the Port Louis case study for LMICs noted to achieve significant public participation in the transportation planning process include:

- preparing in advance the resources needed to facilitate the integration of citizen needs;
- prioritization of gaps between health, economic, and social needs; and
- use citizen needs stratified by demographic indicators as a way to aim for social, health, and equity-driven co-benefits.

4.6.4. COVID-19 implications to future road safety planning

Rapid motorization is not the only factor that contributes to concerns of road safety issues in LMICs. The major pandemics (COVID-19) have had considerable impacts on changes in travel behavior and street space usage. Governments impose various control and preventative measures that change travel behaviors in trip purpose, trip lengths, and mode choice (Abdullah, Muley, & Shahin, 2020[56]). In this study it was observed that trips became exclusive for shopping of essential items, thus becoming generally shorter. Additionally, there was increased use of private motor vehicles and active transport modes due to the perceived risk of infection in public transit and paratransit. The quick change of travel behaviors allowed cities to institute emergency regulations that introduced temporary interventions which prioritized safe spaces for walking and cycling, and curbside pickup (Combs & Prado, 2021[57]). The shortened timeframe in implementing active transportation facilities can reveal noteworthy practices for LMICs to consider that otherwise would experience slow infrastructure changes due to traditional barriers.

Consequently. It is evident that road safety should be included in a broader planning context that incentivizes active transportation modes, reduces speed zones (30km/h), and public transit. This requires LMICs to strengthen their policy and financial framework through legislative actions. The outcomes to achieve are evidence-based transportation plans that undergo a participative process.

Specific efforts in capacity building to get these plans established as recommended by Humanity & Inclusion (2018)[58] include that governments should:

- seek to facilitate the participation of all groups represented in a region, including persons with disabilities.

[55] Thondoo, M., Marquet, O., Márquez, S., & Nieuwenhuijsen, M. (2020). Small cities, big needs: Urban transport planning in cities of developing countries. Journal of transport and health, 19, 100944

[56] Abdullah, M., Dias, C., Muley, D., & Shahin, M. (2020). Exploring the impacts of COVID-19 on travel behavior and mode preferences. Transportation Research Interdisciplinary Perspectives, 8, 100255 - 100255

[57] Combs, T.S., & Pardo, C. (2021). Shifting streets COVID-19 mobility data: Findings from a global dataset and a research agenda for transport planning and policy.

[58] Humanity & Inclusion. (2018). Inclusive urban mobility and road safety in developing countries. Thematic Brief. Humanity & Inclusion.

- Strengthen data collection methods locally and nationally for improved evidence-based policies on vulnerable road users.
- Develop performance measures for local and national policies.
- Encourage multi-stakeholder dialogue on road safety.

Evidence-based transportation plans are documents that encompass the framework for growth at a given scale (plans can vary from the city level to a master plan). A general structure for planning documents that focuses on setting high-level goals includes the following:

- General objectives
- Actions to be implemented
- Projects to be implemented
- Funding resources and the sources of funding
- A framework of interventions with timelines

4.6.5. Focus areas for LMICs

- LMICs to adopt through a systems-oriented approach to put road safety and public health policies in a broad context of improved transport and health.
- LMICs to embrace the compact city approach of shorter distances, slower speeds, higher residential and population densities, and design that promotes walking, cycling, and public transit.
- LMICs to develop evidence-based transportation plans that undergo a participative process.

4.7. SELECTING COST-EFFECTIVE MEASURES

Stephanie Davy, Australian Road Research Board

The application of cost-effective interventions has benefits in terms of saving lives as well as reducing costs to society, which are relevant to LMICs and HICs alike.

In the absence of established road safety policies to support large scale interventions to systematically address road safety risks, in LMICs specifically, where rural road and highway infrastructure is expanding, the cost burden of crashes is likely to increase for individuals and their communities (Mohan et al, 2020[59]).

There are a number of interventions which have been found to be successful and cost-effective in LMICs (Ralaidovy et al, 2018[60]).

4.7.1. Choosing interventions

It is recognised that policy-makers work under resource-constrained conditions and must make decisions about competing programs. For this reason a phased approach is recommended, that ensures the implementation of the most cost-effective individual interventions at first, with an expansion strategy that can be employed as more reliable data and better resources become

[59] Mohan, Dinesh, Geetam Tiwari1 | Mathew Varghese2 | Kavi Bhalla3 | Denny John4 | Ashrita Saran4 | Howard White5 PROTOCOL: Effectiveness of road safety interventions: An evidence and gap map https://doi.org/10.1002/cl2.1077

[60] Ralaidovy, Abdulgafoor M. Bachani2 , Jeremy A. Lauer3 , Taavi Lai4 and Dan Chisholm5, (2018 Ambinintsoa H.) Cost-effectiveness of strategies to prevent road traffic injuries in eastern sub-Saharan Africa and Southeast Asia: new results from WHO-CHOICE

available. This also allows interventions to be better targeted towards the road user groups which are of particular concern or at greater risk within certain countries or regions.

4.7.2. Random breath testing

Random breath testing is defined as an intervention where impaired driving legislation is introduced and enforced via random breath testing of drivers at roadside checkpoints. This was found to be the most cost-effective single intervention in Southeast Asia, where the highest proportion of road fatalities (39%) are among car drivers and passengers.

4.7.3. Enforcement of speed limits

Enforcement of speed limits is defined as a sustained effort by traffic enforcement teams to raise the perceived risk of drivers being caught via the use of mobile/hand held speed cameras at randomly chosen checkpoint sites. The study found it to be the most cost-effective single intervention in sub-Saharan Africa, where pedestrians account for 55% of road fatalities.

4.7.4. Motorcycle helmet use

Motorcycle helmet use is defined as legislation and enforcement of helmet use among riders of mopeds and motorcycles. This was found it to be the second most cost-effective single intervention in Southeast Asia, where a high proportion of road fatalities (24%) are among motorcycle drivers and passengers.

It is understood that improved access to data on the effectiveness and costs involved in establishing these and other interventions will lead to ongoing improvements and support for their broader application.

Other interventions include

4.7.5. Combining individual interventions

“Combined enforcement strategies represent the most efficient way to reduce the burden of Road Traffic Injuries, since combinations benefit from synergies on the cost side while producing greater overall health gain”

For LMICs to achieve success in applying road safety interventions, it is recommended that they take an evidence-based approach. This means targeting key risks posed by vehicles, roads and road users, and goes beyond a less effective approach which tends to focus mainly on blaming road users (Bhalla et al, 2020[61]).

4.7.6. Sustainable safe infrastructure

Worldbank (2020)[62], chapter 4 gives a clear indication about the millions of fatalities and injuries that can be avoided worldwide through proper investment in safer road infrastructure with a cost benefit ratio estimated as 1 to 8. The PIARC Road safety Manual gives an overview of the expected percentage reduction in crashes as a result of infrastructure interventions and their costs.

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[61] Bhalla, Kavi, Dinesh Mohan & Brian O’Neill (2020) What can we learn from the historic road safety performance of high-income countries?, International Journal of Injury Control and Safety Promotion, 27:1, 27-34, DOI: 10.1080/17457300.2019.1704789

[62] World Bank. 2020. Guide for Road Safety Opportunities and Challenges : Low and Middle Income Country Profiles. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/33363 License: CC BY 3.0 IGO

4.7.7. Focus areas for LMICs

Taken together, the following cost effectiveness related issues do deserve priority:

- LMICs to develope a road safety strategy based on a selection scheme of cost effective measures
- LMICs to select low hanging fruit: defining a list of low cost proven countermeasures.

4.8. LEGISLATION AND ENFORCEMENT

Andrew Burbridge, Queensland Department of Transport and Main Roads

Hauer (1994)[63] observes that "there is no escape from the need for politicians, civil servants and professionals to make choices on behalf of a public".

Gostin (2000)[64] states that through education, creation of incentives, deterrence, mandatory product design, and alteration of the informational, physical and economic environment, law is a tool for the creation of conditions for people to lead healthier and safer lives.

Moulton et al (2009)[65] confirms that law is a public health tool that has delivered vital contributions to major public health achievements.

In the undisputed context that road safety is an issue of public health concern, Bates, Soole and Watson (2012)[66] note that governments throughout the world rely on traffic law and enforcement programmes to modify driver behaviour and enhance road safety.

Stanojevic et al (2013)[67] state that traffic enforcement has traditionally been an important means of improving traffic safety, and that "many studies have provided evidence of connections between the level of police enforcement and both driving behaviour and the number of traffic accidents".

Bates (2014)[68] concurs that traffic law enforcement programs are used to alter driver behaviour and thus enhance road safety with police operations a key component of the enforcement process.

WHO (2016)[69] reiterates that "law plays an important role in improving road safety", and offers that "key areas for law reform may include: setting and enforcing speed limits on roads, introducing traffic-calming measures, introducing and enforcing offences for driving while intoxicated, introducing a graduated licensing system (with mandatory speed restrictions) for novice drivers, prohibiting drivers from using hand-held electronic devices while driving, requiring motorcycles to

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[63] Hauer, E. (1994). Can one estimate the value of life or is it better to be dead than stuck in traffic?. *Transportation research part A: policy and practice*, *28*(2), 109-118

[64] Gostin, L. O. (2000). Public health law in a new century: part I: law as a tool to advance the community's health. *Jama*, *283*(21), 2837-2841

[65] Moulton, A. D., Mercer, S. L., Popovic, T., Briss, P. A., Goodman, R. A., Thombley, M. L., ... & Fox, D. M. (2009). The scientific basis for law as a public health tool. American Journal of Public Health, 99(1), 17-24

[66] Bates, L., Soole, D., & Watson, B. (2012). The effectiveness of traffic policing in reducing traffic crashes. Policing and security in practice, 90-109.

[67] Stanojević, P., Jovanović, D., & Lajunen, T. (2013). Influence of traffic enforcement on the attitudes and behavior of drivers. *Accident Analysis & Prevention*, *52*, 29-38

[68] Bates, L. (2014). Procedural justice and road policing: Is it important. In Australasian Road Safety Research. Melbourne, Australia: Policing and Education Conference

[69] World Health Organization. (2016). Advancing the right to health: the vital role of law. World Health Organization. https://apps.who.int/iris/handle/10665/252815. License: CC BY-NC-SA 3.0 IGO

use running lights during daytime, and mandating the use of seat belts and child restraints in cars, and helmets by people using motorcycles and bicycles".

Echoing WHO(2016)[64], a key message in the Global Status Report on Road Safety (WHO, 2018)[1] is that enacting and enforcing legislation … are critical components of an integrated strategy to prevent road traffic deaths and injuries. World Bank (2019)[10] confirms "establishing and rigorously enforcing laws to address key risk behaviours is effective in reducing road crash fatalities and injuries".

WHO (2018)[1] also reports that member states, with the support of WHO, the United Nations Economic Commission for Europe, UNICEF, World Bank and other agencies, have agreed to 12 Voluntary Global Performance Targets for Road Safety Risk Factors and Service Delivery Mechanisms. Van den Berghe et al (2020)[8] describe how each of the twelve performance targets can be addressed via a three-stage logic in which an 'action' properly implemented has outcomes which result in (typically) a reduction in the number of injuries and fatalities.

In the context of legislation, at a strategic level, Target #2[1] indicates that by 2030, all countries accede to one or more of the core road safety-related UN legal instruments, with the associated global indicator being the "number of countries that have ratified or acceded to one or more of the core road safety-related UN legal instruments". At a tactical level, six of the twelve targets include key action elements that are to be achieved by 2030 requiring legislation and enforcement. These are:

- Target 6 Speeding
- Target 7 Motorcycle helmets
- Target 8 Vehicle occupant protection
- Target 9 Driving under the influence
- Target 10 Distraction by mobile phone
- Target 11 Professional drivers

Literature on each of these elements in the context of legislation and enforcement is both broad and deep, so the focus is to draw out good/best practice, and where possible, focus on experience in low- and middle-income countries (LMICs).

4.8.1. Speeding

In the context of speeding, Auñón-Segura et al (2021)[70] investigated the prevalence thereof in the city of Xalapa, Veracruz, in Mexico. They found particularly that speeding, and especially exceedance of the speed limit by less than 30 km/h, is regarded as a minor infraction that is both rarely enforced and carries only a minor economic penalty. They recommend introduction of comprehensive speeding legislation, with appropriate speed limits that are correctly enforced.

Soole, Watson and Fleiter (2014)[71] propose recommendations for best practice principles for speed enforcement efforts. Very broadly, the aim of any speed management program should be to deter,

[70] Auñón-Segura, F. J., Pérez-Núñez, R., Ladrón-de-Guevara-Capistrán, Y., Hernández-Hernández, M. E., & Hidalgo-Solórzano, E. (2021). Speeding in the city of Xalapa, Mexico: Prevalence and associated factors. *Traffic injury prevention*, *22*(7), 536-541

[71] Soole, D., Watson, B., & Fleiter, J. (2014). A review of international speed enforcement policies and practices: Evidence-based recommendations for best practice. In Landry, S, Stanton, N, Vallicelli, A, & Di Bucchianico, G (Eds.) *Advances in Human Aspects of*

rather than catch, speeding drivers. They promote speed enforcement programs that are multifaceted and utilise a variety of enforcement strategies which are tailored to specific situations. The enforcement operations should be implemented with sufficient intensity so the population perceives the risk of being detected as high. Random scheduling of enforcement activities is promoted as being highly effective.

4.8.2. Motorcycle helmets

The perception of risk of detection as an important technique is mirrored in literature relating to helmet use. Li-Ping et al (2008)[72] conducted a study of knowledge, perceptions and behaviours relating to helmet use in two provincial cities in Southern China. They found the main reason motorcyclists reported wearing helmets was to "cope with police", and that compliance was elevated on national highways and principal arteries, and during weekdays and during morning and afternoon peak traffic hour, when it may be that police presence may be higher. They suggest that stricter enforcement may be necessary in smaller cities in developing countries.

Similarly, in a study of motorcycle helmet use in Thailand, Jiwattanakulpaisarn et al (2013)[73] found evidence that routine helmet use tended to be greater for drivers who commonly observed police motorcycle checkpoints, and those who perceived a higher risk of getting caught for not wearing a helmet. It was also found that the frequency of helmet-wearing among drivers depended on their perception of police checkpoints for helmet usage. As well, they found that the prevalence of helmet use appeared to increase among those drivers who perceived that the presence of checkpoints was less likely to be predicted (i.e., random times and locations). The point is driven home by Kumphong et al (2018)[74] who confirm that "helmet law is useless if it is not enforced effectively".

Siebert et al (2021) observed high compliance with mandatory helmet laws for Nepalese motorcycle drivers, when associated with high levels of perceived police enforcement of fine-based regulation, but low compliance for passengers. The authors consider this disparity may be attributed to absence in legislation of a financial penalty regarding the helmet use of passengers. This is consistent with a parallel observation by World Bank (2019)[10] who state that "most LMICs have some form of seatbelt law (90 percent), but only half have laws covering all occupants".

4.8.3. Vehicle occupant protection

By example, Adeoye et al (2014)[75] notes that despite the enactment of seat belt law in Nigeria, 43% of road traffic injury victims presenting to University of Ilorin Teaching Hospital between October 2006 and June 2007 were passengers, none of whom were wearing seatbelts, and calls for enforcement of seat belt. This resulted in the call for enforcement of seat belt use for drivers and

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Transportation, Part I: Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics, AHFE 2014 (pp. 553-566). AHFE International

[72] Li-Ping Li, Gong-Li Li, Qi-En Cai, Anthony Lin Zhang, Sing Kai Lo. (2008). Improper motorcycle helmet use in provincial areas of a developing country, *Accident Analysis & Prevention*, 40(6), 1937-1942

[73] Jiwattanakulpaisarn, P., Kanitpong, K., Ponboon, S., Boontob, N., Aniwattakulchai, P., & Samranjit, S. (2013). Does law enforcement awareness affect motorcycle helmet use? Evidence from urban cities in Thailand. Global health promotion, 20(3), 14-24

[74] Kumphong, J., Satiennam, T., & Satiennam, W. (2018). The determinants of motorcyclists helmet use: Urban arterial road in Khon Kaen City, Thailand. *Journal of safety research*, *67*, 93-97

[75] Adeoye, P. O., Kadri, D. M., Bello, J. O., Ofoegbu, C. K., Abdur-Rahman, L. O., Adekanye, A. O., & Solagberu, B. A. (2014). Host, vehicular and environmental factors responsible for road traffic crashes in a Nigerian city: identifiable issues for road traffic injury control. *The Pan African medical journal*, *19*, 159

passengers of four-wheeled vehicles and a law against passengers travelling on the back of trucks. The point here is that comprehensive road safety legislation must exist for it to be enforceable and therefore enforced.

Vecino-Ortiz et al (2014)[76] describe the prevalence of seatbelt use and associated factors in drivers and front-seat passengers across eight sites in Egypt, Mexico, Russia and Turkey. They report variance of seatbelt use among drivers and front-seat passengers is explained by both country-level and site-level difference, which may be caused by differences in levels of enforcement. They suggest that legislation alone is not sufficient and that by focusing on enforcement, it may be possible to increase seatbelt use.

Likewise, Clay, Hunter and Peden (2019)[77] observe child restraint use for children travelling in a motor vehicle in South Africa, which has been mandatory since April 2015, and report very low levels of children travelling with any restraint at all. They conclude that national legislation alone is not shown to be effective, and that effective supplementary enforcement is necessary.

And lastly in the context of seatbelts, Jin et al (2020)[78] report on a study of mandatory child restraint law in two major cities in China, and concluded that although most parents with private cars in Shanghai and Shenzhen supported the national legislation of child restraint (arguably supporting evidence for national legislation), most still have a poor awareness of legislation, so the work of law publicity still needs to be strengthened.

4.8.4. Driving under the influence

World Bank (2019)[10] states that "Around three quarters of LMICs have blood alcohol content (BAC)-based drink driving laws and similar numbers have random breath testing in some form". Vecino-Ortiz et al (2018)[79] consider enforcement of drink-driving law to be one of the most effective interventions for reducing the number of lives lost due to unintentional injury. This is reinforced by Miller et al (2018)[80] who estimate drink-driving laws will account for 84% of 109,000 lives saved by traffic safety laws passed in six developing countries while participating in the Bloomberg Road Safety Program (BRSP).

It should be noted though that Watling et al (2009)[81] and Armstrong et al (2018)[82] suggest that notions of Classical Deterrence Theory indicate that perceived consequences of engaging in illegal behaviour dissuade such behaviour may not apply. Likewise, Stephens et al (2017) [83]suggest that

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[76] Vecino-Ortiz, A.I., Jafri, A., & Hyder, A. A. (2018). Effective interventions for unintentional injuries: a systematic review and mortality impact assessment among the poorest billion. *The Lancet Global Health*, 6(5), e523-e534

[77] Clay, C., Van As, A. S., Hunter, K., & Peden, M. (2019). Latest results show urgent need to address child restraint use. South African Medical Journal, 109(2), 66-66.

[78] Jin Y, Deng X, Ye P, Peng J, Peng J, Lei L, Yu Y, Duan L. (2020). The Awareness and Attitude of Parents towards the Legislation of Child Restraint in Two Cities of China. *International Journal of Environmental Research and Public Health, 17*(7), 2405

[79] Vecino-Ortiz, A.I., Jafri, A., & Hyder, A. A. (2018). Effective interventions for unintentional injuries: a systematic review and mortality impact assessment among the poorest billion. The Lancet Global Health, 6(5), e523-e534

[80] Miller, T. R., Levy, D. T., & Swedler, D. I. (2018). Lives saved by laws and regulations that resulted from the Bloomberg road safety program. *Accident Analysis & Prevention*, *113*, 131-136

[81] Watling, C., & Leal, N. (2012). Exploring perceived legitimacy of traffic law enforcement. In Senserrick, T (Ed.) Proceedings of the 2012 Australasian College of Road Safety National Conference. Australasian College of Road Safety, Australia, pp. 1-13.

[82] Armstrong, K. A., Watling, C. N., & Davey, J. D. (2018). Deterrence of drug driving: The impact of the ACT drug driving legislation and detection techniques. Transportation research part F: traffic psychology and behaviour, 54, 138-147.

[83] Stephens, A. N., Bishop, C. A., Liu, S., & Fitzharris, M. (2017). Alcohol consumption patterns and attitudes toward drink-drive behaviours and road safety enforcement strategies. Accident Analysis & Prevention, 98, 241-251.

drink-driving is the expression of a broader health issue and should be considered when targeting drink-driving reductions.

4.8.5. Distraction by mobile phone

In the context of distraction by mobile phone, Vera-López et al (2013)[84] report on a study of the prevalence of talking and texting on mobile phones while driving in three cities in Mexico in the wake of recently introduced legislation. A key finding is that is no systematically collected information on the actual prevalence of this behaviour exists, and that there is scant information available regarding the enforcement of this legislation.

Donkor et al (2018)[85] observe that Ghana passed a law in 2012 banning the use of mobile phones while driving, although most commercial drivers (at the Kumasi Kejetia lorry station) know about the law banning phone use while driving, compliance rate remains low. Mirroring other literature that management programs need to be multi-faceted and that perception of detection is a deterrent, they conclude that opportunities exist to improve education about laws prohibiting distracted driving for all drivers, but that that education needs to be accompanied by enforcement efforts, as most drivers believe they are “safe” from crash, but feel at risk of a citation.

4.8.6. Professional drivers

Finally, for professional drivers Asefa et al (2015)[86] report that taxi drivers in Mekelle habitually place themselves at increased risk of road traffic crashes by violating traffic laws, especially related to speeding, distraction by mobile phone, drink-driving and vehicle maintenance. Given that 50% of study participants reported having received a punishment as a result of violating traffic laws, the authors recommend alternative forms of punishment could be considered (although none is specified) as well as increased policing and enforcement. Critically, the authors argue that the system must be supported by continual monitoring and investment of sufficient financial and human resources.

4.8.7. Summary

It goes without saying that legislation must exist for it to be enforced, while enforcement cannot take place unless there is legislation to be enforced. Common themes throughout the literature however are that legislation must be comprehensive and tight (i.e., does not contain loopholes), and that the community must be aware of the legislation and the perceived threat of enforcement with realistic and appropriate punishment for it to be effective. The point here is that legislation and enforcement are necessarily part of a program of treatments that typically must include training of police and public awareness. That said, driving under the influence, which may be indicative of a broader health issue, may require a different approach.

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[84] Vera-López, J. D., Pérez-Núñez, R., Híjar, M., Hidalgo-Solórzano, E., Lunnen, J. C., Chandran, A., & Hyder, A. A. (2013). Distracted driving: mobile phone use while driving in three Mexican cities. Injury prevention, 19(4), 276-279.

[85] Donkor, I., Gyedu, A., Edusei, A. K., Ebel, B. E., & Donkor, P. (2018). Mobile phone use among commercial drivers in Ghana: An important threat to road safety. Ghana medical journal, 52(3), 122-126.

[86] Asefa, N. G., Ingale, L., Shumey, A., & Yang, H. (2015). Prevalence and factors associated with road traffic crash among taxi drivers in Mekelle town, northern Ethiopia, 2014: a cross sectional study. *PLoS one, 10*(3), e0118675

4.8.8. Focus areas for LMICs

Taken together the following areas do deserve priority:

- LMICs must consider developing and implementing legislation and enforcement strategies to tackle speed, helmet use, seat belt use, drink driving, mobile phone use and regulation of professional drivers.
- LMICs to develop legislation strategies that are both enforceable and enforced to have effect.
- LMICs to adopt strategies that can be easily communicated to and that are accepted by the community.
- LMICs need to be open to considering strategies that are tried and tested in other jurisdictions. This might include adoption of novel technologies such as alcohol interlocks, seat-belt warning systems and speed limitation technology.

4.9. SPEED

Ahmed Ksentini, consultant, University of Sfax.

As a major factor in the safe system approach, speed is still considered as the core of the most important risk factors of crashes. Many studies have shown the wide impact of speed variation on the crash number of fatal and serious injuries (FSI). It has been observed that an increase of 15% over the mean speed (which is likely to be almost higher than limits in LMICs) induces an 88% increase in road accident fatalities. Conversely, a reduction of 15% in the mean speed, reduces this number by 52%. More statistical trends are given in the following figure (adapted from ELVIK et al. 2004)[87].

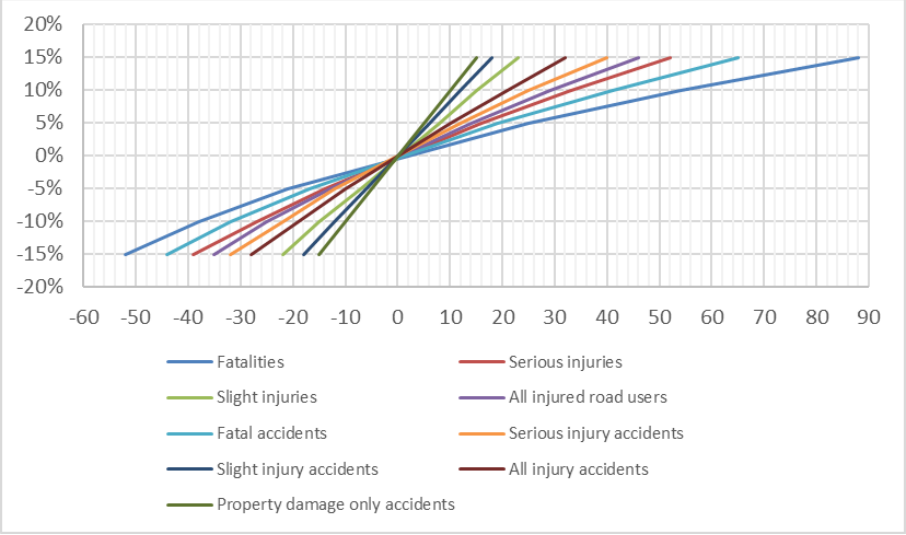

Figure: Change in Accidents Rates Resulting From a Change of +/- 15% in Speed

In accordance, speed management and control are the most important issues with regards to its high cost-benefit ratio in LMICs. Many speed limiting approach, methods and countermeasures were therefore applied and tested in both HICs and LMICs. For example, it was shown in Thailand

[87] Elvik, Rune; Christensen, Peter; Helene Amundsen, Astrid (2004) Speed and road accidents : an evaluation of the power model

that speed reduction of 10 km/hr results in preventing one in three fatal and serious injuries on two investigated roads in Bangkok (World Bank, 2019)[88]. Bhalla et al (2020) [89]analysed the potential benefits of a series of countermeasures for six countries that span all developing regions: China, Colombia, Ethiopia, India, Iran, and Russia. Highest positive effects were found for speed control with a reduction of 27% in fatalities.

To reduce operating speed, a good balance between road design, speed limit, and public perception of appropriate speed is vital . Relevant and sound lessons found by PIARC in speed management approaches for LMICs were learned, by its former working group, from China. Some countermeasures which were addressed are :

- adding vibration deceleration marking at curved roads,
- using stone pavement section at village entrance,
- narrowing lanes by turning the centerline to color wide solid line and
- setting up snapshot systems.

In the PIARC manual[4] , It is also concluded that enforcement of speed management is a serious dilemma between users' behavior and road authority. It is recommended then to follow the road assessment program method by "implementing the new speed limit strategy and corresponding road safety improvement measures".

Credible speed limits implementation vary according to the local conditions, driving habits, traffic rules, regulations and/or signing and marking standards[90]. One standard solution to reduce operational speed is not available. It is rather recommended to adopt a hierarchy of control as the following:

	A. Reducing operating speed	B. Increasing road safe speed
Countermeasures	**A1.** Improving Signs Readability and Understanding **A2.** Road and Road Environment Improvement and (Slight) Modification **A3.** Enforcement	**B1.** Improving Road Physical Characteristics **B2.** Road and Road Environment (Heavy) Modification

In the context of reducing operating speed, speed limits signs must be credible (used in the right place, reflect road characteristics and environment, not used massively), homogeneous over the road network to maintain driver's awareness, visible by day and by night, maintained over time and consistent with horizontal markings and delineation.

Low-cost countermeasures called slight road improvement engineering can also help achieving effective speed reduction. Systems such as speed humps, lane narrowing, chicanes, new pedestrian

[88] World Bank (2019) Speed variation analysis – A case study for Thailand's roads,
[89] Bhalla, K, Mohan, D and O'Neill, B, (2020), How much would low- and middle-income countries benefit from addressing the key risk factors of road traffic injuries? International Journal of Injury Control and Safety Promotion, Volume 27, 2020 - Issue 1: Special Issue: Evidence for Global Road Safety.
[90] PIARC (2019) Setting credible speed limits – case studies report

crossing solutions, optimized cross section sharing with respect to flow-speed curves analysis and varying wearing course material are essential techniques in urban areas in LMICs.

The Stockholm Declaration(2021)[12] asks for traffic calming in environments where motorized traffic meets vulnerable road users and calls for a "Focus on speed management, including the strengthening of law enforcement to prevent speeding and mandate a maximum road travel speed limit of 30 km/h in areas where vulnerable road users and vehicles mix in a frequent and planned manner, except where strong evidence exists that higher speeds are safe, noting that efforts to reduce speed will have a beneficial impact on air quality and climate change as well as being vital to reduce road traffic deaths and injuries".

Carsten and Tate (2005[91]) and more recently Hyden (2019)[92] illustrated the potential benefits of Intelligent Speed Adaptation (ISA). The predicted effect is a reduction of up to 50% of fatalities and a benefit to cost ratio of 3.5 to 4.8. They argue that it is time for authorities to see to it that lower speeds with the help of efficient vehicle-based solutions becomes part of the agenda. Meanwhile ISA is one of the vehicle safety technologies included in the EU's new General Safety Regulation for motor vehicles and will become mandatory for all new vehicles types as of 2022 and all new vehicles as of 2024.

Even if these issues are adopted, it is not excluded that some users will still violate intentionally speed limits. This kind of drivers must be controlled by police services and credible punishments that lead to compliance with the local laws must be applied. Enforcement strategies like section control has proven very successful in many countries (De Ceunynck, 2017)[93] and might be beneficial in LMICs as well. Drivers must also be risk informed about speed problems and speeding and they must be educated about the positive impact of speed management and countermeasures.

As for considering higher speeds on certain roads local road authorities should focus on improving physical characteristics, road and road environment modification such as recommended in the resolution of the UN second decade of action for road safety. This includes reactive (blackspot treatment) and proactive (by identifying dangerous configurations and making safer roads) approaches.

4.9.1. Focus areas for LMICs

The following Speed related aspects do deserve priority:

- Adopt the 20mph/30kmh speed limit regime in areas with a mix of motorized and VRU traffic
- Explore new enforcement strategies like section control,
- Explore the potential benefits of speed control systems like ISA in cars, motorcycles and motor-tricycle

[91] Carsten, O.M.J. and Tate, F.N. (2005) Intelligent speed adaptation: accident savings and cost–benefit analysis. Accident Analysis and Prevention, 37 (3). pp. 407-416. 2005, ISSN 0001-4575

[92] Hyden, C. (2020). Speed in a high speed society. International Journal of Injury Control and Safety Promotion, Volume 27, no. 1 p. 44 -50.

[93] De Ceunynck, T. (2017), Installation of section control & speed cameras, European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu

4.10. SUSTAINABLE SAFE ROADS

Leszek Kania, GGDKia, John Barrell, Road safety consultant, Hans Godthelp, Road safety for all

Road design is generally considered as one of the fundamental building blocks of the safe system[94] approach – a system that places at its centre the vulnerability of the human body. Therefore, roads need to be:

- self-explaining , i.e. clearly guide traffic and road users in their behaviour in order to prevent crashes[95], and
- forgiving, i.e. mitigate the injury consequence of crashes that still occur.

Chapter 4 of World Bank's Guide for Road Safety Opportunities and Challenges [12], gives a clear indication about the millions of fatalities and injuries that can be saved worldwide through proper investment in safer road infrastructure with a cost benefit ratio estimated as 1 to 8.

Speed of a collision is the overriding factor in the severity of injury sustained in crashes. Control of impact speed especially where vulnerable road users (VRUs) are involved is vita[96]. Countries are recommended to use road design guidelines, describing the characteristics of the road network in line with these principles[97]. On behalf of this, the road networks should be clearly arranged through a set of road categories.

A common approach in road network design is the structuring of roads depending on the function of the road. This sometimes conflicts with the adjacent land use characteristics and functionality must be related to the road context[98].

One way or another the road network has to be divided to a hierarchy of uses. This may vary from high speed through roads on which vulnerable road users are separated from trucks and cars, to low-speed urban access roads where different road user groups share space[99].

Examples of guidelines from many HIC are available for on line:

UK Design Manual for Roads and Bridges https://www.standardsforhighways.co.uk/dmrb/)

(Austroads Guide to Road Design (https://austroads.com.au/safety-and-design/road-design/guide-to-road-design)

US Federal Highways Administration (https://www.fhwa.dot.gov/programadmin/standards.cfm).

[94] Harris, P.C. (2015) Application of safe system (safe roads) to existing highways in developing countries, Roadside Safety Design and Devices: International Workshop 2015, Location: Melbourne , Australia, Date: 2015-3-26 to 2015-3-26

[95] iRAP (2018) Roads that cars can read, iRAP

[96] Horst, A. Richard A. van der, Martijn C. Thierry, Jasper M. Vet, A.K.M. Fazlur Rahma (2016) An evaluation of speed management measures in Bangladesh based upon alternative accident recording, speed measurements, and DOCTOR traffic conflict observations. Transportation Research Part F (2016),

[97] B. Turner and G. Smith (2013) Safe System infrastructure: implementation issues in low and middle income countries ARRB Group Ltd, Research Report ARR, August 2013

[98] UNRSC (2020) The Ten Step Plan for Safer Road Infrastructure, Produced by the Project Group "Safer Roads and Mobility" of the United Nations Road Safety Collaboration group (UNRSC)*, Geneva, February 2020

[99] NACTO, (2019) Designing streets for kids

Although LMICs may use the same principles, design guidelines but traffic regulations may differ depending on cultural differences. In any case, infrastructure related road safety measures should concentrate on reducing potentially dangerous encounters and manoeuvres [100], [101].

Safety of vulnerable road users (VRUs) is a major problem in many countries[102] [103].

For example:

- In rural areas separation of unprotected road users from motor vehicles by provision of separate paths, cycle lanes and pavements are a basic measure to improve safety of VRUs.
- Vehicle speeds need to be reduced to a level that allows safe traffic encounters wherever VRUs are present. In order to reach this goal more and more, villages and cities adopt the 30kmh speed limit.
- At pedestrian crossings the key factors are vehicle speed and visibility of the crossing, including proper lighting during night-time.
- Pedestrian crossings on dual carriageway and high-speed roads without traffic lights should be avoided.
- For motor vehicles the most dangerous manoeuvre is overtaking, which may result in head-on collisions, especially on rural roads. To avoid this, the best solution is to provide a dual carriageway road. A less expensive solution is to use a 2+1 road. In several countries stretches of roads with wide hard shoulders (2.0-2.5 m wide) were reconstructed to 2+1 roads.
- On stretches of main roads the number of entrances to carriageway should be reduced to minimum.
- On linear roads through villages and urban areas speed should be regulated through proper gateways, raised intersections and speed humps.
- In the rural areas roads can be made forgiving through provision of ‘clear zones’ that allow loss of control vehicles to recover and re-join the carriageway. Alternatively, prevent serious run -off road injuries using guardrails and crash cushions, minimise injury through breakable posts, etc.

At intersections the most dangerous types of collisions are side collisions and collisions with left turning vehicles. The best solutions to improve safety at intersections are:

- roundabouts,
- innovative intersection designs, with or without traffic lights, minimizing the number and severity of conflicts
- traditional designs that provide separate lanes for left turning vehicles and their own protected signal phasing.

To guarantee the proper functioning of national system of road design guidelines and traffic rules, countries are encouraged to use a robust inspection and audit protocol throughout the design and operational life of a road. Planning and design of new roads should include systematic safety audits

[100] PIARC catalogue of design safety problems and potential countermeasures (2009)
[101] PIARC Road safety manual (2019)
[102] Hoque, Mazharul, , Mohammad Ashifur Rahman, Greg Smith (2014) Assessment and treatment of high risk roads in Bangladesh, 26'h ARRB Conference - Research driving efficiency, Sydney, New South Wales 2014
[103] NACTO, (2019) Designing streets for kids

before final implementation [104]. The maintenance schedule of existing roads should be accompanied with a scheme of regular inspections. These proactive protocols can identify safety issues before they cost lives. Examples of protocols are available through AfDB Road Safety Manuals for Africa (2014)[105]

4.10.1. Focus areas for LMICs

The following road design related issues do deserve priority:

- Developing road design guidelines and regulation, based on local safety culture, including a clear road categorization scheme.
- Developing a robust audit and inspection protocol.
- Making roads in cities and villages safe for pedestrians/bicyclists/vulnerable road users, i.e. based on 30km protocol.

4.11. SAFE VEHICLES

Hans Godthelp, Road safety for all

During the history of the automobile major efforts have been made to improve the safety of its occupants and other traffic participants. Particularly after the 1970ties programs of crash testing resulted in strong improvements. In 2009 the Insurance Institute for Highway Safety showed a crash test of a 2009 Chevrolet Malibu and compared that with a 1959 Chevrolet Bel Air sedan. It clearly demonstrated the effectiveness of modern car safety design over 1950s design, particularly regarding rigid passenger safety cells and crumple zones. Presently a rich set of passive and active safety systems exist. And not only for cars, but also for motorcycles, buses, etc. Passive safety systems intend to limit the damage caused to driver and passengers in the event of a crash. Airbags, seatbelts, helmets, whiplash protection system etc. are common passive safety systems deployed in vehicles these days. Active safety systems play a preventive role in mitigating crashes by providing advance warning or by providing the driver with additional assistance in steering/controlling the vehicle. Anti-lock braking systems and electronic stability control are examples that are frequently used in today's modern vehicles and or motor cycles.

Unfortunately in many LMICs vehicle safety is not effectively regulated through design standards or maintained through mandatory vehicle inspection schemes. Recent studies show that a well-chosen combination of passive safety measures and new techniques like electronic stability control may give a strong benefit in LMICs road safety. Bhalla and Gleason [106](2020) analyzed the potential life-saving effects of nine proven vehicle technologies for the Latin American (LAC) region. Their results show that electronic stability control, the more frequent use of seatbelts and child restraints and better side/front impact systems would be very beneficial.

Calculations indicated that improving these vehicle design features might result in 28·1% fewer deaths. The authors also argue that – contrary to popular belief – the vehicle fleet in LMICs – at least in the LAC area - tends to be young. They estimate that, almost three-quarters of vehicles in

[104] Road Safety Audits Practical Guide for Road Safety Auditors (http://irscroadsafety.org/wp-content/uploads/2016/07/04-RSA-Practical-Guide-EN-2016.pdf

[105] African Development Bank Group (2014) Road safety manuals for Africa. Existing/new roads: proactive.reactive approaches, Transport and ICT Department, July 2014

[106] Bhalla, Kavi and Gleason, Kevin, (2020) Effects of vehicle safety design on road traffic deaths, injuries, and public health burden in the Latin American region: a modelling study. Lancet Global Health, Volume 8., p. 19 – 28.

use in the Latin American region are less than 10 years old. They suggest that if vehicle safety technologies had been introduced in all new cars at the start of the UN Decade of Action for Road Safety (2011–20), by now there would be approximately 21% fewer traffic deaths in the LAC region, leaving this region much closer to SDG of halving traffic deaths by 2020.

Recent reports[107] [108] [109] also indicate that the situation in Africa deviates from LAC: many African countries suffer from high numbers of polluting and unsafe vehicles imported from HICs particularly from Europe. This implies that as compared to LAC even larger safety gains can be reached by African countries by:

- setting quality standards of both new and used cars and
- regulating minimum age of imported vehicles.

In Asia the composition of the vehicle fleet differs strongly. In many countries motorcycles strongly dominate the traffic scene.

A series of New Car Assessment Programs initiated by Global NCAP (2020)[110] strongly promotes higher penetration levels of vehicle safety technology, particularly also in LMICs. Initiatives like Safer cars for Africa and Safer Cars for India do give a boost to this strategy. This gradually leads to a higher level of vehicle safety in LMICs. Although most LMICs (70 percent) do have regulations on the import of used vehicles, only a very few have periodic vehicle inspections or are fully compliant with United Nations vehicle safety regulations. Furthermore, the range of age restrictions is very large, varying from 3 years (Mauritius) to 15 years (Nigeria)[111].

A report of the Dutch Ministry of Infrastructure and Water[112] analyzing the export of used cars to Africa concludes that many of these export vehicles are a cause for pollutant and climate emissions and less road safety in the recipient countries. It is expected that within a few years 80% of the used cars exported to Africa will no longer be acceptable due to stricter environmental regulations of the recipient countries in West Africa as connected in the ECOWAS, Economic Commission of West African States.

Despite the enormous safety effects of these passive and active systems the question still rises how vehicle technology may further benefit to safety developments, both in HIC and LMICs. It is argued frequently that the self-driving vehicle will answer this question. However more and more authors make clear that this will not be the case, i.e. at least not until 2050. Furas (2019)[113] gave a strong (pre-pandemic) statement about the potential of automation for the coming decades: Waiting for driverless cars is like hoping for a perfect vaccine to eliminate a road death epidemic that we can already control with known treatments.

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[107] Automobile Association of South Africa, (2020) Promoting Safer and Cleaner Used Vehicles for Africa. Federation Internationale de l'Automobile Region I, Brussels, Belgium

[108] United Nations Environment Programme (2020) Used vehicles and the Environment. A global overview of used light duty vehicles: flow scale and regulation. Economy Division United Nations Environment Programme P.O. Box 30552 Nairobi, 00100, Kenya

[109] Baskin, A. (2018), Overview of the UN environment used vehicle report. United Nations Environment

[110] Global NCAP (2020) http://www.globalncap.org/ncaps/

[111] Worldbank Global Road Safety Facility (2020) Guide for road safety opportunities and Challenges: low and middle income country profiles. Worldbank, Washington, United States of America.

[112] Ministry of Infrastructure and Water, Netherlands Human Environment and Transport Inspectorate, 2020. Used vehicles exported to Africa. A study on the quality of used export vehicles. October 2020

[113] Furas, A (2019) . Vehicle safety and UN reguations. Presentation given during the Delft Road Safety Course , Delft, September 2019

To avoid a tragedy we need accelerated fitment of life saving technologies that are already available, effective, and affordable…used in road environments that are more forgiving, self-explaining and self-enforcing. In short, the Safe System approach! In a similar sense Ward (2021)[114] argues that in order to build consumer trust in vehicle safety in the digital age we must stop absurd hype that AVs can prevent 90% of crashes.

In the same line of thinking Godthelp (2019)[115] pleads for further refining the safe system approach in that it should conceptually integrate the sustainable road concept with that of sustainable safe vehicles. A road network with a functional hierarchy of roads, roundabouts, speed humps, that give guidance to safe driver behavior in terms of route choice, speed, and interactions with vulnerable road users. A similar way of thinking may be developed for advanced driver assistance systems. Such systems may give guidance to drivers in choosing safe routes, force the use seat belts, control speeds through intelligent speed adaptation and cognitively prepare drivers for crossing and oncoming traffic.

Carsten and Tate [116] (2005) and more recently Hyden[117] (2019) give illustrations about the large potential benefits of Intelligent Speed Adaptation, indicating the strong safety benefits of speed regulating systems. ISA is one of the vehicle safety technologies included in the EU's new General Safety Regulation for motor vehicles and will become mandatory for all new vehicle types as of 2022 and all new vehicles as of 2024. In terms of vehicle automation level 2 and 3 technologies such as ISA are available through existing, cheap technology. They may not only be applied in new vehicles but also be retrofitted in vehicles, and not only in HIC, but also in LMICs. Buses, trucks, cars and motorcycles may use such an active safety system to guide them on safe roads, limit speed to local circumstances (schools, residential areas), regulate seat belt use, and controls signals and warnings dependent on road categories and intersection types.

4.11.1. Focus areas for LMICs

The following vehicle safety aspects do deserve priority:

- Adapt and enforce regulations regarding vehicle safety of new and importedvehicles.
- HICs to regulated the quality of used vehicles exported to LMICs
- Automobile companies and tier suppliers to explore options to implement new technologies like ISA in new and used vehicles to give a boost to road safety in LMICs.

4.12. POST CRASH HEALTH CARE

Gael Italiano, Transport Canada

As indicated in chapter I strong efforts were made in the last decade to reduce motor vehicle collisions. Although these efforts did produce some positives results, little progress was reported in LMICs The reality is, despite advancements in technologies, legislation, infrastructure, etc., motor vehicle crashes are still going to occur, and disproportionally more so in LMICs for a variety of

[114] Ward, D. (2021) Presentation at the Future Networked Car symposium, Moving toward automated driving. March, 2021.
[115] Godthelp, J (2019). Traffic safety in emerging countries: making roads self-explaining through intelligent support systems. Proceedings XXVIth World Road Congress, Abu Dhabi, United Arab Emirates, October 2019
[116] Carsten, O.M.J. and Tate, F.N. (2005) Intelligent speed adaptation: accident savings and cost–benefit analysis. Accident Analysis and Prevention, 37 (3). pp. 407-416. 2005, ISSN 0001-4575
[117] Hyden, C. (2020). Speed in a high speed society. International Journal of Injury Control and Safety Promotion, Volume 27, no. 1 p. 44 -50

reasons. In order to reduce the extensive costs to societies, the goal continues to focus on reducing such crashes. However, when they do occur, access to universal health care would ameliorate the situation by reducing the financial and economic burden including the potential financial hardship on the individual and/or their families. A component of universal health care includes post-crash care. Time sensitive in nature, it can make the difference between life and death by playing a role in minimizing the overall effects of road collisions.

"The aim of post-crash care is to avoid preventable death and disability, limit the severity of injury and the suffering caused by it, and ensure the crash survivor's best possible recovery and reintegration into society." [118]

Although the primary objective is to prevent and reduce the occurrence of road traffic collisions, delays in detecting and providing care for those involved in a road traffic crash increase the likelihood of the severity of the injuries and possibly death. Improving post-crash care for victims of road crashes is just one effective intervention amongst a number of others, identified through research and data. Post-crash response involves timely emergency rescue, improving the quality of pre-hospital medical care, and ensuring hospital personnel have appropriate training.

https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries

https://www.sciencedirect.com/science/article/pii/S0386111217300055#bb0070

Studies conducted in the United States provide evidence that the presence of a state trauma system is associated with a reduction in the risk of death attributed to motor vehicle crashes by approximately 9% as compared to States which did not possess such systems. Although creating a trauma system is expensive, such costs pales in comparison to the economic and societal costs attributed to fatalities and serious injuries resulting from motor vehicle crashes.

https://journals.lww.com/jtrauma/Fulltext/2000/01000/Cerebral_Fat_Embolism_Studied_by_Magnetic.5.aspx

Post-crash response can be described as the chain of care provided after a road crash, with the aim of reducing the severity of the injury consequences sustained by the road users involved, including avoiding death, Nemeckova, M. (2018) [119]. Worldbank (2019) [19] gives the key components of post-crash care, categorized into three phases:

- pre-hospital care (at the scene of the crash);
- hospital care (at the treatment facility); and
- follow up (after initial treatment).

Improvement of trauma systems in developing countries is a critical step in the reduction of the burden of road crash fatalities and injuries. It is estimated that more than a million lives, approximately 30 percent of all injury deaths, could be saved in developing countries through

[118] Mock, C. N., Jurkovich, G. J., Arreola-Risa, C., & Maier, R. V. (1998). Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. Journal of Trauma and Acute Care Surgery, 44(5), 804-814.
[119] Nemeckova, M. (2018). An overview of post-collision response and emergency care in the EU. European TransportSafety Council.

improvements in trauma care (Mock et al, 2012)[120] WHO[121] (2016) and Worldbank [117](2019) give the following analysis of this field:

4.12.1. Pre-hospital Trauma Care

The morbidity outcome of road crash serious injuries in developing countries is high. A large proportion of the fatalities occur in the pre-hospital setting, which may be as high as 50 percent of casualties. Early effective treatment can not only increase survival but also reduce the extent of disability suffered by survivors. In Spain, a 10-minute reduction in response time may lead to a reduction in deaths by one-third, Sánchez-Mangas, R., et al. (2010)[122]. Adequate training in prehospital care, scene management, rescue, stabilization, and transport are essential to achieve an improved prehospital trauma care system. Given that many developing countries lack a formal Emergency Medical Service system, short term improvements can be made to the prehospital trauma care system by building on existing, although informal, patterns of crash response and prehospital transport Mock et al,[123] (2002). This can be in the form of providing specific courses on first aid and road crash response to laypersons and the community at large. These short-term improvement measures should be done in parallel with the development of a structured and adequately resourced emergency medical service.[124]

4.12.2. Trauma Centers in Developing Countries

Trauma represents a major health problem with the majority of these deaths occurring in LMICs where the survival rates are lower than in high income countries (HIC)[125]. This lower survival rate for injured patients is attributed to the quality of the health care available in LMICs compared to survival rates in HICs where the quality of health care services is significantly higher. Understanding the barriers and delays when seeking, reaching and receiving care in a timely fashion is key. The main challenges facing trauma centers in developing countries are listed below[126 127 128 129 130]:

- Lack of infrastructure within healthcare facilities
- Lack of vital medical equipment
- Lack of medical staff with trauma training

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[120] Mock, C., Joshipura, M., Arreola-Risa, C., & Quansah, R. (2012). An estimate of the number of lives that could be saved through improvements in trauma care globally. World journal of surgery, 36(5), 959-963.

[121] World Health Organization. (2016). Post-crash response: supporting those affected by road traffic crashes (No. WHO/NMH/NVI/16.9). World Health Organization. Regional Office for South-East Asia.

[122] Sánchez-Mangas, R., et al. (2010). The probability of death in road traffic accidents. How important is a quick medical response? Accident Analysis & Prevention. doi:10.1016/j.aap.2009.12.012

[123] Mock, C. N., Tiska, M., Adu-Ampofo, M., & Boakye, G. (2002). Improvements in prehospital trauma care in an African country with no formal emergency medical services. Journal of Trauma and Acute Care Surgery, 53(1), 90-97.

[124] Reynolds, T. A., Stewart, B., Drewett, I., Salerno, S., Sawe, H. R., Toroyan, T., & Mock, C. (2017). The impact of trauma care systems in lowand middle-income countries. Annual review of public health, 38, 507-532.

[125] John Whitaker et al, Assessing Trauma Care Health Systems in Low- and Middle-Income Countries, a protocol for a systematic literature review and narrative synthesis: (published online 2019 Jul 2 doi: 10.1186/s13643-019-1075-8)

[126] London, J. A., Mock, C. N., Quansah, R. E., Abantanga, F. A., & Jurkovich, G. J. (2001). Priorities for improving hospital-based trauma care in an African city. Journal of Trauma and Acute Care Surgery, 51(4), 747-753.

[127] Quansah, R. (2001). Availability of emergency medical services along major highways. Ghana Medical Journal, 35(1), 8-10

[128] Mock, C., Arreola-Risa, C., & Quansah, R. (2003). Strengthening care for injured persons in less developed countries: a case study of Ghana and Mexico. Injury control and safety promotion, 10(1-2), 45-51.

[129] Joshipura, M. K., Shah, H. S., Patel, P. R., Divatia, P. A., & Desai, P. M. (2003). Trauma care systems in India. Injury, 34(9), 686-692.

[130] Hofman, K., Primack, A., Keusch, G., & Hrynkow, S. (2005). Addressing the growing burden of trauma and injury in low-and middle-income countries. American journal of public health, 95(1), 13-17. 209 Trunkey, D. D. (1990). Trauma: A public health problem. En: Moore EE. Early care of the injured patient. 4th ed BC Decker Inc.

- Lack of research on the nature of trauma in developing countries
- Lack of adequate funding for the development of fully functional trauma centers

Quality-improvement programs have been effective, and have been offered at a low cost Reynolds et al, 2017)121. They give a form of standardized trauma protocols which have been very successful in improving trauma care in developed countries. This can include both enhanced training and encouraging retention for those already skilled in trauma care.

4.12.3. Focus areas for LMICs

Taken together the following post-crash care aspects do deserve priority:

- LMICs to improve pre-hospital trauma care
- LMICs to improve quality of trauma centers
- LMICs to improve the training of first responders

5. DISCUSSION AND CONCLUSIONS

This report presents an overview of issues that are particularly relevant for road safety improvements in LMICs. Some issues may be relevant for LMICs because of their universal and generic value. Some may be effective on a short notice, others on a long term. Issues may also be relevant for LMICs because of the road traffic characteristics and safety culture that are typical for LMIC environments Based on an analysis of LMICs road safety problems the state of the art paragraphs in the former chapter resulted in focus areas that are considered as most relevant for future developments. These focus areas are summarised below for conveniences.

5.1. STRATEGICAL

I. Focus areas for LMICs Strategic Development Goals

- LMICs to integrate road safety strategy as an integrated component of their sustainable development goals
- LMICs to stimulate a multi-sectorial approach with all relevant stakeholders involved.

II. Focus areas for LMICs Safety culture

- LMICs to develop a strategy with traffic rules and design guidelines that are based on knowledge about local behavioral characteristics
- LMICs to develop strong organizations that represent the local community and serve as the eyes and ears regarding traffic problems and solutions.
- LMICs transport companies to develop and/or uses effective incentive systems with the focus on safe driving.

III. Focus areas for LMICs Road safety management

- LMICs to develop a strong lead agency which has full-time expert staff, legally endowed powers, permanent funding, and political support
- LMICs to develop a robust road safety data system
- LMICs to develop a robust set of local guidelines and regulations
- LMICs to develop a center of road safety excellence (see 4.IV, Capacity building)

IV. Focus areas for LMICs. Capacity building

- LMICs to develop university road safety programs at bachelor and master level
- LMICs to build research capacity in centers of road safety excellence
- LMICs to connect to regional road safety observatories
- LMICs to connect to international network of universities and centers of excellence.
- PIARC to support this network process.

5.2. TACTICAL

V. Focus areas for LMICs. Transportation system

- LMICs to develop a public transport system, with road safety criteria included
- LMICs to promote a Transit Oriented Development with road safety criteria included

VI. Focus areas for LMICs. Rural and urban planning

- LMICs to adopt through a systems-oriented approach which puts road safety and public health policies in a broad context of improved transport and health
- LMICs to embrace the compact city approach of shorter distances, slower speeds, higher residential and population densities, and design that promotes walking, cycling, and public transit.
- LMICs to develop evidence-based transportation plans that undergo a participative process

VII. Focus areas for LMICs. Cost effectiveness

- LMICs to develop a road safety strategy based on a selection scheme of cost-effective measures
- LMICs to select low hanging fruit: defining a list of low cost proven countermeasures.

VIII. Focus areas for LMICs. Legislation and enforcement

- LMICs to adopt legislation and enforcement strategies on speed, helmet use, seat belt use, drink driving and mobile phone use
- LMIC to explore new technologies regarding enforcement strategies, i.e. speed limitations, driver alcohol detection, seat belt warning, etc

5.3. OPERATIONAL

IX. Focus areas for LMICs Speed

- LMICs to adopt the 20mph/30kmh speed limit regime in areas with a mix of motorized and VRU traffic
- LMIC to explore new enforcement strategies like section control,
- LMICs to explore the potential benefits of speed control systems like ISA in cars, motorcycles and motor-tricycle

X. Focus areas for LMICs Safe roads

- LMICs to develop road design guidelines and regulation, based on local safety culture, including a clear road categorization scheme.
- LMICs to develop a robust audit and inspection protocol.
- LMICs to make roads in cities and villages safe for pedestrians /bicyclists/vulnerable road users, i.e. based on 30km protocol.

XI. Focus areas for LMICs Safe vehicles

- LMICs to adapt and enforce regulations regarding vehicle safety of new and imported vehicles.
- HICs to regulated the quality of used vehicles exported to LMICs
- Automobile companies and tier suppliers to explore options to implement new technologies like ISA in new and used vehicles to give a boost to road safety in LMICs.

XII. Focus areas for LMICs Post crash health care

- LMICs to improve pre-hospital trauma care
- LMICs to improve quality of trauma centers
- LMICs to improve the training of first responders

Based on the results of this literature review the working group (WG) organized an international survey in order to collect one or more LMIC-related case studies for each of the issues. The collection of cases intends to present a broad and rich impression of local initiatives, which may be used to build on in the future for each of the issues. The collection of cases will be presented as a Deliverable II of the WG output (ref. 2)

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