Implications of Road Safety in National Productivity and Human Development in Asia

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Executive Summary

Fatalities and injuries due to road transport have an enormous impact on the well-being of people, economy and productivity. Therefore Road Safety is one of the core elements of a sustainable transport system as is reflected in the 2013 Bali Declaration, which introduced the "Vision Three Zeros - Zero Congestion, Zero Pollution, and **Zero Accidents**".

The latest WHO and IMHE-World Bank publications estimate that yearly around 1.3 million deaths due to road accidents occur worldwide. Almost 80 million are injured of which more than 9 million would need hospital admissions with often long-term disabilities as a consequence. If also indirect deaths caused by air pollution from motorized transport are included the total number of deaths exceeds 1.5 million corresponding to over 4000 lost lives per day.

The objectives of this paper are to:

- Review and summarize the most recent and relevant information on the global road safety problem and its impact on productivity. The focus is on the Asian EST region currently consisting of 24 countries including the two most populated areas in the world - China and India.
- Present accident and injury prevention strategies based on experience and effectiveness in developed countries and their potential for implementation in Asia.
- Discuss the way forward by summarizing the most relevant opportunities to prevent road fatalities and injuries in the Asian EST region and thus how road safety can contribute to achieve the **Bali Vision- Zero Accidents.**

The size of the road safety problem in the 24 Asian EST is evident from several numbers: the total number of estimated deaths in the region due to road accidents is 750,000 per year based on WHO and IMHE/World Bank estimates. The total number of injuries is more than 50 million (of which 12% are hospital admissions), corresponding to 2/3 of all injuries worldwide, while 56% of the world's population lives in the 24 Asian EST countries. The number of indirect deaths due to air pollution caused by motorized transport is almost 100,000 with a relatively large share from India. The death rate (fatalities per 100,000 population) is in many of the Asian EST countries more than twice as high as in Europe.

Vulnerable road users (pedestrians, cyclists and motor cyclists combined) are at particular risk. They constitute 60% of the deaths due to road accidents in Asian EST countries and in many of the low and middle income countries in this region this percentage is even higher. The total costs of injuries in the Asian EST countries, calculated as a loss to the economy, is estimated to 735 billion US$ or 3.3% of GDP. In 8 countries (Bangladesh Bhutan, India, Malaysia, Nepal, Pakistan, Thailand and Vietnam) it is even more than 4% of the GDP. In many of the Asian EST low and middle income countries the yearly number of fatalities and injuries is still further increasing while in several high income countries these numbers are decreasing.

One problem seen in many countries is the large underreporting in the official country statistics which are usually based on police data. The WHO and IMHE/World Bank estimates for the numbers of fatalities in the Asian EST region are more than twice the values from the official data from the respective countries. This large national underreporting stresses the need for reliable accident data. These are necessary to understand the causes of accidents, to determine evidence based intervention strategies and also for monitoring the success of these interventions. On the other hand lack of good accident data is not an excuse not to implement good practices based on experiences from other

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countries.

The first systematic approach concerning accident and injury prevention strategies was the so-called Haddon Matrix which is introduced in section 2.5. It identifies the three sequential phases of a crash: pre-event, event and post-event; as well as the three components: human (behaviour and tolerance), vehicle and infrastructure (environment). This approach has led since then to many successful safety improvements within all elements of the Matrix.

Newer safety system approaches like the "Vision Zero" pioneered in Sweden, with followers in several other regions, view the traffic system more holistically. This approach to road trauma, which is presented in 4.2, requires system designers to provide a transport system that supports the highest level of safety possible. Such a system recognises that humans will always make mistakes in traffic and it demands that the crash energy in an accident is low enough to prevent serious injuries. Formulating road safety strategies, setting targets and monitoring performance are also important elements of a safe system approach. Taking this as a basis the United Nations General Assembly resolution 64/255 of March 2010 declared 2011-2020 as the Decade of Action for road safety with a global goal of stabilizing and then reducing the forecasted level of global road fatalities by increasing road safety improvement activities conducted at national, regional and global levels.

In section 3.3 an overview of the status of road safety measures in the Asian EST countries is given based on WHO's 2013 status report. Focus is on the 5 risk factors identified in the Decade of Action plan: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints. In addition the status of implementation of national road safety strategies, vehicle safety regulations and consumer information on safe vehicles is addressed. It can be seen that a number of the low and middle-income countries lag far behind in implementation of adequate safety measures.

On the other hand there are also many good examples of successful road safety projects in the Asian EST countries. Examples of best practices are given in 3.4., including motorcycle helmets in Vietnam, partnership platforms, "Best Practice Guides" for key road safety areas and examples of Technology Transfer and International Research cooperation.

Experience with the implementation of road safety strategies in the developed world is illustrated in section 4.1 using Europe as the example. There in the period 2000-2010 a reduction of almost 40% in fatalities was achieved. This in particular was the result of the transfer of experiences from the best performing countries in Europe to less well-performing countries, introduction of new safety technologies supported by corresponding safety regulations, consumer testing in order to promote these technologies and increased enforcement of traffic laws like for maximum speed. These actions focused on the vehicle since measures concerning vehicle safety and related measures (speed, helmets etc.) can be implemented relatively fast and had shown to have a large impact.

The effectiveness and efficiency of different road safety measures is discussed in 4.2 for Europe in general terms. A methodological approach on this topic is presented in 4.3, which includes among others worldwide effectiveness values for the earlier mentioned 5 risk factors (speed, drunk-driving, helmets, seatbelts and child restraints).

An introduction to global safety regulation (UN regulations) for vehicles is given in 4.4. These regulations should be seen as a set of minimal performance requirements. They are applied in several countries, but the application in many of the Asian countries is still limited. Section 4.4 also discusses New Car Assessment programmes (NCAP's) where the protection offered by a vehicle or a

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component is rated by means of a star rating system and compared with the performance of other vehicles or safety systems. Test severity and/or requirements are often more demanding than for UN regulations. The prime objective of NCAPs is to stimulate consumers to buy the safest vehicles and safety equipment. Japan and South Korea have had this type of programs for quite some time. More recently they have also been introduced in China (C-NCAP) and Malaysia, Singapore and Philippines (Asean NCAP).

The road safety field is changing fast due to a number of trends and developments that may have global impact, and also will affect developing countries. One aspect, which is discussed in 4.5, is that we may see important shifts to public means of transport. Private car ownership may also play a different role for families in the future compared to today. But also the vehicles will change drastically where the trends to more sustainable lighter vehicles (in particular electric vehicles, including electric bikes) and towards automated driving with its intermediate levels of automation are the most obvious ones as is shown in 4.5.

Section 5 'The Way Forward' concludes this paper with recommendations on how the safety situation in the Asian EST countries can be improved and in particular within the developing countries. This is done by stressing a number of the most important recommendations from the 2011-2020 Decade of Action for Road Safety and by a number of recommendations directly following from the review in this paper. The recommendations are grouped within the 5 pillars of the Decade of Action: Road safety management, Safer roads and mobility, Safer vehicles, Safer road users and Post-crash response. The WHO recommendations include, among others, the following ones which have shown to be effective in many countries and which can be introduced on a relative short term:

- Implementation of UN vehicle safety regulations and new car assessment programmes (NCAPs).
- Implementation of measures concerning the 5 risk factors: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints.

Additional specific recommendations resulting from this paper deal with safe public transport, utilisation of ICT for safety improvement, separate lanes for Non-Motorized Traffic (NMT), maintenance of roads, introduction of collision avoidance technologies in vehicles (including compulsory alcohol locks), truck safety in crashes with other road users, measures to improve motorcycle safety (ABS, protective clothing, visibility) and recommendations concerning safety of pedestrians, cyclists and elderly road users.

Finally it is recommended that when introducing any measure a "base-line" status is established and means to track progress and effectiveness. Few of the recommendations mentioned in this paper can act in isolation – enhanced road safety is the result of a persistent systems approach and collaboration towards a shared challenging goal.

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Foreword

Road safety has been recognised as one of the main pillars of a sustainable transport system since the start of the Asian Environmentally Sustainable Transport (EST) Initiative. Under the EST-Initiative, the 1st Regional EST Forum in Asia, held in 2005, resulted in the Aichi Statement which in turn led to a list of sustainable transport objectives, of which a number were directly related to road safety issues.

The 5th Regional EST Forum in Asia, held in Bangkok in 2010, produced the so-called Bangkok 2020 Declaration, referring to the World Health Organisation (WHO) 2011-2020 Decade of Action for road safety. The Bangkok 2020 Declaration expressed deep concern that about half of all the world's road traffic fatalities and injuries occur in the Asian and Pacific region. The importance of road safety as a core element of a sustainable transport system is stressed by the Bali Declaration, an output from the 7th Regional EST Forum in Asia in Bali in 2013. It introduces the "Vision Three Zeros - Zero Congestion, Zero Pollution, and Zero Accidents towards Next Generation Transport Systems in Asia". Working towards the Vision Three Zeros is expected to lead to strong improvements in productivity and human development through proper implementation of a sustainable transport system in Asia.

This paper is prepared to give a background for a dedicated session on "Road Safety and Injury Prevention – Indispensable for National Productivity" at the 8th Regional EST Forum in Asia in Colombo, Nov 19-21, 2014. The theme of this EST Forum is: "Next Generation Solutions for Clean Air and Sustainable Transport − Towards a Liveable Society in Asia. The general objective of this paper is to guide and support policy consultation to the Asian EST countries[1] for the effective implementation of the **Zero Accidents** vision of the Bali Declaration.

[1] It is recognized that the 24 EST countries represent a wide span of road safety maturity. The position of Japan is worthwhile mentioning: its automotive industry has been among the leaders in safety technology development and in providing safe, durable and affordable vehicles. There is advanced research in many areas, and Japan is often piloting its application, especially in information and communication technologies. Even if this paper mainly addresses developing, low- and middle income, or newly motorized countries, several of the recommendations and issues still are applicable also for developed countries as Japan.

Abbreviations and acronyms

ABS	Anti-lock Brake System (vehicle system)
ACC	Adaptive Cruise Control (vehicle system)
ADAS	Advanced Drives Assistance System (vehicle system)
AEB	Autonomous Emergency Braking (vehicle system)
AIP	Asian Injury Prevention Foundation
APROSYS	Advanced PROtection SYStems (EU research project)
BAC	Blood Alcohol Content
CBA	Cost Benefit Analysis
CMF	Crash Modification Function
C-NCAP	New Car Assessment Program in China
COPD	Chronic Obstructive Pulmonary Disease
CTS	China Sweden Research Centre for Traffic Safety (China)
DALY	Disability Adjusted Life Year
DSP	Disease Surveillance Points (China)
EC	European Commission
ELVA	Advanced Electric Vehicle Architectures (EU Project)
ERTRAC	European Road Transport Research Advisory Council
ESC	Electronic Stability Control (vehicle system)
EST	Environmentally Sustainable Transport
EU	European Union
EuroNCAP	European New Car Assessment Programme
FIA	Federation International d'Automobile
FIMCAR	Frontal Impact and Compatibility Assessment Research (EU research project)
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GRSP	Global Road Safety Partnership
GTR	Global Technical Regulation
ICT	Intelligent Communication Technology
IHME	Institute for Health Metrics and Evaluation
IRAP	International Road Assessment Programme
IRTAD	International Road Traffic and Accident Database
ISO	International Organization for Standardization

ITF	International Transport Forum
ITS	Intelligent Transportation System
J-NCAP	New Car Assessment Program – Japan
K-NCAP	New Car Assessment Program – South Korea
LDW	Lane Departure Warning (vehicle system)
LKA	Lane Keeping Assist (vehicle system)
MIROS	Malaysian Institute for Road Safety Research
NCAP	New Car Assessment Program
NGO	Non-Governmental Organization
NHTSA	National Highway Traffic Safety Administration (USA)
NMT	Non-Motorized Transport
OECD	Organization of Economic Cooperation and Development
PROS	Priorities for Road Safety Research in Europe (EU Project)
RTS	Road Traffic Safety
SAFER	Vehicle and Traffic Safety Centre at Chalmers (Sweden)
SAS	Speed Assistant System (vehicle system)
TRIPP	Transportation Research and Injury Prevention Programme (India)
UNCRD	United Nations Centre for Regional Development
UNECE	United Nations Economic Commission for Europe
UNRSC	United Nations Road Safety Collaboration
VRU	Vulnerable Road User
VSL	Value of Statistical Life
WHO	World Health Organization
YLD	Years lived with disability
YLL	Years of life lost

1 Introduction

The latest WHO [1] and IMHE-World Bank [2] publications estimate that worldwide around 1.3 million people die yearly due to injuries in road accidents, while many more are injured (78.2 million according to [2]) often with long-term disabilities as a consequence. If also indirect deaths caused by air pollution from motorized transport are included the total number of deaths is more than 1.5 million [2] or more than 4000 lives lost per day. The younger age groups are over represented in these figures: in fact for males in the age group 15-29 it is the leading cause of death, and in the age group 29-44 it is the 2nd leading cause (after HIV/AIDS) [3]. So this tragedy affects in particular those entering their most productive years. As a social consequence, many poor families are driven deeper into poverty by the loss of a family breadwinner, funeral costs, the expenses of prolonged medical care and rehabilitation, or through earnings lost while caring for someone who is injured.

The number of road traffic injuries is increasing in low- and middle-income countries while it is stabilizing or decreasing in many high-income countries. The rapid motorization in many developing countries without timely introduction of accident and injury prevention strategies is the main reason for this. The world vehicle fleet which was about 1 billion in 2010 is estimated to double by 2020 and this increase particularly occurs in developing countries [31].

The United Nations Road Safety Collaboration (UNRSC) was established in 2004, recognizing the need for the United Nations system to support efforts to address the global road safety crisis. WHO, working in close cooperation with the United Nations regional commissions, was invited to coordinate the road safety issues within the United Nations System [13].

The decade 2011-2020 was declared by the United Nations General Assembly resolution 64/255 of March 2010 as the Decade of Action for Road Safety with a global goal of stabilizing until 2020 and then reducing the forecasted level of global road fatalities by increasing road safety improvement activities conducted at national, regional and global levels, see

Figure 1 [13] and section 2.5 of this paper. The main actions defined within the Decade of Action for Road Safety 2011-2020 were further affirmed in April 2014 by UN Resolution 68/269 “Improving global road safety”.

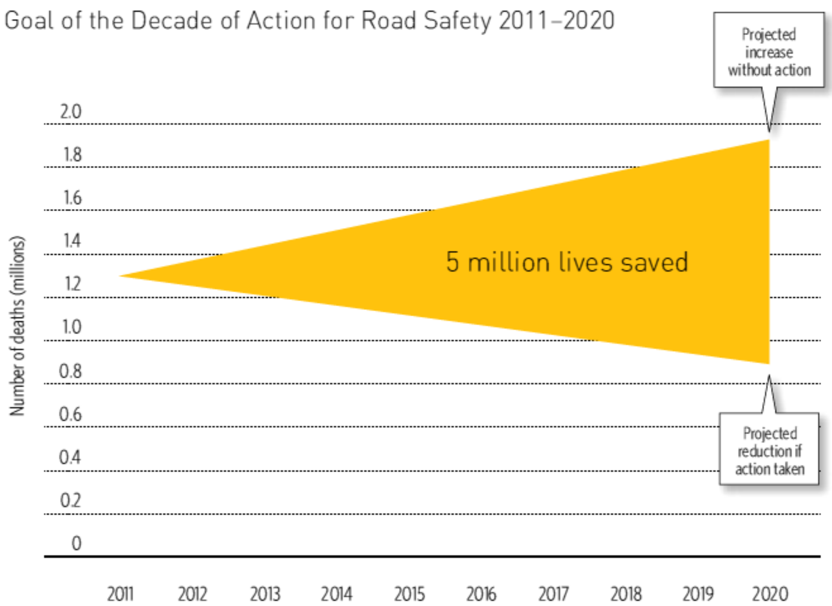

Figure 1 The United Nations Decade of Action for Road Safety 2011-2020 [13]

1.1 The Asian UNCRD EST-Initiative and road transport safety

The United Nations Centre for Regional Development (UNCRD) was established in 1971 to promote sustainable regional development in developing countries. The focus of UNCRD is on development, planning and management in the context of globalization, decentralization trends and the growing concern towards global environmental issues [4].

The Environmentally Sustainable Transport (EST) concept was originally introduced by the OECD countries in the mid-1990s. Road transport safety was at that time not yet considered a core element of an environmentally sustainable transport system. For background on the original EST concept, goals and strategy refer to [5].

The Asian Environmentally Sustainable Transport (EST) Initiative, which is a joint initiative of the United Nations Centre for Regional Development (UNCRD) and the Ministry of the Environment-Japan, was launched in 2004. It aims to build a common understanding across Asia on the essential elements of a sustainable transport system and the need for an integrated approach at local and national level to deal with multi-sectorial environment and transport issues [3].

As part of the EST-Initiative, since 2005 regular Regional EST Forums in Asia have been organized as a strategic/knowledge platform for sharing experiences and disseminating best practices, policy instruments, tools, and technologies, by addressing multi-sectorial socio-economic and environmental issues related with transport. Currently the participating countries in the regional EST forum in Asia include the member nations of ASEAN, North East Asian countries, South Asian countries and the Russian Federation, in total 24 countries as shown in Table 1.

Table 1 Participating Countries in Asian Regional EST Forum [6]

Asian EST Forum countries (24 countries as of 2013)	
Afghanistan	The Maldives
Bangladesh	Mongolia
Bhutan	Myanmar
Brunei Darussalam	Nepal
Cambodia	the Philippines
People's Republic of China	Pakistan
Indonesia	the Russian Federation
India	Singapore
Japan	Sri Lanka
Republic of Korea	Thailand
Lao PDR	Timor-Leste
Malaysia	Viet Nam

Road safety has been recognised as one of the main pillars of a sustainable transport system since the start of the Asian EST-Initiative. The 1st Regional EST Forum in Asia, held in 2005, resulted in the Aichi Statement leading to a list of sustainable transport objectives, some of which were directly related to road safety issues as summarized in Table 2.

The 5th Regional EST Forum in Asia, held in Bangkok in 2010, resulted in the so-called Bangkok 2020 Declaration, referring to the 2011-2020 Decade of Action for Road Safety [7]. The Bangkok 2020 Declaration expressed deep concern that about half of the worldwide road traffic fatalities and injuries occur in the Asia and Pacific region. Most of these are related to vulnerable road users such as pedestrians, children, and cyclists. This is due to lack of the necessary safety infrastructure such as exclusive pedestrian and bicycle lanes, safe street crossings, kerb ramps for the disabled, and lack of post-accident care. The participants of this 5th Forum agreed on the intent to voluntarily develop and realize integrated and sustainable transport policy options, programmes, and projects that will help realize 20 EST goals by the year 2020 in the Asian region.

Table 2 Road safety objectives in the 2005 Aichi Statement [3]

Theme	Aichi Statements concerning Road safety
Land-use planning	Supporting urban planning with a particular emphasis on public transport, non-motorized transport, **traffic safety** and environmental control
Non-motorized transport	Increasing **safety** for non-motorized transport
Social equity and gender perspectives	Acknowledging the need for, and contribution of, **safe** and affordable urban transport systems to the alleviation of poverty and the promotion of social development
Road safety and maintenance	Creating appropriate inter-agency coordination and management mechanism to address the **road safety** in transport policies and programmes
	Acknowledging **road safety** as a primary guiding principle for transport planning
	Mobilizing resources for formulation and implementation of multi-stakeholder integrated **road safety** action plans
Vehicle emission control, standards, and inspection and maintenance	Adopting and enforcing vehicle inspection and maintenance programmes for vehicle emissions and **safety**, based on high-volume, test-only inspection centres with stringent quality control

The 20 EST goals are grouped in 4 strategies:

I. Strategies to avoid unnecessary travel and reduce trip distances
II. Strategies to shift towards more sustainable modes
III. Strategies to improve transport practices and technologies
IV. Cross-cutting strategies

A number of the agreed goals directly or indirectly have implications for a reduction of the road safety problem, but in particular Goal 13 (see Table 3), under Cross-cutting strategies, is important to highlight here.

Table 3 Goal 13 of the Bangkok 2020 declaration [7]

Goal 13 Bangkok 2020 declaration
"Adopt a zero-fatality policy with respect to road, rail, and waterway safety and implement appropriate speed control, traffic calming strategies, strict driver licensing, motor vehicle registration, insurance requirements, and better post-accident care oriented to significant reductions in accidents and injuries"

The importance of road safety as a core element of a sustainable transport system is stressed by the Bali Declaration, an output from the 7th Regional EST Forum in Asia in Bali in 2013. It introduces the "Vision Three Zeros - Zero Congestion, Zero Pollution, and Zero Accidents - towards Next Generation Transport Systems in Asia". Working towards the Vision Three Zeros is expected to lead to strong improvements in productivity and human development through proper implementation of a sustainable transport system in Asia.

1.2 Objectives of this paper

The general objective is to guide, support policy and offer consultation to Asian countries for the effective implementation of the Bali Vision - Zero Accidents in the context, where possible, of productivity and human development.

The challenge where this paper aims to contribute, is to promote a progress in traffic safety in emerging economies, acknowledging that the development of transportation in these economies have different prerequisites than when safety measures were introduced decades ago in car dominated, industrialized countries. The countermeasures then focused on safer roads and safe vehicles. Government policies and regulations together with consumer testing have contributed strongly to the development of safer vehicles and safety equipment in developed countries. This paper consequently reflects much of these knowledge gains, and its specific objectives are to:

- Review and summarize the most recent and most relevant information on the global road safety problem and its impact on productivity
- Analyse and present in more detail the road safety situation in the Asian EST region
- Present accident and injury prevention strategies based on experience and effectiveness in developed countries and their potential for implementation in the 24 Asian EST countries
- Discuss the way forward by summarizing the most relevant opportunities to prevent road accident fatalities and injuries in the Asian EST region and how road safety can contribute to achieve the Bali Vision - Zero Accidents and contribute to the post-2015 sustainable development agenda

The global road safety problem, with a particular emphasis also on the impact on productivity, will be described in the next Section 2. A general introduction to the most important accident and injury prevention strategies will also be presented in Section 2 including the 5 pillars of the Decade of Action for Road Safety 2011-2020. Section 3 addresses road safety problems in the Asian EST countries and examples of best practices are shown. Road safety targets and strategies in developed countries will be presented in Section 4. Finally Section 5 discusses the way forward with recommendations how to achieve the Bali Vision - Zero Accidents in the developing countries.

2 The global road safety problem and prevention strategies

Road safety is an overarching concept that can be addressed only when its components are described and analysed. The improvement and the prevention strategies must be formulated based on understanding of the local context and facts from real traffic. However, the accumulated experience of improvement of traffic safety in different parts of the world can constitute a base for faster introduction of proper methods for countries that want to take new actions. It is essential that data and knowledge are increasingly transparent and comparable. In this section first the need for accurate accident data will be addressed (section 2.1) followed by an overview of the latest information on global fatality and injury data (section 2.2). The impact of road safety on productivity will be discussed in 2.3 and accident causation factors in 2.4. Finally section 2.5 concludes with an introduction in injury prevention strategies.

2.1 The need for accurate accident data collection

Reliable accident data are needed to study the occurrence, causes, and prevention of accidents and injuries. A prerequisite for the study of the epidemiology of injuries is the collection, classification and interpretation of accident data and its storage in accident databases. Accident databases are also referred to as injury surveillance systems. These databases can be used to determine or monitor the priorities for research and interventions.

The two most important categories of accident databases are:

- general accident databases based for instance on police records, hospital data or insurance company databases,
- in-depth databases with data gathered in specific geographical areas (so-called on the spot or in-depth accident analyses) and then sometimes generalized on a country basis [17].

General accident databases typically contain a large number of accidents, however with relatively limited information for each accident. Databases of in-depth studies contain detailed accident data often including information on injuries and accident causation. They are usually limited to a relatively small number of accidents.

In 2004 the World Health Organization (WHO) and the World Bank jointly launched the World report on road traffic injury prevention [9]. The report identified, among others, the need for accurate reliable accident data systems in order to allow countries to develop evidence based road safety strategies. Since then two Global Status Reports on Road Safety have been published by the WHO in 2009 [11] and in 2013 [1] respectively. In these reports data that were collected with help of different sectors and stakeholders in each country are presented (see Figure 2). For details on the methodology refer to [1]. The data in the 2009 report are for the year 2007 and in the 2013 report for the year 2010. For 2015 a 3rd status report is planned.

Data presented in 2014 by the Global Road Safety Facility at the World Bank in cooperation with the Institute for Health Metrics and Evaluation (IHME/World Bank) [2] are based on the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (“GBD 2010”) published in seven papers in The Lancet in 2012. The data are for the same year 2010 as the WHO 2013 status report mentioned above. The GBD 2010 quantified the comparative magnitude of health loss due to 291 listed diseases and injuries, including direct consequences of disease and injury and risk factors for 20 age groups and also covered both sexes. It produced estimates for 187 countries and 21 regions and assessments of the burden of road injuries as well as the burden that can be attributed to outdoor air pollution. For a description of the methodology used, see [2] and the papers in the Lancet for which the references are included in [2].

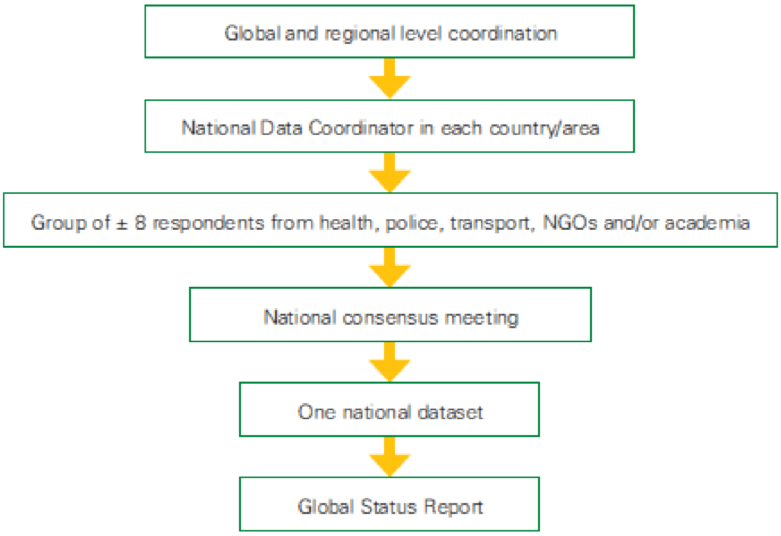

Figure 2 Methodology used by the WHO to collect national accident data [1].

The road accident death figures on a country basis as reported by the IHME/World Bank 2014 study differ from the WHO 2013 data for many countries, even if the order of magnitude of the presented data is similar in many cases. See Section 3 for detailed country figures for the 24 Asian EST countries. However, larger differences often exist between on the one side the WHO 2013 and IHME/World Bank 2014 and, on the other side, many official national country statistics. This is particularly the case in low and middle income countries, indicating that underreporting is a major problem.

One example is China: the official country statistics are provided by the national traffic police. But China also has a nationally representative sample registration system (the Disease Surveillance Points (DSP) system) that uses verbal autopsy to monitor causes of death, and a national death registration system [2]. The IHME/World Bank 2014 study showed an underreporting of more than 300% for the official country data when compared to the DSP based data.

The importance of reliable road accident data can be illustrated by the example from Indonesia presented in the Global Status Report on Road Safety 2013 [1]. In 2009 the government of Indonesia introduced a new law to improve the quality of accident data in order to address the underreporting in the country. It included supplementing the police recorded data by collecting data from other sources including hospital data. After introduction of these new measures an increase of more than 10.000 deaths could be seen in the official statistics as illustrated in Figure 3. But of course this is not a real increase but just the result of more reliable data coming available.

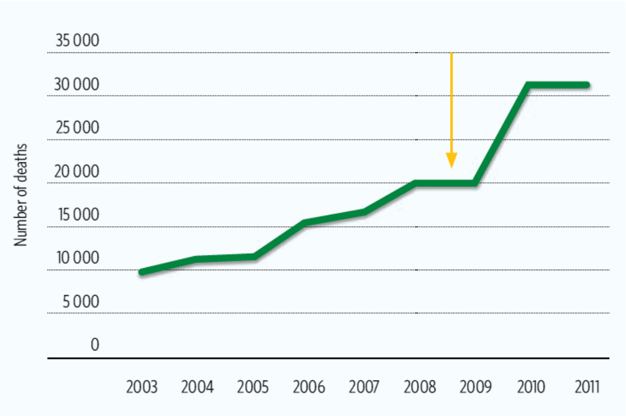

Figure 3 The effect of measures to improve the accuracy of accident data in Indonesia [1]

2.2 Fatalities and injuries

The WHO 2013 study [1] estimates about 1.24 million road fatalities annually in 2010. The IHME/World Bank 2014 estimates are slightly higher: almost 1.33 million injury caused deaths due to motorized transport [2]. On a country level sometimes however larger deviations between different assessments can however be observed; see section 3 for estimates concerning the year 2010 for the 24 Asian EST countries. Figure 4 shows predicted trends in global deaths for the most important causes. Road traffic injuries were the 8th leading cause of death in 2004. They are expected to double to 2.4 million in 2030 becoming the 5th leading cause in 2030 [15].

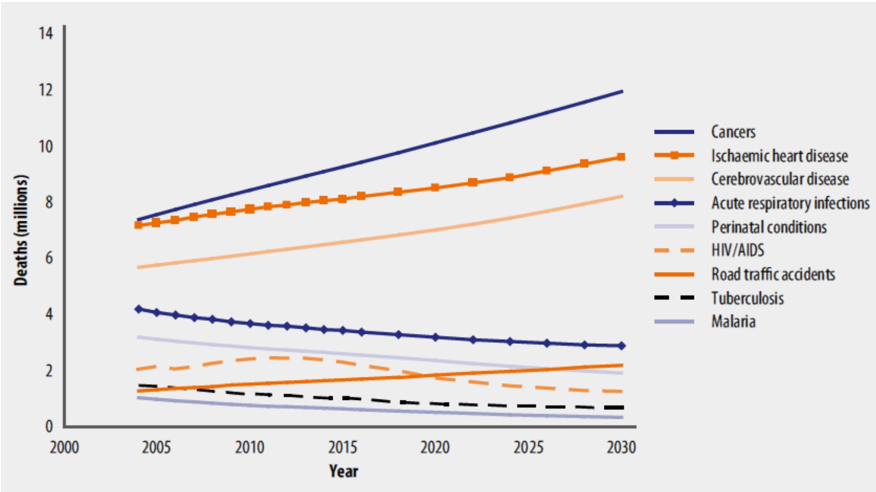

Figure 4 Projected global deaths for 9 selected causes in the period 2004–2030 [15]

Trends in road injury deaths per 100.000 population from 1980-2010 for different regions, for high-income countries, and globally, are shown in Figure 5. The risk of dying as a result of a road traffic injury is the highest in the Sub-Saharan region (rate in 2010 about 27 per 100.000) and lowest in the high income countries (about 11.5 per 100.000 in 2010).

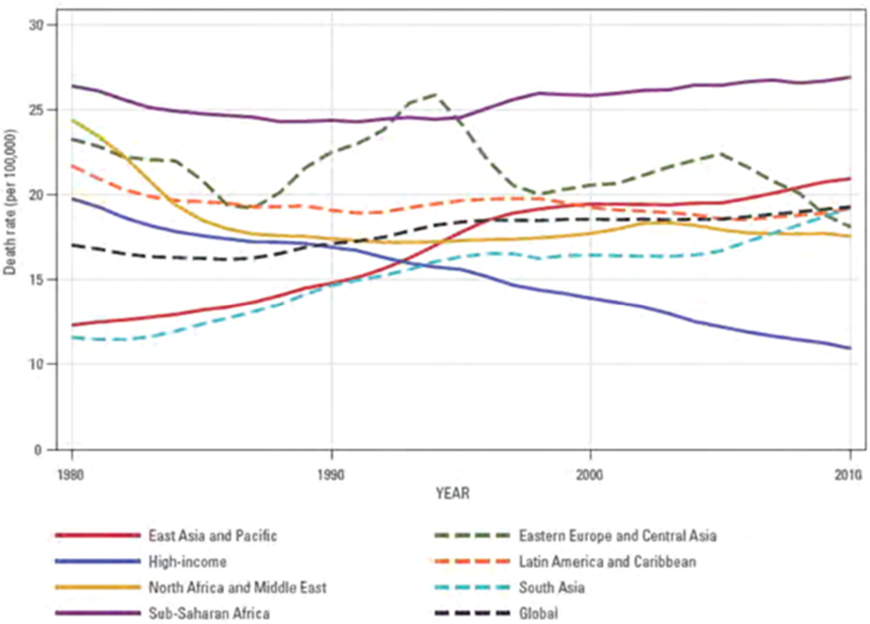

Figure 5 Trends in road injury death for various regions (1980-2010) [2]

As can be seen global rates of death from road injury have risen slowly over the last two decades. For high-income countries however a continuous decline in death rates can be observed, while on the other hand East Asia (including Pacific) and South Asia, the two most populous regions of the world, show high and continuous increases in road injury death rates. East and South Asia also have displayed the fastest growth in motorization in 1990-2010, which stresses the need for speedy introduction of better safety measures in these regions [2].

If also including indirect deaths caused by air pollution from motorized transport the total number of deaths in 2010 exceeds 1.5 million annually [2], so more than 4000 per day. The main causes of the additional 180.000 annual deaths are ischemic heart disease, stroke, COPD (chronic obstructive pulmonary disease) and lung cancer.

The distribution of deaths due to road accidents for various travel modes varies between countries of different income status. Figure 6 shows results from WHO 2013 [1]. In high income countries the number of road fatalities among vulnerable road users (cyclists, pedestrians and motorized 2-3 wheelers) is 39% while in low-income countries this is almost 1.5 times higher: 57%.

In Figure 7 the distribution of road traffic death by age and country income status can be seen. Independent of the country income most deaths are in the 15-29 and 30-44 age groups. The combined age group 15-44 accounts for 50% of the deaths in high-income countries and 67% in low-income countries, most of them being males [1].

However, apart from different traffic situations in different countries, exposure is another important factor. One measure is the time a certain type of road user spends in traffic, another the distance of the travel. While Figure 6 indicates a high amount of fatalities for car occupants in high income countries, Figure 8 shows European data demonstrating that for the hours or kilometers travelled the car fatalities rank much lower in risk than the number of killed vulnerable road users, but for the time spent in traffic the differences become much smaller.

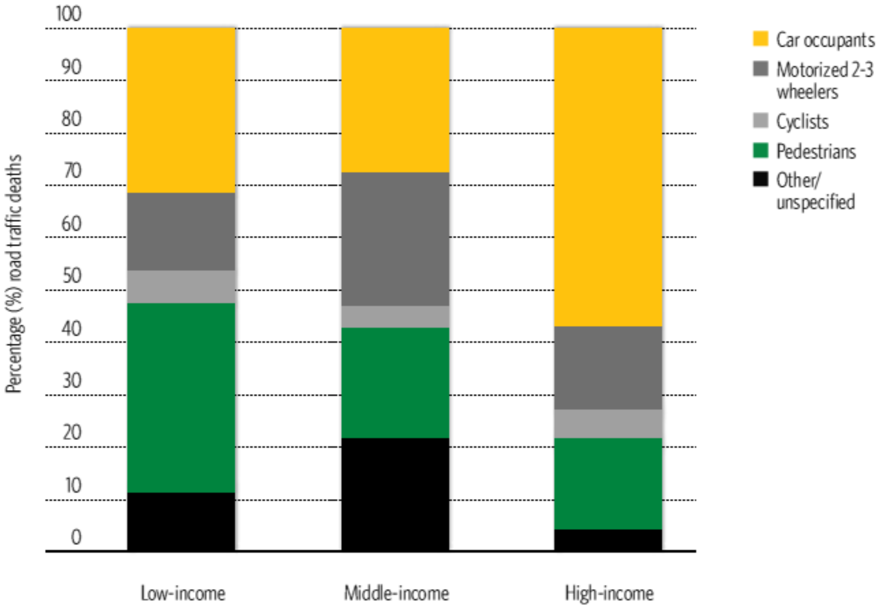

Figure 6 Fatalities due to road crashes per mode of transport and per country income status [1]

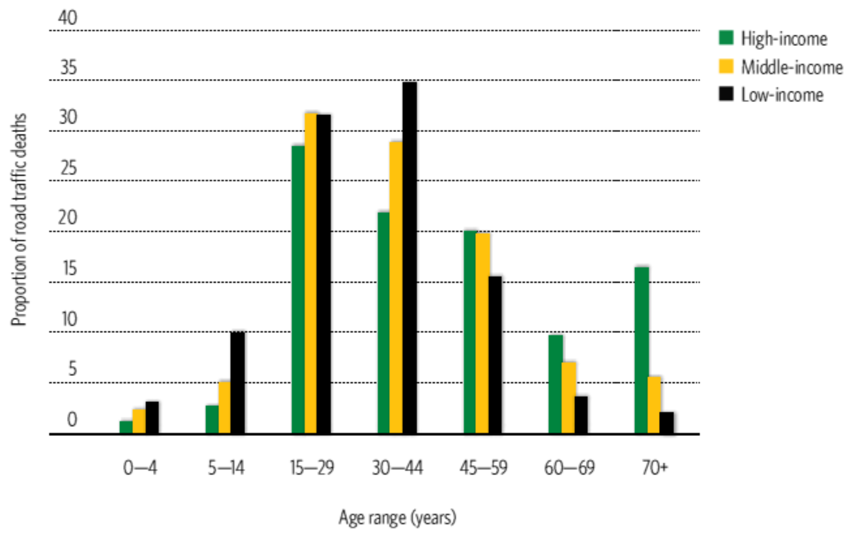

Figure 7 Fatalities due to road crashes by age range and country income status [1]

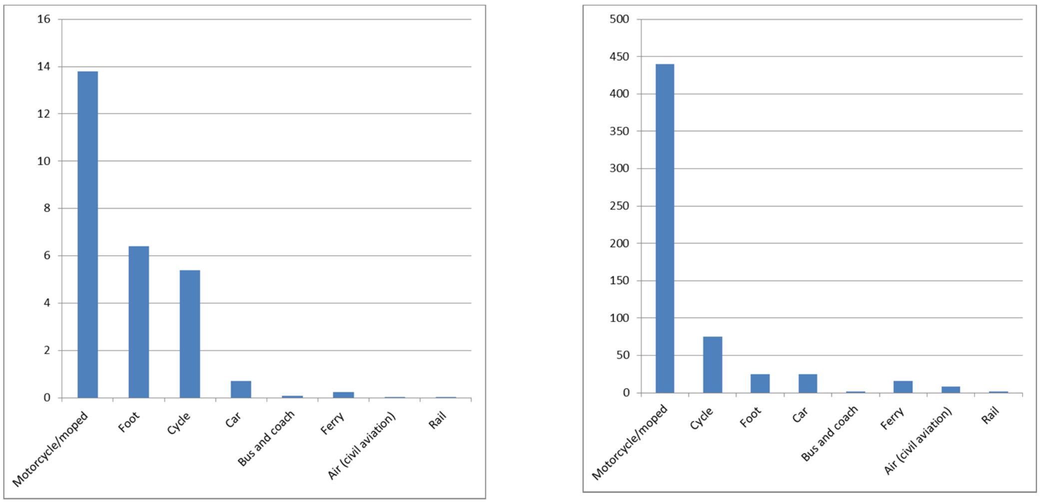

Figure 8 Death risk for the different travel modes in the EU for the period 2001/2002. Death per 100.000 million person km's (left) and death per 100 million person hours travelled (right) [14].

Deaths due to road accidents is just the tip of the iceberg. Non-fatal injuries are much more difficult to measure than fatal injuries also for high-income countries. The reasons for this include difficulties in defining the severity of injuries and availability of good hospital data preferable linked to police data (see for instance [1][2][16]). This is particularly true for pedestrians and cyclists who at times are completely unreported. According to [1] 77 countries have a national injury surveillance system - 47% of high-income, 46% of middle-income countries, but only 24% of low-income countries.

The GBD 2010 data analysed in the IHME/World Bank 2014 study represent the first attempt to quantify data on non-fatal injury on a global level [2]. For the year 2010 the number of injured persons worldwide due to road injuries was estimated to be 78.2 million persons needing medical care of which 9.2 million hospital admissions. These hospital admissions were defined as: "injuries that would have required at least an overnight hospital stay if adequate access to medical care had been available to the victims". Considering the number of 1.33 million deaths in 2010 due to road accidents the resulting ratio between fatalities, hospital admissions and other injuries based on these GBD 2010 estimates would be **1 : 7 : 52** (see Figure 9). The number of injuries reported in the IHME/World Bank study [2] are higher and more precise than the earlier figures for injuries reported by the WHO in various reports (20-50 million).

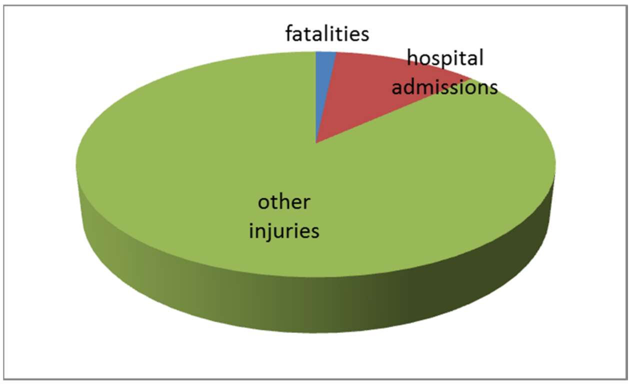

Figure 9 Ratio between fatalities, injuries requiring hospital admission and other injuries requiring medical care according to IMHE/World Bank 2014 [2]

From this study also an indication of the number of injuries, the type of injuries and consequences of injuries requiring hospital admission for the year 2010 can be obtained (see Figure 10, which uses measures that are further addressed in section 2.3). The number of years lived with a disability was estimated based on household surveys and hospital data. Open wounds and superficial injuries accounted for over 2.5 million cases and 47% of the total health loss from road accidents. All fractures together accounted for 3.8 million non-fatal injuries and 33% of the health loss and severe traumatic brain injuries accounted for over 1.5 million cases and contribute 10% of the health loss. The authors of the study noted that “the science of estimating the incidence of injuries and estimating the resulting disabilities is still in its infancy” and concluded that “Improving the epidemiological foundation of such estimates will require sustained research efforts to improve definitions and standardize data-collection methods and new studies to measure the long-term disability outcomes of injuries”.

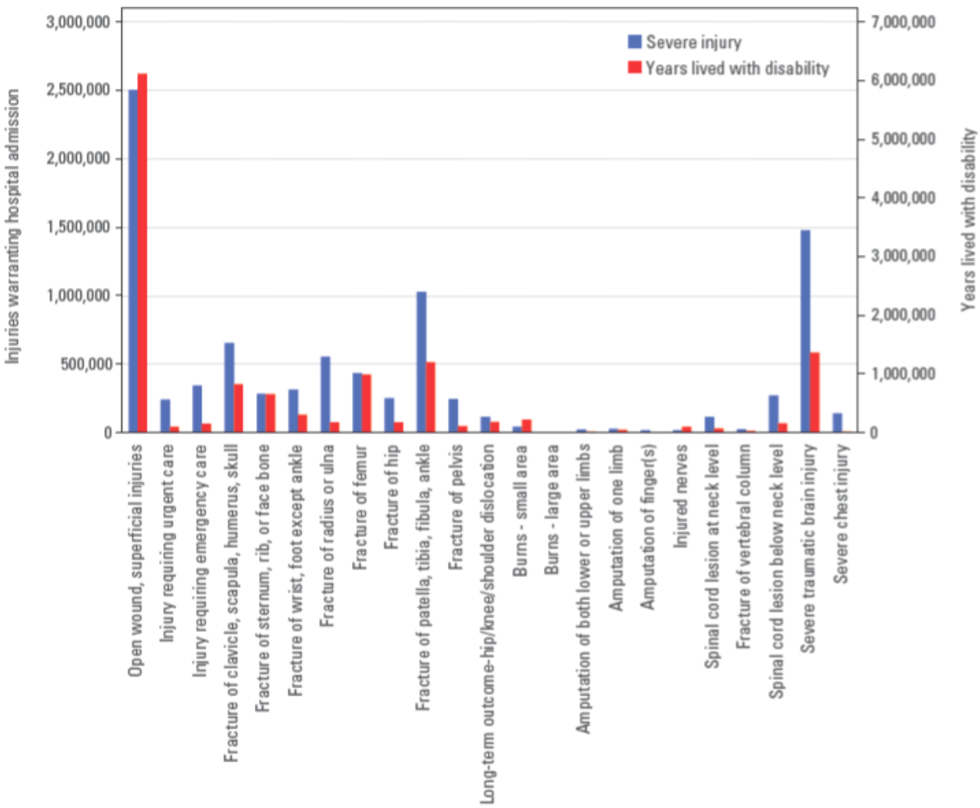

Figure 10 Number, type and consequences of non-fatal road traffic injuries requiring hospital admission worldwide 2010 [2]

2.3 Road safety and productivity impact

Traffic victims are often younger than victims of other serious threats to life and road accidents also result in a large number of victims with disabilities lasting over their entire lifetime. Young victims and the large number of injuries make the productivity loss of road accidents a substantial burden for the economy.

To account for the lost lifespan due to premature mortality the number of years of life lost (YLL) are measured as the difference between the expected lifetime and actual age at accident. YLL will thus measure the number of lost productive years if it is adjusted for local retirement age. To take the impact of injuries into account the number of years lived with disability (YLD) is used. Disability adjusted life years (DALY) is a summary measure that combines mortality (YLL) and morbidity (YLD) measures (see Table 4).

Table 4: Different measures to account for productivity loss

Measure	Description
Years of life lost (YLL)	Numbers of expected years of life lost due to premature death. Will depend on expected lifetime and age of premature mortality. Needs to be adjusted for retirement age in productivity analysis.
Years lived with disability (YLD)	Years of life lived with long or short-term health loss adjusted for severity.
Disability adjusted life years (DALY)	The sum of YLL and YLD and measures the number of years of healthy life lost.

When taking the number of years lost (YLL) and the quality of life (expressed through YLD) into account, road accidents become the 7th leading cause of DALY worldwide (Table 5). In addition to road accidents air pollution from transport is a serious threat to health and causes heart diseases, stroke, lung cancer etc. WHO [2] has assessed the consequences of both accidents and air pollution's due to motorized transport. Road accidents are a much more serious health problem for society than air pollution especially when focusing DALY's. The huge number of lost DALY's for road accidents also reflects its impact on lost productivity for the economy.

Table 5: Leading causes of death and DALY's worldwide and relative ranking (in brackets) in 2010 [2]

	Global burden of disease		**Burden attributable to motorized road transport (road accidents & air pollution)**	
	Fatality	**DALY**	**Fatality**	**DALY**
Ischemic heart disease	7 029 270 (1)	129 795 464 (1)	90 639 (2)	1 909 563 (2)
Stroke	5 874 181 (2)	102 238 999 (3)	58 827 (3)	1 148 699 (3)
COPD	2 899 941 (3)	76 778 819 (6)	17 266 (4)	346 376 (5)
Lower respiratory infections	2 814 379 (4)	115 227 062 (2)	5 670 (6)	489 540 (4)
Lung cancer	1 527 102 (5)	32 405 411 (10)	11 395 (5)	232 646 (6)
HIV/AIDS	1 465 369 (6)	81 549 177 (5)	-	-
Diarrheal diseases	1 445 798 (7)	89 523 909 (4)	-	-
Road accidents	**1 328 536 (8)**	**75 487 102 (7)**	**1 328 536 (1)**	**75 487 102 (1)**
Diabetes mellitus	1 281 345 (9)	46 857 136 (9)	-	-
Tuberculosis	1 195 990 (10)	49 399 351 (8)	-	-

In addition to the invaluable human tragedy, traffic accidents are also a huge loss of economic resources. The economic cost of traffic accidents can be divided into direct economic cost, indirect economic cost and value of life per se (Table 6). The direct economic costs are more or less visible, as medical cost, legal and emergency service cost and property damage cost. The medical treatment of an accident one year will for some patients continue over many years ahead, in the worst cases over their whole lifetime.

Table 6: Economic cost of traffic accidents

Category	Type of cost
Direct economic cost	Medical and rehabilitation cost Legal cost Emergency services cost Property damage cost
Indirect economic cost	Lost production capacity (gross or net)
Value of safety per se	Value of statistical life (VSL)

The indirect economic cost of accidents consists of the value to society of goods and services that could have been produced by the person, if the accident had not occurred. The value of a person's production is assumed to be equal to the gross labour cost, wage and additional labour cost, paid by employer. The losses of one year's accident will continue over time up to the retirement and will grow with a growing economy over time. However, the weight of the later years will be smaller as we use a discount rate.

Additionally, the human tragedy comes with a cost above the loss of economic resources. People value their safety for more subtle reasons than their lost production capacity. This value of reduced accident risk may be expressed as a value of statistical life (VSL). In most countries this value is the dominant element in the valuation of accidents. With a focus on the welfare of the individual, VSL is estimated as the individual's willingness-to-pay for a small risk reduction which is summed up to one "statistical life". VSL can be based on labour market observations [40] or responses to questionnaires [39]. A huge literature on methodology and meta studies exists today [40][41][42] concluding that although the methodology is not flawless it is more appropriate than the alternatives.

To do country specific VSL studies is a difficult task and rule-of-thumb approaches have been developed linking VSL per victim to the GDP per capita. This is obviously a simplification and an original study will be able to reveal differences between different causes of accident and different segments of the population. However, on average we would expect that a country specific study on VSL will generate a value of approximately 70*GDP per capita. The same approach can be taken for injuries, although the spectrum of different outcomes makes it more difficult to generalise. The willingness-to-pay to reduce a severe injury could be around ¼ of willingness-to-pay to reduce fatalities generating a ratio between VSL and GDP per capita of 17 (=70*1/4) [43].

We have here presented a broad perspective of the productivity loss to the economy due to road accidents where the main productivity impact is the huge loss of future working capacity. A more instant effect to the productivity of the economy is the large proportion of work-related accidents. Work-related accidents could constitute a third of the road casualty victims and up to 50% if commuting is included. Traffic accidents are thus a serious work place hazard and may represent 30% to 50% of workplace fatalities depending on region [49]. These workplace fatalities include road accidents with various forms of driving, including professional transport, driving during work hours (for example, truck, bus and van drivers as well as sales people), workers on the road (for instance road maintenance crews) and commuting to work.

2.4 Accident causation

A road accident resulting in injuries is often the result of a number of causes rather than just a single one. Several accident causation models have been developed which can help analysing the causes of an accident. For an overview of such models see [18]. The more recent accident causation models consider an accident as a complex integrated system including the human and with direct and in-direct contributing factors. This approach prevents a single focus only on countermeasures that address the apparent direct cause of the accident, whereas there may be other more efficient but indirect solutions available. During the recent years a very strong tool has been introduced in accident causation analysis – the naturalistic driving studies. By video filming the driver (or biker) and the traffic environment and simultaneously record speed, braking, steering and position (and more) an entirely new understanding of causation factors is acquired (see e.g. [46] [47]).

Table 7 Main risk factors for road traffic injuries according to the 2004 World report on road traffic injury prevention [9]

The main risk factors for road traffic injuries	
Factors influencing exposure to risk	**Risk factors influencing crash severity**
Economic factors, including social deprivation	Human tolerance factors
Demographic factors	Inappropriate or excessive speed
Land use planning practices which influence the length of a trip or travel mode choice	Seat-belts and child restraints not used
Mixture of high-speed motorized traffic with vulnerable road users	Crash helmets not worn by users of two-wheeled vehicles
Insufficient attention to integration of road function with decisions about speed limits, road layout and design	Roadside objects not crash protective
	Insufficient vehicle crash protection for occupants and for those hit by vehicles
	Presence of alcohol and other drugs
Risk factors influencing crash involvement	**Risk factors influencing severity of post-crash injuries**
Inappropriate or excessive speed	Delay in detecting crash
Presence of alcohol, medicinal or recreational drugs	Presence of fire resulting from collision
Fatigue	Leakage of hazardous materials
Being a young male	Presence of alcohol and other drugs
Being a vulnerable road user in urban and residential areas	Difficulty rescuing and extracting people from vehicles
Travelling in darkness	Difficulty evacuating people from buses and coaches involved in crash
Vehicle factors – such as braking, handling and maintenance	Lack of appropriate pre-hospital care
Defects in road design, layout and maintenance which can also lead to unsafe road user behaviour	Lack of appropriate care in the hospital emergency rooms
Inadequate visibility due to environmental factors (making it hard to detect vehicles and other road users)	
Poor road user eyesight	

An overview of important risk factors in road traffic accidents is given in Table 7 as presented in the 2004 World report on road traffic injury prevention [9]. Within the Plan for the Decade of Action for Road Safety 2011-2020, five key risk factors have been identified for which global introduction and enforcing of legislation would be important:

- speed
- drunk–driving
- not wearing motorcycle helmets
- not wearing seat-belts
- not using child restraints in cars

Global statistical data on risk factors however appear to be very limited except for the case of alcohol.

Since 2004**,** human inattention and distraction has emerged as an important factor in accident causation and thus a risk factor influencing crash involvement (see e.g. [48]). The increased role is both due to a new understanding of human behaviour thanks to new methodologies like naturalistic driving studies, but also due to the increased use of electronic and communication devices that can lead to inattention (texting etc.).

2.5 Prevention strategies

Probably the first systematic approach concerning accident and injury prevention strategies was the so-called Haddon Matrix shown in Figure 11. Developed by Dr William Haddon in 1968 [19] it caused a shift from an almost exclusive focus on trying to improve the driver behaviour to a more comprehensive approach. The Haddon Matrix identifies the 3 phases: pre-event, event and post-event as sequential phases within a crash event as well as the 3 components: human (behaviour and tolerance), vehicle and infrastructure (environment). This approach has since led to many successful safety improvements within all elements of the Matrix. Recognized limitations of this model are that neither the concept of exposure nor the importance of interactions between the elements of the Matrix are addressed [18].

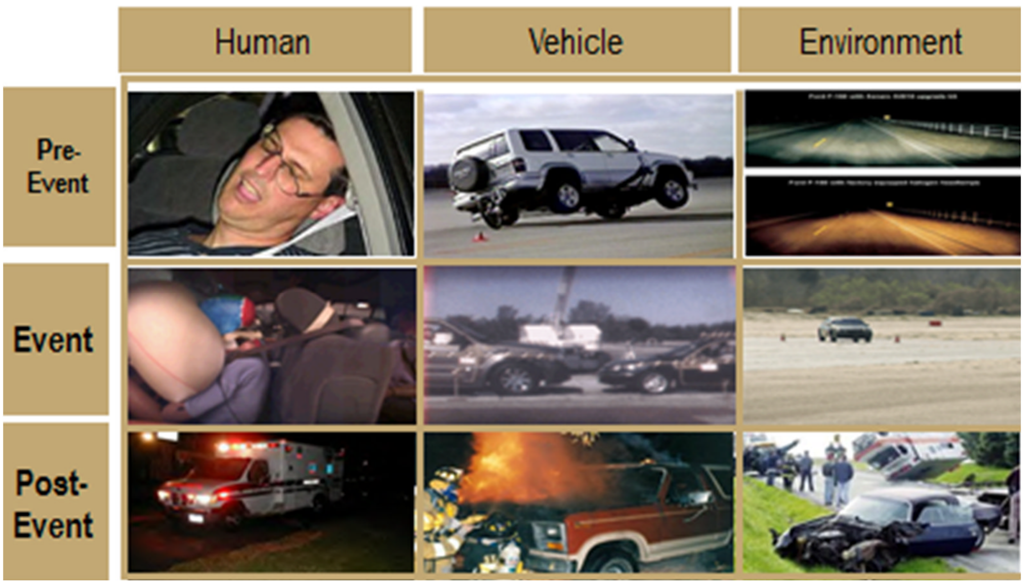

Figure 11 Haddon Matrix [19]

New approaches like the "Vision Zero" in Sweden [54] and the "Safe System" approach [20] view the traffic system more holistically and will be presented in detail Section 4.2. A full Safe System approach to road trauma requires that the crash energy in an accident is low enough to prevent (serious) injuries, recognises that humans will always make mistakes in traffic and requires system designers to provide a transport system that supports the highest level of safety possible [20]. Other important elements are formulating road safety strategies, setting targets and monitoring performance. Based on the Safe System approach the Commission for Global Road safety defined the following five pillars as road safety policy framework used in the Decade of Action for Road Safety 2011-2020 [21], see Table 8.

Table 8 The 5 pillars of the Decade of Action for Road Safety 2011-2020 [21]

Pillars	Description
1: building management capacity	with the creation of multi-sectorial partnerships and designation of lead agencies with the capacity to develop national road safety strategies, plans and targets, supported by the data collection and evidential research to assess countermeasure design and, monitor implementation and effectiveness
2: influencing road design and network management	using road infrastructure assessment rating and improved design to raise the inherent safety of road networks for the ben efit of all road users, especially the most vulnerable.
3: influencing vehicle safety design	with global deployment of improved vehicle safety technologies for both passive and active safety through a combination of harmonisation of relevant global standards, consumer information schemes and incentives to accelerate the uptake of new technologies
4: influencing road user behaviour	through sustained enforcement of road traffic rules combined with public awareness/education activities that will raise compliance with regulations that reduce the impact of the key risk factors (non-use of seat belts and helmets, drunk driving and speeding)
5: improving post-crash care	to increase responsiveness to emergencies and improve the ability of health systems to provide appropriate emergency treatment and longer term rehabilitation

3 Road safety in the Asian EST countries

This section will summarize the road safety situation in the 24 Asian EST countries. The data presented here are largely derived from the information included in the WHO Global Status Report on Road Safety 2013 [1] and the IHME/World Bank 2014 report which was based on the GBD 2010 data [2]. Both studies were introduced in Section 2. The 24 Asian EST countries represent 56% of the world population and include the two most populated countries in the world, China and India. . Of all registered motor vehicles in the world, 41% are registered in the 24 Asian EST countries (WHO 2013). First fatality and injury will be presented in 3.1 followed by economic burden data in 3.2. The status of a number of important road safety measures will be reviewed in 3.3 and examples of best practices for safety improvements will be presented in 3.4. Several of the tables in this chapter utilize a number of different sources that have been compiled into a comparison of different aspects related to road traffic safety for all 24 EST countries.

3.1 Fatalities and Injuries

Table 9 shows the number of deaths caused by road accidents in 2010. The 2010 population of each EST country is included (WHO 2013) as well as estimates for the numbers of indirect deaths in 2010 due to motorized caused pollution. Also shown here are the number of non-fatal injuries (hospital admissions and total number of injuries) based on IMHE/Wold Bank 2014.

The total number of estimated deaths by WHO 2013 and IMHE/World Bank 2014, respectively, in the 24 Asian EST has the same order of magnitude: around ¾ million, but large differences within some individual countries can be seen between these two sources: up to a factor 2 or more in countries like Afghanistan, Bangladesh and Pakistan. When comparing the WHO and IMHE/World Bank data with the official country data the estimated total number of deaths for the 24 EST countries is more than twice the value from official sources indicating large underreporting. This in particular appears to be the case in Afghanistan, Bangladesh, Pakistan, Myanmar, India and China. Regarding injuries, the total number in the 24 Asian EST countries is more than 50 million, of which 12% are hospital admissions. This means that 66%, or 2/3, of all injuries worldwide occur in Asian EST countries, while the region's total population is 56% of the world population. The total number of indirect deaths due to motorized caused air pollution is almost 100,000 with a relatively large share from India.

In order to compare safety levels of the countries in the Asian EST region we have calculated death rates due to road accidents (death per 100.000 population) for each country from the average of the WHO 2013 and IMHE/World Bank 2014 death estimates (Figure 12).

The average death rate (19 per 100.000) for the Asian EST region is similar to the world death rate but exceeds significantly the rates of high income countries (11.5 per 100,000) presented in section 2.2. Singapore, Maldives and Japan are among the safest countries according to road accident death rates while Afghanistan and Thailand while are the most unsafe.

Both WHO 2013 and IMHE/World Bank 2014 also provide data on the distribution of road accident deaths over the transport mode used. The data however are not the same from the two sources indicating the limited reliability of these data. In case of WHO 2013 data are not provided for all Asian EST countries, among those missing are Afghanistan, Nepal, Philippines and Vietnam. From the IMHE/World Bank 2014 data we have calculated the total number of deaths (in percentages) in the Asian EST region for the various transport modes. This is shown in Figure 13. Pedestrians are the largest single category with 35% of all deaths followed by car occupants with 30%. Vulnerable road users (pedestrians, cyclists and motor cyclist combined) make up 60% of the deaths due to road accidents.

Table 9 Number of deaths and injuries in 24 Asian EST countries caused by road accidents in 2010 from several sources: official country statistics, the WHO 2013 estimates and the IMHE/World Bank 2014 estimates, as well as official country data and the number of deaths due to motorized air pollution (data derived from [1][2]).

	Population	**Road Inj. Official Country**	**Death**	**Death**	**Death due to air Pollution**	**Hospital admission**	**Total number of injuries**
Source	*WHO 2013*	*IMHE/World Bank 2014*	*IMHE/World Bank 2014*	*WHO 2013*	*IMHE/World Bank 2014*	*IMHE/World Bank 2014*	*IMHE/World Bank 2014*
Country							
Afghanistan	31,411,742	1,501	10,213	6,209	1,388	36,483	345,765
Bangladesh	148,692,128	2,872	6,113	17,289	2,667	298,166	2,304,607
Bhutan	725,940	79	87	96	12	1,482	11,794
Brunei	398,920	46	50	27	1	356	3,076
Cambodia	14,138,255	1,816	2,394	2,431	129	21,924	183,274
China	1,348,932,032	70,134	282,576	275,983	27,379	1,903,239	16,300,000
India	1,224,614,272	130,037	273,835	231,027	38,804	2,197,047	18,500,000
Indonesia	239,870,944	31,234	65,335	42,434	1,374	360,187	3,170,472
Japan	126,535,916	5,772	10,017	6,625	8,280	118,924	974,382
Laos	6,200,894	767	1,068	1,266	68	7,668	65,649
Malaysia	28,401,017	6,872	4,106	7,085	405	52,427	422,519
Maldives	315,885	6	29	6	2	535	4,267
Mongolia	2,756,001	477	661	491	26	3,668	32,991
Myanmar	47,963,010	2,464	9,277	7,177	548	56,886	490,076
Nepal	29,959,364	1,689	3,293	4,787	675	57,934	461,572
Pakistan	173,593,384	5,192	16,573	30,131	4,496	331,613	2,651,023
Philippines	92,260,800	6,739	8,396	8,499	554	110,309	900,551
Russia	142,958,156	26,567	33,379	26,567	6,572	179,432	1,569,191
Singapore	5,086,418	193	164	259	44	3,574	28,787
South Korea	48,183,586	5,505	7,839	6,784	2,126	42,262	374,837
Sri Lanka	20,859,949	2,483	2,650	2,854	217	27,914	228,517
Thailand	69,122,232	13,365	19,867	26,312	1,521	56,372	542,010
Timor-Leste	1,124,355	99	90	219	1	1,726	13,741
Vietnam	87,848,460	11,859	16,371	21,651	607	249,726	2,034,092
Total	**3,891,953,660**	**327,768**	**774,383**	**726,209**	**97,896**	**6,119,854**	**51,613,193**

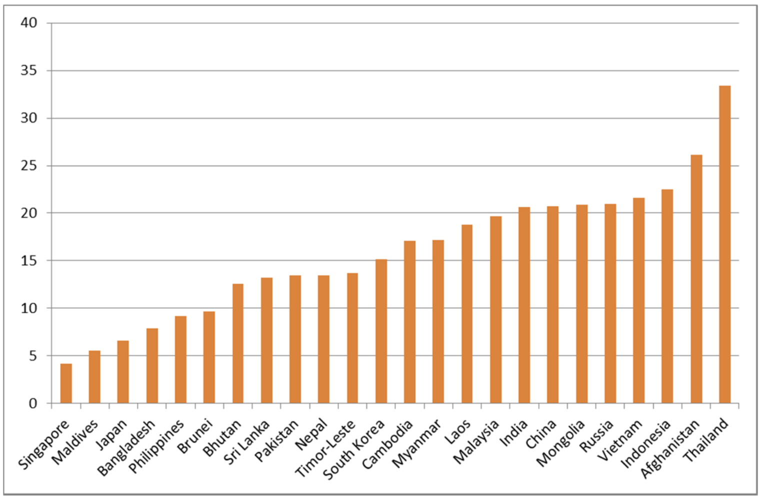

Figure 12 Death rates (per 100.000 population) in 24 Asian EST countries based on an average of WHO 2013 and IMHE/World Bank 2014 data [1][2].

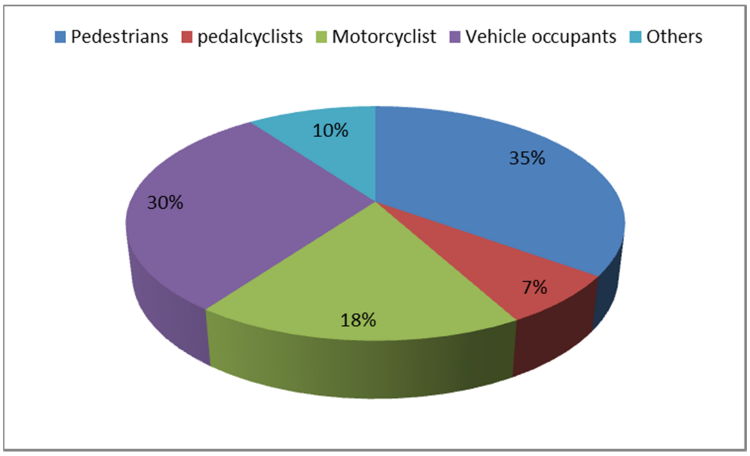

Figure 13 Distribution of death per travel mode in 24 Asian EST countries. Based on IMHE/World Bank data [2]

3.2 The economic burden

The number of years of life lost for an average traffic mortality in middle income countries can be estimated to 34 years if we assume a life length of 70 years (see Figure 7). For the 24 Asian EST countries, the road accident fatalities during one year only (Table 9) will result in a loss of years of life (YLL) of approximately 24.7 million in the future.

The loss of life is a tragedy and a burden for the productivity of the economy. The average GDP per capita in the 24 Asian EST countries is approximately US$ 5700 as an average over the period 2009 - 2013 (data.worldbank.org). The instant consequence of the traffic fatalities in 2010 is thus a loss of GDP of 3.7 billion US$ during that year. Taking the lost lifetime into account the present value of the fatalities in 2010 (with a growth rate of 5% and discount rate of 7%) can be estimated to 81 billion US$ or 0.4% of GDP for road deaths only.

Taking a broader welfare perspective (including VSL) the cost of fatalities is estimated to 250 billion US$ or 1.1% of GDP. When the VSL estimate is included the term "cost" should be read "the willingness of the population to sacrifice GDP to reduce the number of accidents". Adding the cost of injuries (hospital admissions from Table 9) the loss to the economy is estimated to 735 billion US$ or 3.3% of GDP.

Figure 14 summarizes the economic burden by country including observations from WHO [1] which is a summary of different country estimates, sometimes based on different approaches. In relation to GDP the lowest cost of accident is found in Singapore, Japan and Brunei (below 2% of GDP) while the results indicate that 8 countries have cost of accidents above 4% of GDP - Bangladesh, Bhutan, India, Malaysia, Nepal, Pakistan, Thailand and Vietnam.

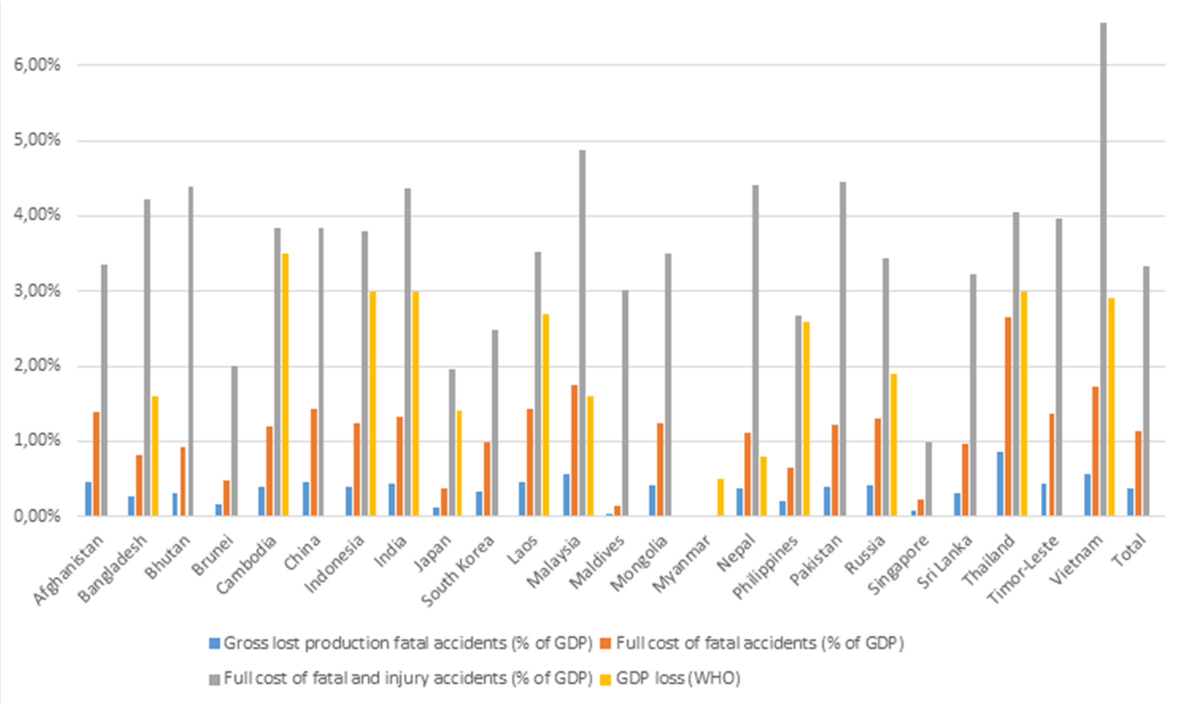

Figure 14 The cost of injuries in Asian EST countries

3.3 Status of road safety measures

The WHO 2013 study [1] provides an overview of the road safety measures, including laws and standards etc. in the 24 Asian EST countries. A number of the findings are summarized in Table 10.

The focus is on the WHO key risk factors specified in the Decade of Action for Road Safety 2011-2020: speed, drunk–driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints in cars. Furthermore the WHO 2013 report includes an overview of requirements concerning safety provisions of imported cars (presence of seatbelts, airbags, ABS (Anti-lock Brake System) and ESC (Electronic Stability Control). Also the existence of a national road safety strategy and the presence of road safety targets concerning fatalities and injuries were evaluated as well as the presence of a lead agency in charge of the national road safety strategy. For information on the status of implementation of requirements for vehicle safety see Section 4.4, addressing both the World Forum of Harmonisation of Vehicle Standards and consumer test ratings (New Car Assessment Programs, NCAP).

All countries have some kind of **maximum speed** laws like maximum speeds in city centres. The effectiveness of enforcement of speed laws was rated by respondents in the country on a scale from 0-10, where 8 and above is good (see Table 10). Only South-Korea rated the enforcement as an 8 and four countries as a 7 (Cambodia, Japan, Singapore and Vietnam). Countries like Afghanistan, Bangladesh, India, Pakistan, Philippines and Thailand however showed a very low score of only 3.

Drunk-driving laws exist in all countries except Afghanistan and the Maldives. In 5 countries no BAC (Blood Alcohol Content) levels are specified: Bangladesh, Indonesia, Nepal, Pakistan and the Philippines. The overall effectiveness of enforcement concerning drunk-driving was rated by 21 of the countries on a scale from 0-10 (see Table 10) with very high (8 and higher) ratings in Brunei, China, Japan and Singapore and very low ratings (3 and below) in nine of the Asian EST countries including India.

Concerning helmets no information is included in Table 10. All countries except Afghanistan have **helmet** laws for motorcycles and most countries control the quality of a helmet by a helmet standard except Bangladesh, Laos, Maldives, Mongolia, Nepal and Timor-Leste. Without adequate laws the risk of counterfeit helmets without sufficient protection increases. The wearing rate for helmets is available for 11 countries (see [1]) and appears to be high (75% and more wearing rate) in Indonesia (drivers), Laos (drivers). Malaysia (all), Philippines (drivers), Sri Lanka (all) and Vietnam (all).

Table 10 Overview of status of some safety measures in Asian EST countries

	Effectiveness speed enforcement (scale 0-10)	Effectiveness of drunk-driving enforcement (scale 0-10)	Seat belt law back seat	Child restraint law	Effectiveness of seat belt wearing enforcement (scale 0-10)	Legislation imported cars	National target fatalities
Afghanistan	3		no	no		no	no
Bangladesh	3		no	no	3	seat belts	yes
Bhutan	2	5	yes	no	5	no	yes
Brunei	6	9	no	yes	6	seatbelts	no
Cambodia	7	3	no	yes	5	seatbelts	yes
China	4	9	yes	no	2	seatbelts	yes
India	3	3	yes	no	2	no	no
Indonesia	4	3	no	no	8	no	yes
Japan	7	8	yes	yes	7	Seatbelts +airbags +ESC	yes
Laos	6	3	no		2	seatbelts	yes
Malaysia	5	4	yes	no	4	seatbelts	yes
Maldives	6		yes	no	7	seatbelts	
Mongolia	3	5	yes	yes	6	no	
Myanmar	5	5	no	no		no	yes
Nepal	3	3	yes	no	1	no	
Pakistan	3	3	no	no	3	seatbelts	no
Philippines	3	0	yes	no	8	seatbelts	yes
Russia	6	7	yes	yes	6	seatbelts	yes
Singapore	7	9	yes	yes	8	seatbelts	no
South Korea	8	7	yes	yes	8	Seatbelts +airbags +abs	yes
Sri Lanka	4	6	no	no		no	
Thailand	3	5	no	no	6	seatbelts	yes
Timor-Leste	4	3	yes	yes	2	Seatbelts +abs +esc	no
Vietnam	7	3	no	no	7	Seatbelts +abs +esc	no

The use of seatbelts in the front seat is required in all countries except Afghanistan and Myanmar. The situation for the back seat is different: only 13 countries require seat-belt wearing in the back seat (see Table 11). The effectiveness of enforcement of seat belt wearing was rated high (8 and higher) in Indonesia, Philippines, Singapore and South-Korea and very low figures (3 and below) in 7 countries among others in China and India with just a rating of 2 (see Table 11). Actual wearing figures are also available for about 10 countries (see [1]). They are high (more than 75% wearing rate) for drivers in Japan, Malaysia, Philippines, Russia, South Korea and Sri Lanka and low in India (27% wearing rate for drivers) and Pakistan (only 4% for drivers). For Thailand the belt wearing rate is 61 % for drivers and for China no data are available.

Child restraint systems for cars are required in eight countries (see Table 10). No information is available from the WHO 2013 report on effectiveness and enforcement of child restraint laws in the Asian EST countries. Worldwide about 500 children die in road accidents each day (all transport modes). The effectiveness of child restraint systems for children as car occupants has been proven by several studies, some of which are referenced in [55]. Note that in 2015 the UN global road safety week will be devoted to children as traffic victims. The Week will be held 4 – 10 May 2015 and the theme will be children and road safety. The Week will draw attention to the urgent need to better protect children in all transport modes and generate action on the measures needed to do so [56].

Eight countries have no requirements concerning safety equipment in imported used cars. The other countries require at least seat belts (see Table 10) and a few countries also other provisions like airbags, anti-lock brakes (ABS) or electronic stability control (ESC). For example Vietnam requires seatbelts, ABS and ESC according to WHO 2013.

Most countries have national road safety programs except Maldives, Mongolia, Nepal and Sri Lanka. Furthermore 13 countries have specified national targets on reduction of death due to road accidents (see Table 10). Only Japan, South-Korea and Philippines have set also targets for reduction of non-fatal injuries [1].

3.4 Examples of good practices

3.4.1 Characteristics of good practices

There are many good examples of successful road safety projects. Most of them share at least four characteristics:

- a challenging goal,
- recognition of the multi-stakeholder involvement needed,
- the importance of having a common understanding of the problem at hand,
- a shared will to transfer the insights into hands-on actions.

This calls for sustainable partnerships involving the civil society sector, local or national government for putting efficient social change into practice via legislation, and business which can catalyse implementation and contribute a focused efficiency of action. The need is expressed well e.g. by the World Bank in its review of road safety activities in China [32].

3.4.2 Example of partnership platforms for hands-on action

A neutral partnership platform can act as facilitator in cases where these stakeholders are not so comfortable working together. One such example is the Global Road Safety Partnership, GRSP [35], hosted by the International Federation of the Red Cross and Red Crescent. GRSP typically focuses low and middle income countries, and aims at bringing together all the relevant stakeholders, from business, government and civil society organisations, and help in the implementation of good practice road safety solutions adapted to their local language and culture. There are activities on the regional and local level in the forms of hands-on projects, and also administration of a grants fund for projects. Furthermore "Best Practice Guides" for key road safety areas have been developed by the WHO, World Bank, FIA and GRSP in collaboration, and address the key areas (see Figure 15, [75]:

- Data systems
- Drinking and Driving
- Helmets
- Pedestrian Safety
- Seat belts and Child restraints
- Speed management

Figure 15 Best Practice Guides developed in joint cooperation by WHO, World Bank, FIA and GRSP [75].

As important as developing these guidelines are mechanisms that facilitate their implementation. The Best Practice Guides typically make up a cornerstone in local capacity-building activities and hands-on projects initiated by e.g. GRSP.

3.4.3 Example of good practice project: Motorcycle helmet usage in Vietnam

Since 2007 Vietnam has a law requiring all motorcycle drivers and passengers to wear a helmet. Systematic enforcement of the strong legislation together with road safety educational efforts and social marketing campaigns resulted in an impressive rapid increase of helmet-wearing from 10% to 90%. Still child motor cycle passengers in general did not wear helmets, and an explicit amendment of the regulation mandated helmet use for children aged six and older. Several organizations joined forces and implemented a comprehensive, multi-year child helmet campaign. Based on a research-driven approach three main components were developed: 1) public awareness campaign, 2) police enforcement, and 3) partnership and capacity building. Provincial authorities, local communities and schools, helmet manufacturers, philanthropies and corporate sponsors complemented research bodies, NGO’s and advisors in the partnership which was managed via the Asian Injury Prevention Foundation (AIP). By 2013 the use rate had risen from 18% in 2011 to 38% in targeted cities. The campaign is now continuing in the targeted cities, and is also being replicated in other provinces [57].

3.4.4 Example of good practice: Consumer information - Safe vehicles and Safe operators

A large amount of road transportation is undertaken in cars. Several Asian EST countries are involved in new car assessment programs (NCAP’s). These programs aim at enabling car buyers to make informed choices of vehicles by providing a comparative safety rating. NCAP is also a tool that encourages automobile manufacturers to promote development and sales of safer vehicles. More information on NCAP, including the programs in the Asian EST region is provided in 4.4.2.

The star-rating system in typical NCAPs is also applied in other areas; one example is the Malaysian Safety Star Grading for Bus Operators where operators can apply to be rated, and the rating has a time of validity [60].

3.4.5 Examples of Technology Transfer and International Research cooperation

It is widely recognized that transportation policies aiming at reducing the adverse health impacts of road transport will require sophisticated inter-disciplinary research efforts and cross-disciplinary communication. Several Asian organizations, such as leading universities, are establishing cooperation with international cross-functional safety research centers in other countries to go beyond individual initiatives and existing expertise, and also to contribute important insights from the region and its characteristics. Among the mechanisms are memorandums of understanding and common research projects. There are many examples, and below three are mentioned. They all involve the Swedish collaborative, multi-stakeholder research center SAFER - Vehicle and Traffic Safety Centre at Chalmers, Sweden [61] are mentioned.

- TRIPP (Transportation Research and Injury Prevention Program) at Indian Institute of Technology, Delhi, has ongoing collaboration with SAFER, sharing expertise and research results e.g. in the fields of pedestrian and child safety as well as other issues. The result is enhanced knowledge in both organizations involved.
- China Sweden Research Centre for Traffic Safety (CTS) is a collaboration between partners in China - Tongji University and Research Institute for Highway Safety (RIOH) and Swedish partners Chalmers, Volvo Group (global commercial vehicle corporation) and Volvo Car Corporation. Inaugurated in December 2012, the CTS has the vision to deliver world-class traffic safety research that reduces traffic accidents and causalities with a focus on China. CTS is presently running collaborative projects with the aim to better understand the Chinese traffic situation regarding accident causation and human behaviour as well as safety issues related to heavy trucks.
- Industry and academy cooperation is another example of best practices. In Malaysia the University of Putra Malaysia has performed a research study on how to mitigate motorcycle accidents with trucks. Working with Volvo Trucks and with SAFER as advisor, real world studies have pointed out ways to make motorcyclists more identifiable and detectable at both shorter and longer distances for the truck driver.

4 Road safety targets and strategies in developed countries

4.1 Targets and achievements in Europe

In 2001, road accidents killed 54,000[2] people in the European Union (EU) [23]. The European "White Paper" of 2001[24] noted that if all EU countries would achieve the same safety performance as the best performing countries (United Kingdom, Netherlands and Sweden) the number of fatalities would be reduced by 20,000. Targeting a halving of the number of road deaths by 2010, the responsibility was largely put to the national and local level. The role of the EU was to contribute to the exchange of good practice between the EU countries through action at two levels: harmonisation of penalties, and promotion of new technologies to improve road safety.

The 3rd EU road action plan published in 2003 [29] noted the following main causes of accidents and injuries:

- Excessive and inappropriate speed causing 1/3 of the fatal and serious accidents.
- Drunk-driving responsible for about 10 000 deaths each year.
- Failure to wear a seat belt or crash helmet. If seat-belt use would increase to the best performing countries more than 7 000 lives would be saved each year.
- Driving less safe cars: if all cars on the road would have the same safety as the best performing cars in a class 50% of all fatal and disabling injuries could be prevented.
- High-risk accident sites (black spots) for all road users.
- Non-compliance with driving and rest times by commercial drivers.
- Poor visibility of other road users

The target of halving the number of road fatalities within the EU until 2010 has not been reached (Figure 16). In 2009 there were still more than 35,000 deaths due to road accidents and about 1,500,000 persons were injured [23]. The cost for society is huge, representing approximately 130 billion Euro in 2009 [23], and assessed to represent 2% of GDP in 2013 [62]. But Europe is also a relatively safe transport region: according to WHO 2013 [1] Europe has the lowest death rates due to road accidents compared to other regions in the world (Figure 17).

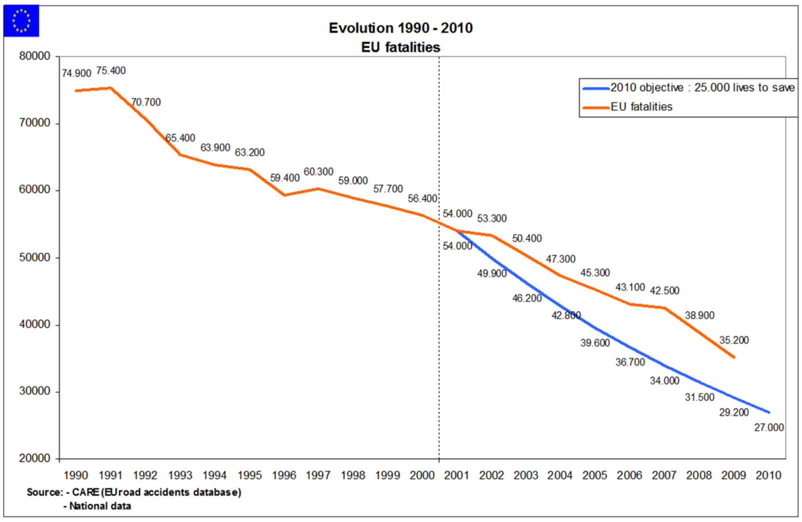

Figure 16 EU road fatality objectives and actual realisation

[2] This number was corrected from the original 40,000 due to the inclusion of new countries to the EU

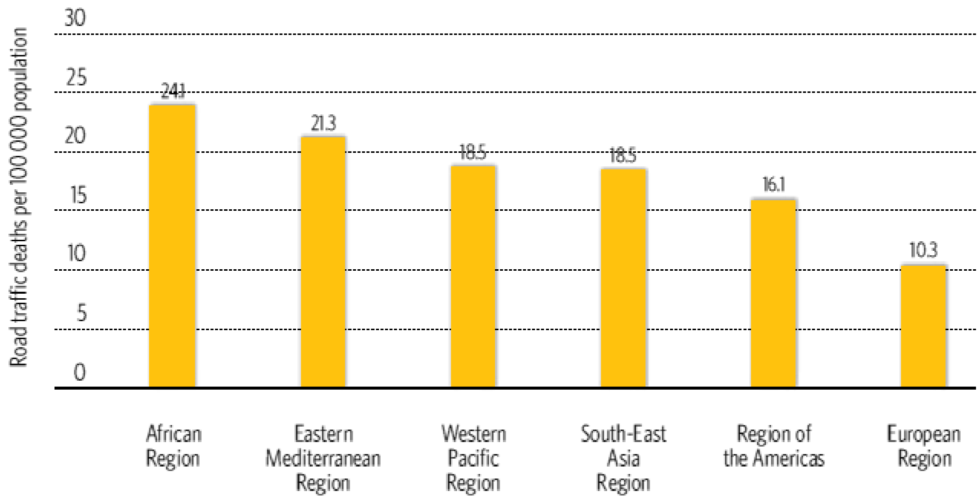

Figure 17 Death rates per 100.000 population due to road accident for different regions [1]

In the 2011 White Paper – "Roadmap to a Single European Transport Area" [25] the EU aims at a further reduction of 50% of road fatalities from 2011 until 2020 and for 2050 to move close to zero fatalities. This "zero vision" goal should be achieved by new intelligent safety technologies, applying improved safety testing (also considering new vehicle concepts with alternative propulsion systems), education and promotion of use of safety equipment and in particular also attention to vulnerable road users (pedestrians, cyclists and motorcyclists) through safer infrastructure and new vehicle technologies [25].

The significant improvements in road safety in Europe have, among others, been achieved by implementing research findings from large joint European research programmes funded by the European Commission in the field of road safety. This has resulted in better test methods for vehicle safety assessment, new crash dummies, improved accident analysis methods and accident databases, driver behaviour research findings, intelligent vehicle and active safety innovations, guidelines for safety of electric vehicles etc. For an overview of recent research programmes see [26]. Some of these results have been used in new safety regulations and updated EuroNCAP test methods, also covering pedestrian protection. Future research programmes will be based on safety roadmaps jointly developed by the most important stakeholders from industry, governments, consumer interest groups, research establishments etc. Examples are the 2011 ERTRAC (European Road Transport Research Advisory Council) Safe Road Transport Roadmap [27] and the 2014 PROS (Priorities for Road Safety Research in Europe) Long-term road safety research roadmap [28].

4.2 Safety Management systems

The road transport system is an open and complex system. A multitude of actors are influencing the design and use of the system. There is also a general idea that the system should be open and useable for all kind of road users. Over the years from the early time of motorization the system's safety shortcomings have been an issue but solutions have been sporadic and sometimes not orchestrated. In a way the tragic loss of life and health has been considered a cost we have to pay for mobility.

In most industrialized countries the number of road traffic fatalities was increasing in proportion with growth in traffic until around 1970. The breaking of this trend was a result of significant efforts made during the 60´s. These include vehicle regulations but also speed limits were introduced in a more systematic way. In the following time period traffic volume continued to grow but without increased fatality rates, some countries even experienced a reduction. Measures taken then include rules and regulations that have been used to control in particular motorized road users. Education and training have been the basis to ensure certain knowledge levels and behaviour. Enforcement has been used to fill the gap between what is allowed and what road users actually do. There have been significant engineering and design efforts trying to build efficient and safe roads and vehicles. All of these actions are still relevant in the traffic context of today.

A historic example, illustrating that the traffic safety aspect should be integrated from the starting point when creating new urban areas or transport infrastructure, was when Sweden in 1967 changed from driving on the left side on the road to driving on the right side [77]. This was a decision made by Swedish parliament in 1963, mainly driven by the will to adopt to European transport standards. All Swedish cars were already made for right hand driving. With the decision to chance from left to right, traffic safety became a big concern and several traffic safety improvements were implemented (road infrastructure changes, speed limits, training, campaigns, vehicle regulations and a new agency). When the actual change took place the fatalities suddenly dropped to levels far below the year before. The fatality rate in Sweden never again reached the figures of 1966.

4.2.1 Vision Zero approach

When Vision Zero was adopted as the main safety strategy by the Swedish Parliament in the late 1990s that was a significant step forward in a new direction. The ambitious target was not only to diminish fatalities and severe injury as a result of crashes. The ultimate goal was to eliminate these negative side effects of the transport system. The elimination of the severe injuries and fatalities is a very strong ethical statement indicating that in the long run there is little support to balance mobility and safety. Safety should instead be a prerequisite for mobility.

The basis for Vision Zero was a holistic view on the road transport system [54]. The users were in focus and the system should be developed to absorb human errors and mistakes. Instead of trying to adapt the road users to the system, the aim was to adapt the system to the users. However, this did not imply that users could behave as they wanted and still be kept safe. Vision Zero is stating that safety is a shared responsibility and that the user should to the best of their ability comply with the rules and regulation. The focus in Vision Zero is that errors, misjudgements and mistakes should not lead to severe injuries or of death. The same concept has been the basis for what in the Netherlands is called “**Sustainable Safety**” or the “**Safe System Approach**” originating from Australia (see Figure 18).

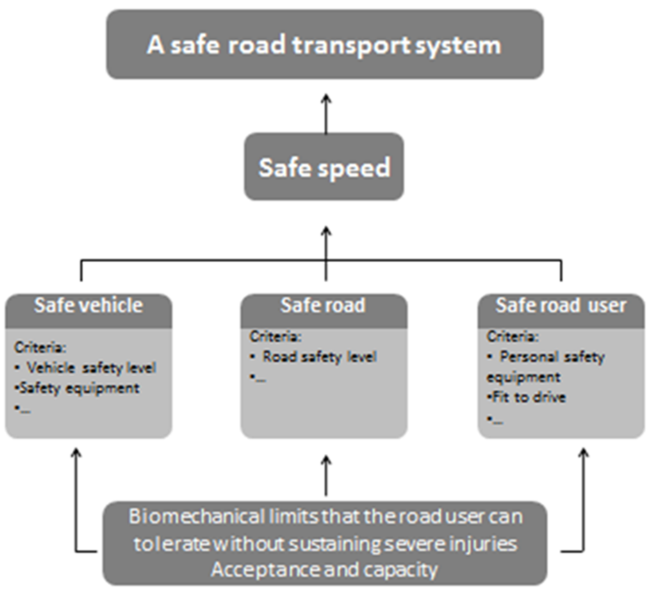

Figure 18 Example of a safe system approach

System absorption of errors and mistakes is one corner stone in Vision Zero, biomechanical tolerance is another. The human body has developed over millions of years to be able to sustain forces relevant to our typical pre industrialization everyday activities. We humans are “designed” for energy levels of running or falling from our standing height. Modern traffic has developed in a way that exposes us to energies and forces exceeding by far what we are developed to handle and survive. Therefore we need to manage speeds and/or protect the road users in a way assuring the energy levels are filtered to survivable levels. The typical example of the relation between impact speed and safety is that the fatality risk for pedestrians when hit by cars increases very rapidly when impacts occur at speeds over 30km/h (see Figure 19).

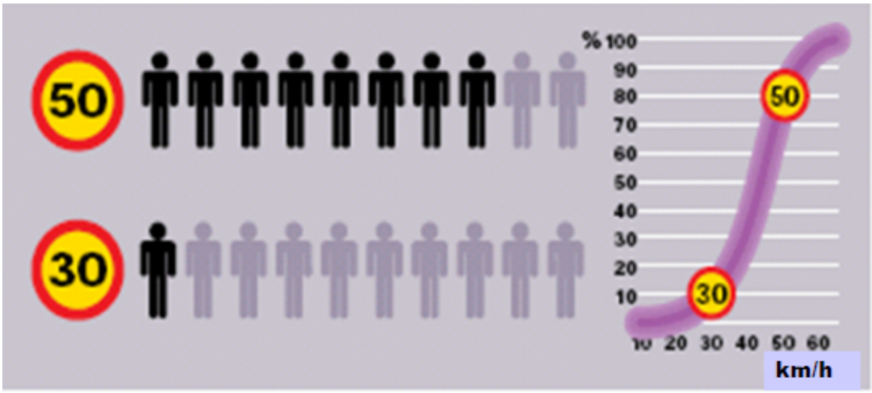

Figure 19 The relative risk for pedestrian injuries in relation to impact speed when hit by a car. Source: [63] and the Swedish Transport Administration” [53]

The same is true for car occupants without seat belt. When the change of velocity in the crash is increasing over 30 km/h the fatality risk starts to increase in a rapid pace. But if putting the seat belt on, and using the safest available cars, we can typically survive crashes having changes of velocity up to around 65 km/h. Better crash protection can be linked to higher travel speeds in the system without risking severe injuries. But the basis is always what the human body can sustain.

In the same way as vehicle design can absorb and filter energy before it hits the human body, road design can influence how travel speed is converted into potential forces to the human body. In Sweden road median dividers have been used to almost eliminate head on collisions in the high speed network. Before the median dividers were installed high speed front to front crashes were common and the fatality outcome significant. After the installation of barriers higher travel speed could be allowed without risking fatalities. Another evident example of energy control by road design is the introduction of roundabouts in intersections. An appropriate roundabout is designed to lower speeds and by doing that reducing the harm. In many situations they also have higher capacity compared to traffic lights. It is essential to understand that low travel speed always can compensate for low safety. Putting it the other way around, investments in safety is a way to increase speed and mobility.

In Vision Zero the “systems designers” play a significant role in the improvement of safety. Any organization that influences the design and use of the road transport system is member of that group. The most evident is of course the road authorities, the vehicle designers, the police etc. But also many smaller organizations and actors influence road safety. There is a significant need to involve large parts of the society in the work to improve road traffic safety.

4.2.2 *Safety management standard*

ISO, the International Organization for Standardization, has developed a management system standard with road traffic safety in focus. Following the success with management systems standards for quality and environmental management ISO started in 2008 to develop what is today "ISO 39001, Road traffic safety (RTS) management systems - Requirements with guidance for use" [22]. See Figure 20 for a schematic overview of the process in ISO 39001. ISO 39001 is a tool for any organization that wants to work in a systematic way with road traffic safety. It is setting out a process where the management has an overarching responsibility for safety and the elimination of fatalities and severe injuries in the organization's sphere of influence of the organization. As a first element a mapping of that sphere should be performed, further objectives and targets should be set based on a predefined set of "Safety Performance Factors". These factors are supporting by identifying areas of significant importance to safety and are aiming at transferring important safety competence to non-expert organizations. The safety performance factors cover exposure elements and outcomes in the form of injuries and fatalities. But more important are the factors related to speed, roads, vehicles, safety equipment and road usage. These factors can be measured also in smaller organizations and give important indications on the safety performance. By using ISO 39001 and setting up stringent targets and follow up procedures, organizations can contribute to better road traffic safety in a structured and focused way.

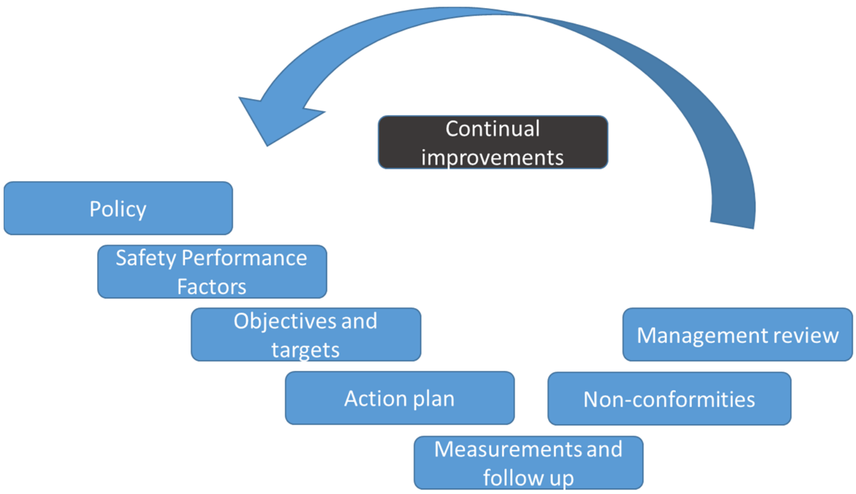

Figure 20 A schematic overview of the process in ISO 39001

4.2.3 *Multidisciplinary collaboration and open innovation*

In the wake of a more holistic approach to traffic safety the need for and strength of collaborative, multi-disciplinary, multi-stakeholder platforms have become apparent. There are several interesting initiatives of more or less formal nature in many countries and they are often encouraged by research and innovation bodies.

One example of this is the Swedish centre for vehicle and traffic safety research – SAFER – hosted by Chalmers University of Technology. Located in a modern science park in Gothenburg, Sweden, it brings together 30 partners from society, industry and academia. Some 300 researchers and experts are connected to SAFER. 85 research projects are presently running, covering the whole scope of traffic safety thus enabling cross-fertilisation between different stakeholders, disciplines and real world challenges. The SAFER set-up facilitates a holistic approach and as an example SAFER managed to gather more than 45 organisations and 150 individuals to compile "Safe Future" - a research and innovation agenda for traffic safety in Sweden [71].

4.3 Effectiveness of road safety measures

While it is important in many countries and regions of the world to increase the political awareness of the traffic safety problem and the need for policy action it is equally important to design an efficient traffic safety policy. Such a policy will not be the same in all regions of the world and needs to encompass regional specific circumstances. However, all efficient policies will be built on effective and efficient traffic safety measures.

Two types of objectives can be used when designing an effective or efficient traffic safety measure. In a *cost-effectiveness study* the focus is on finding the measures that achieve the effect, i.e. reduced fatalities, to the lowest possible cost. The approach can be used when comparing measures with similar one-dimensional outcome, i.e. fatalities. If we take a broader perspective and want to know if the resources spent are worthwhile for the country we need to use a *cost-benefit analysis* (CBA). In a CBA we need to establish a value (benefit) on the reduced accidents (see section 3.2) to compare with the used resources to implement the measure (cost). In both approaches it is important to take other non-monetary costs and benefits into account such as climate effects, lost travel time etc.

Decades of research have created a huge amount of scientific knowledge on traffic safety measures. OECD/ITF has highlighted the need to base policy on performance and efficiency evaluation [43]. In the Handbook of Road Safety Measures [44] a systematic search of the literature on traffic safety is done and summarised by means of the formal technique of meta-analysis. This approach minimises the contribution of subjective factors that are common in traditional literature surveys. However, it should be recalled that many of the studies are made in Europe or US which may bias the results.

The Handbook summarises a total of 110 specific road safety measures in the English edition from 2004 and the latest 2012 edition (currently available only in Norwegian) includes 142 safety measures (See Table 11). For each measure problems and objectives are described as well as description of the measure, effect on accidents, mobility and environment and finally, where available, cost and a cost-benefit analysis. Measures are evaluated in ten different areas.

Table 11 Measures evaluated in Handbook of Road Safety Measures [44]

Measures	**Measures evaluated**	
	Edition 2004	**Edition 2012**
General purpose policy instruments	14	13
Road design and road equipment	20	22
Road maintenance	9	9
Traffic control	21	27
Vehicle design and protective devices	28	34
Vehicle inspections	4	4
Requirements for drivers, driver training and professional driving	13	12
Road user education and information	4	4
Enforcement and sanctions	11	15
First aid	-	3

As mentioned in section 2.4, the Plan for the Decade of Action for Road Safety points out the following five key risk factors; speed, drunk-driving, not wearing motorcycle helmets, not wearing seat-belts and not using child restraints. Below follows a discussion about cost benefit aspects for the respective risk factors. This is the result of a combination of the material described above and an analysis of 117 studies from the international literature [44].

A reduction of the **speed limit** with 10 km/h from an initial limit of 90, 80, or 70 km/h will reduce the number of fatalities with 14% and severe injuries with 9%. To do a CBA of the optimal speed limit the increased travel time and reduced environmental burden have to be taken into account as well as a specific correlation between changed speed limit and changed actual average speed.

Being under the influence of **alcohol** is one of the single most important factors for increased accident risk. The relative risk compared to a sober driver can be summarised as in Table 12. This ratio may be different between different countries [44]. It is also clear that the effect is more pronounced for young drivers. To have a zero BAC acceptance for young drivers seems to be an efficient measure (CBA ratio 11 in USA) and to increase the control is also efficient (CBA ratio 1.2 in Norway).

It is well known that the use of a **helmet** will reduce the consequence if an accident occurs. The best estimates of the effect of helmet is a reduction in fatal accidents with 44% and severe injuries with 49%. The use of a helmet is an efficient measure with a CBA ratio of 17. A law on helmet use will increase the use of helmets but the effect will be depend on whether it actually creates a culture of helmets being worn.

Table 12 Relative risk for different BAC [44]

BAC (Blood Alcohol Content) %	**Relative Risk**
0.02 – 0.05	2.1
0.05 – 0.08	8.3
0.08 – 1.3	17.6
over 1.3	87.2

Wearing **seat-belts** is another of the important measures with a long history of research on effects and efficiency. In general the probability to have a fatal outcome is reduced with 40-50% in the front seat of the car and with 25% in the rear seat if seat-belts are used. Also the use of seat-belts is an efficient measure with a CBA ratio of somewhere between 3 and 8.

The effect on reduction in child fatalities in car accidents when using **child seats** is most often studied on small children (age 0-4). If a child seat is used properly the expected reduction in injuries is 55% for a forward facing seat and 71% for a rearward-facing seat. Studies also indicate that this measure has a positive CBA ratio [44].

4.4 Global vehicle safety regulations and New Car Assessment Programmes (NCAP's)

In the current decade the number of passenger cars in use worldwide is forecast to almost double and most of this growth happens in emerging countries, where the road safety challenges are greatest [31]. The safety performance of motor vehicles to reduce the risk of an accident and to protect the occupants and other road users in a crash can be evaluated by tests. Also the quality of safety systems like helmets or child restraint systems can be evaluated in this way. Tests can be full scale test with real vehicles as well as tests of systems or components. In case of crash tests often crash dummies are used to measure the injury risk. Two different evaluation systems exist:

- **Regulatory** tests required before a vehicle or a safety system can enter a certain market. They are usually minimal performance requirements.
- **Consumer** information testing like the New Car Assessment Programmes (NCAP's) where the protection offered by a vehicle or a component is rated by a third party and compared with the performance of other vehicles or safety systems. Test severity and/or requirements are often more demanding than for regulatory testing. The primary objective is to stimulate consumers to buy the safest vehicles and safety equipment.

4.4.1 *Global Vehicle Regulations*

Although a number of countries have their own national regulatory safety tests, global regulations developed within the UNECE[3] World Forum for Harmonization of Vehicle Regulations are significantly increasing in importance for a number of reasons. Economic concern is one aspect, and global regulations are seen as a way to facilitate international trade and reduce regulatory costs. Within the UNECE two[4] types of agreements are relevant here:

- *UN Regulations* (formerly called "UNECE Regulations" or "ECE Regulations) – based on what is called the 1958 agreement. A key element of a this type of regulation is mutual recognition, which means that a product approved to a UN Regulation must automatically be accepted in all countries having signed that specific regulation.
- *Global Technical Regulations* (GTR) – from an agreement in 1998. A GTR has to be specified into a national / regional regulation and a country is free to decide when and under what circumstances the technical requirements become mandated for their jurisdiction.

An overview of the current regulations is provided on the UNECE website [37]. Currently there are 133 UN Regulations and 15 GTR's, many of them in the safety area. Examples of a number of important Safety UN Regulations and GTR's are shown in Table 13.

In October 2014 48 countries (contracting parties) have signed the 1958 agreement and 34 countries the 1998 agreement. For an overview of the most recent status of contracting parties please refer to [36].

Table 13 Overview of important safety regulations

UN Regulation/GTR	Subject
UN Reg. 16	Seatbelts
UN Reg. 22	Helmets
UN Reg. 44	Child restraint systems
UN Reg. 94	Occupant protection in frontal collisions
UN Reg. 95	Occupant protection in lateral collisions
UN Reg. 129	Enhanced child restraint systems
GTR 8	Electronic stability control systems
GTR 9	Pedestrian Safety
GTR 14	Pole side impacts

Japan, South Korea, Russia and Malaysia have signed both agreements. In addition Thailand has signed the 1958 agreement and China and India the 1998 agreement. Most Asian EST countries are however currently not participating in the World Forum and have not signed the UN agreements. As a result there are many cars produced and sold in these countries that are sub-standard in comparison with the UN's minimum safety requirements. According to Global NCAP [31] from 65 million new

[3] UNECE = United Nations Economic Commission for Europe

[4] In addition to these UN regulations there are also **UN rules** concerning periodical inspections (road worthiness [30]) signed by a small number of member states. . Studies show that around 10% of accidents are caused by mechanical failures of the vehicle and periodic vehicle inspections should help reducing this problem.

passenger cars built last year one third would not pass the UN regulations for front and side crash tests (UN Reg. 94 and 95) and do not have ABS and ESC systems fitted.

4.4.2 New Car Assessment Programs (NCAP’s)

These programs aim at enabling car buyers to make informed choices of vehicles by providing a comparative safety rating. NCAP is also a tool that encourages automobile manufacturers to promote development and sales of vehicles with high safety performance and a certain level of safety equipment installed. The NCAP programs typically consist of a number of crash tests with dummies representing the driver and occupants. For each test the risk of injury in different body parts is assessed based on biomechanical criteria, and these and other results from the different tests are aggregated into a “star rating” for the vehicle – the more stars the better. The selection of tests and criteria are based on accident statistics and extensive research. In addition there is recognition of availability of certain safety equipment of a predefined performance level. Sometimes criticized for over-simplification the star-ratings nevertheless give the consumer a user friendly way to consider the importance and performance of safety.

Worldwide there are now nine NCAP organisations of which four are active in the Asian EST area: C-NCAP (China), JNCAP (Japan), KNCAP (South Korea) and Asean-NCAP. The Global New Car Assessment Programme (Global NCAP) was launched in 2011 to share best practices and support NCAP’s setting up new test programmes. ASEAN NCAP was set-up by the Malaysian Institute of Road Safety Research (MIROS) with support of Global NCAP and is supported by automobile associations from Malaysia (AAM), the Philippines (AAP) and Singapore (AA Singapore). NCAP test programs worldwide do not always have the same test methods and assessment criteria. For an overview of the latest status of NCAP crash tests and regulatory crash tests see [38]. Examples of crash tests in JNCAP are shown in Figure 21.

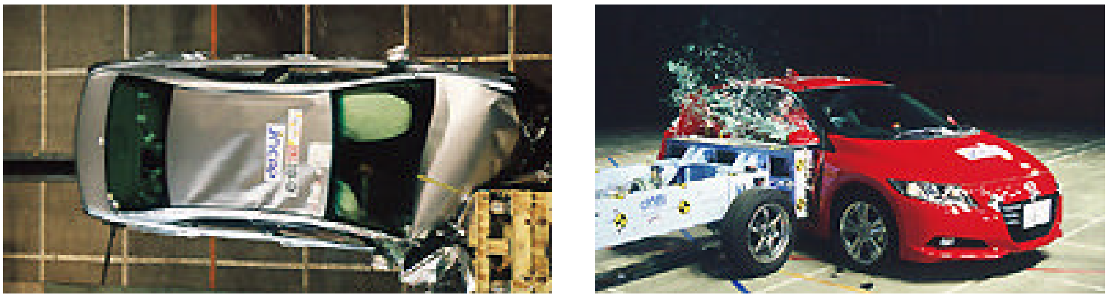

Figure 21 Examples of crash tests in JNCAP, Japanese NCAP –
frontal partial overlap test (left), side impact test (right) [64]

ASEAN-NCAP has currently one crash test in their program: a frontal partial overlap test at 64 km/hour with two dummies representing midsize males. Similar tests are also included in most other NCAP’s although some of them use only one crash dummy on the driver seat, while others also include child restraint systems, while still other have additional test setups. The test is based on UN regulation 94 but with a higher test speed: 64 km/hr instead of 56 km/hr in the UN regulation.

NCAP’s in Europe, Japan, Korea, China and Australia also include a side impact test (similar to UN regulation 95, “R95”), while US has different test conditions and unique dummies. A similar test is also considered for ASEAN-NCAP. Other tests in various NCAP’s include rear impact tests (assessing whiplash neck injury risk), pole side impact tests, pedestrian protection tests (safe vehicle fronts) and rollover tests. Also for intelligent assistance systems (crash avoidance technologies) some NCAP’s have included requirements.

It should be noted that due to the different rating systems applied not all 5 stars in the various NCAP's are the same. On the other hand all cars that are rated as 5 stars will be safer than one which just meets the minimum UN front and side impact crash tests [31]. The poor performance of vehicles in some countries that did not implement UN regulations and/or participate in NCAP's has been demonstrated in a number of test programs like the test program carried out recently in cooperation with Global NCAP on 5 popular vehicles sold in the Indian market. Most of the 5 vehicles which were tested both in NCAP and in UN regulation tests showed very poor safety performance. See [65] concerning details of the test program and some of the findings. An example of a tested car is shown in Figure 22.

The effectiveness of NCAP has been shown in various studies in which good correlation between EuroNCAP scores and injury outcome in real-world accidents could be demonstrated both for occupant and pedestrian protection (see for example the following Swedish studies: [50][51][52]).

Figure 22 Example of result of NCAP frontal test on vehicle sold in Indian market [65]

The UN recognises the important role played by NCAP's. In the 66th Session of the UN General Assembly (A/66/389) in 2011 it was stated that NCAP's "have proved to be very effective in creating a market that encourages consumers to choose vehicles based on their safety ratings" and a recommendation to the Member States was made to "participate in the new car assessment programmes in order to foster availability of consumer information about the safety performance of motor vehicles" [31].

4.5 Future trends and research needs

The transport of people and goods in in the world will undergo many changes the next 20-30 years due to increase in urbanisation and increased environmental concerns, changes in use of transport modes and mobility needs, shortage of natural resources, strong application of Intelligent Transportation Systems (ITS) solutions, changing views on private car ownership etc. These changes will both effect the high income and developing countries but the changes will be different, among others due to different motorisation levels, differences in land use planning. Two important linked trends and changes will be discussed here: The **shift in transport paradigm** and **future safety technologies.**

4.5.1 Shift in transport paradigm

Several international organisations are analysing possible scenarios and looking into alternative transport futures based on a shift in transport paradigm. Some of the main characteristics of these ideas are outlined in the following.

The introduction of the "Vision Three Zeros - Zero Congestion, Zero Pollution, and Zero Accidents towards Next Generation Transport Systems in Asia" 2013 is an initiative aiming at a more productive and positive development for all users by means of sustainable transport in Asia. A new approach to match the need for mobility and access is slowly emerging and the challenge is now to increase access to services and utilities for all by means of, for instance, improving efficiency, safety and security in public space. Such policies include a “safety culture” to make travelling and streets safer and more secure.

The global car-and-road system will of course continue to develop but the time when all families were seen as potential car owners have passed and the transition to a new transport regime has begun. Several countries and cities are slowly shifting focus from planning for the car society to instead, make plans for low-carbon mobility based on a multitude of modes of transport. Already today, a huge part or, perhaps even, most travels in certain areas are made on non-motorised means of mobility and public transport. These modes will have to be further developed, modernised, designed, regulated, managed and controlled by authorities in order to meet the safety requirements and to be more secure. Today, it is often the case, that informal public transport, footpaths and roads are not designed or maintained accordingly, and hence, impeding on walkability and access for low-income families. Street lights are often missing; cars and heavy vehicles drive to fast and so on. Therefore a greater responsibility for making non-motorised and/or informal means of mobility safe will be a genuine part of the next generation of transport policies.

Goods transports are an important cause of unsafe conditions and also play a big role in health issues since growing cities increases the requirement of goods distribution and waste management. The goods transportation in urban areas is one example of traffic safety risks, especially for vulnerable road users. Research shows that introducing new logistic planning resulting in more efficient and less intrusive transport operations increases safety significantly and, at the same time, decreases congestion and $CO2$ emissions. Such improvements can be achieved for goods distribution by urban consolidation centres, which allow consolidated deliveries with environmental friendly and less intrusive vehicles [76].

In the near future E-commerce is likely to have a greater influence on distribution patterns. Huge investments are expected to be made in transport infrastructure that will improve the conditions for an ever-increasing global population and to cut the emissions of $CO2$ [72] as long as they are made in sustainable transport systems.

In the future more commuter journeys are expected to be made by public transport and probably even more people will access their destinations walking and bicycling. In several countries life expectancy is increasing and the composition of families are changing in cities which means that a growing number of elderly will depend on taking a bus or travel by train. Accordingly, an increasing number of vulnerable road users will spend time on roads, stressing the requirement of urban designs that meet the safety and security needs of these road users and encourage safe behaviour. The street space can e.g. be designed to facilitate the safe interaction between drivers and pedestrians at intersections. With regards to social equity, special attention will be paid to the most vulnerable road users such as children, elderly, street vendors, and motorcyclists that spend considerable time on or nearby roads.

The increasing numbers of travellers in the systems of transport and on roads imply a range of partly, new and old issues of a greater magnitude than ever before in history, will have to be addressed by the authorities. Examples include city planning, the design of safe streets and intersections for all road users, and secure public transport infrastructure. It is foreseen that a mix of heterogeneous measures, some of them building on smart technology, is may be needed to improve safety together with behavioural and attitudinal changes to assume a shared responsibility for the enormous amount of travelling in what is called the Asian Century. The transport behaviours of road users from all socio-economic groups, ages and sexes need to be surveyed and the results integrated in a comprehensive national traffic and transport planning based on the principles of road safety.

4.5.2 *Future safety technologies*

Among the trends in the fast development of technology, there are in particular two that will influence the research roadmaps and future vehicles, especially in high-income countries:

- introduction of more sustainable vehicle using alternative propulsion systems
- vehicle automation, ultimately leading to fully automated driving where the driver may be out of the loop at the end.

More sustainable and lighter vehicles

New propulsion system (like electric vehicles) in conjunction with weight and size reduction will lead to new vehicle architectures which pose new challenges concerning vehicle safety, such as protection of occupants in crashes with significantly heavier vehicles. Figure 23 shows some ideas of future vehicle designs resulting from the European project ELVA (Advanced Electric Vehicle Architectures [66]. The electrification trend is also affecting pedal cycle design. Bicycles are increasingly becoming partially electrified and this is likely leading to elevated speeds for this vulnerable road user category and consequently higher injury risk. The light weight trend will also result in increased popularity of ultra-light vehicles, for which no safety requirements yet exist.

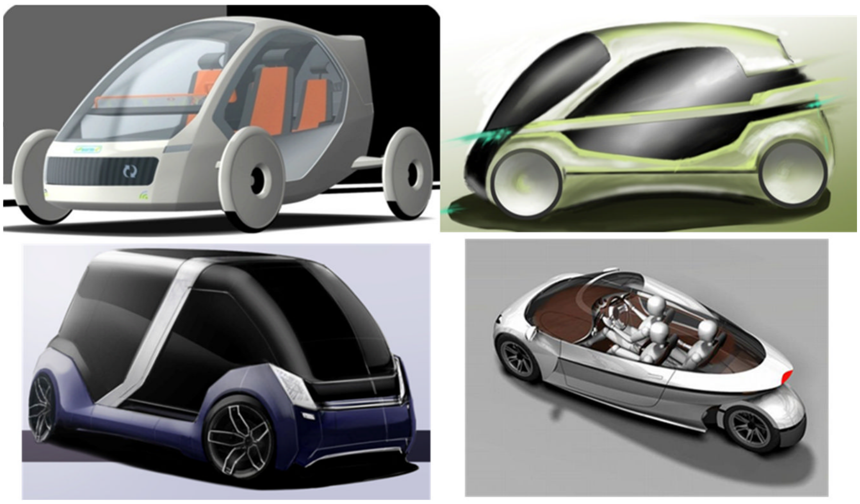

Figure 23 Examples of designs resulting from the ELVA vehicle design contest [66]

Automated driving

The automotive community has achieved significant progress in the development of automated vehicles in conjunction with fast developments in the field of ITS (Intelligent Transport Systems) technology. There are also new players outside the traditional automotive sector entering the field. In addition to many technical issues there are several other questions to sort out, such as: Do we actually want automated vehicles and if so, how can we deal with the legal and social consequences? How to secure a net safety benefit from automated traffic? Can developing countries benefit from these developments?

Several levels of automated driving can be distinguished. Several organisations have proposed definitions for the levels of automation in automated driving. One example is given in Table 14, which summarizes the five automation levels proposed by NHTSA, the US National Highway Traffic Safety Administration. The levels vary from 0 (no automation) to 4 (full self-driving automation) [67].

Table 14 Level of automation as distinguished by NHTSA [67]

Automation Level	Description
No-Automation (Level 0)	The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times
Function-specific Automation (Level 1)	Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.
Combined Function Automation (Level 2	This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centering.
Limited Self-Driving Automation (Level 3):	Vehicles at this level of automation enable the driver to keep full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time
Full Self-Driving Automation (Level 4)	The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles

Currently several systems are already commercially available, such as Adaptive Cruise Control (ACC), Lane Keeping Assist (LKA) and Autonomous Emergency Braking (AEB) which are all examples of Level 1 automation, i.e. the stage of driver assistance. Some of the systems would already now offer significant benefit in developing countries due to their safety potential. This is particular true for emergency braking in case of a potential crash with a vulnerable road user. Tests with automated vehicles and/or driving on all levels are conducted world-wide but the question remains when automation will be widely available in consumer vehicles. To have automated vehicles drive safely and efficiently on public roads, numerous challenges have to be resolved including behavioural, legal, social and technological aspects. Automated driving is expected to have significant safety benefits since its ultimate aim is a 100% reduction of accidents involving vehicles.

4.5.3 Research Needs

It will be no surprise that safety research roadmaps in the developed world are heavily influenced by the above mentioned trends to more sustainable vehicles and automated driving. One example is to define boundary conditions to ensure safe automated traffic. Several other research items however need to be included as well. Among these is a demand for improved data on accidents and incidents in order to define future priorities and assess the effect of new measures. There is also need for research into human behaviour like inattention, protection of all vulnerable road users including better knowledge on human tolerance and methods for more economical assessment of safety systems by virtual (computer simulation) assessment rather that physical testing. In Europe a unique cooperation between the major European stakeholders has resulted in the summary of Priorities for Road Safety Research in Europe – shown in Table 15. There is also an associated long-term road safety research roadmap [28].

Table 15 Research needs in PROS roadmap [28]

Research area	Research topics
Human	*Behaviour in traffic - making us safer road users*
	Improving protection in crashes - counteracting our fragility
Vehicle	*Technological leadership in safe future vehicles - from assisted to automated driving*
	Technological leadership in safe future vehicles - improving protection in crashes
	Vehicle technology for two-wheeler safety
Infrastructure, ITS & ICT	*Safe road design - making them self-explaining, forgiving and interactive to the benefit of all*
	Advanced road maintenance concepts for safety
	Innovation in ITS for road safety - making use of the connected world
	Traffic management for safety
Safety analysis & assessment	*Understanding what is happening on the road and linking it to measures*
	Evaluating the impact of safety concepts

The advancement in vehicle automation is also the leading theme in the EuroNCAP roadmap 2020 published June 2014 [68]. It can be expected that the Global NCAP roadmap which is planned to be published in 2015 will contain a number of elements from this latest EuroNCAP roadmap.

4.5.4 Motorcycles and trucks

Apart from addressing passenger cars, pedestrians and cyclists it is also important to focus on accidents involving motorcycles and trucks which make up a significant share in the number of accident fatalities and injuries. For motorcycles and mopeds next to helmets and advanced braking systems, visibility and protective clothes are important but also well-designed guard rails that help mitigating the effect of an impact rather than making it more severe [69]. Various research projects like the one in Malaysia (section 3.4) and APROSYS [69] in Europe have dealt with these topics and new studies are planned. Concerning visibility of motorcycles use of day-time running lights has been proven to very effective in several countries like for instance Singapore [70].

For trucks many of the accident avoidance systems mentioned earlier in this paper will be applicable and some kind of automated driving will become a realistic option for trucks on highways in a not too far future. Also effective blind spot information systems, better compatibility in crashes with other road users by front energy absorbing structures for the benefit of impacts with vulnerable users and passenger cars have shown to be beneficial [73][74].

5 The Way Forward

This paper clearly shows that road safety is causing large problems and costs in the Asian EST countries with an enormous impact on the well-being of people, economy and productivity. The total cost of road traffic related fatalities and injuries in the 24 Asian EST countries, calculated as a loss to the economy, is estimated to 3.3% of GDP and in some countries it is even exceeding 4% of the GDP. In many of the Asian EST low and middle income countries the yearly number of fatalities and injuries is still further increasing while in many high income countries worldwide these numbers are decreasing. Vulnerable road users (pedestrians, cyclists and motor cyclist combined) are particularly at risk.

The above figures and the material throughout the paper definitely justify that road safety in Asian EST should be given rightful attention, including taking powerful, effective actions. It stresses the need for reliable accident data which are imperative to determine evidence based intervention strategies and monitor the success of these interventions and analyses. As has been shown above there is a large underreporting in the official statistics which is usually based on police data. Ensuring access to adequate data is therefore a primary recommendation in order to move forward to the Bali Vision. Still, lack of good high quality accident data should not be an excuse to postpone interventions. There are many opportunities based on experiences from other countries, as is shown in this paper.

The aim of this section is to illustrate how road safety measures can contribute towards the economic growth, social integration, national productivity and human development to achieve the Bali Vision - Zero Accidents. Suggestions for safety improvements in the Asian EST region will be presented with a particular emphasis on measures proven to be effective in other parts of the world. The areas addressed below follow the 5 pillar structure of the WHO Decade of Action for Road Safety 2010-2020. A number of the Asian EST countries already have made great progress in implementing a number of the suggested activities in this WHO action plan as was shown in 3.3, but other countries hardly have implemented any of the recommendations or failed to promote and enforce them. In the various sections below a summary of WHO action plan for each specific pillar is given, complemented with specific recommendations of high importance based on the findings of this paper.

5.1 Road safety management

In order to secure safe mobility in future scenarios, safe interaction between the different players in the traffic environment is needed, e.g. the road users and traffic management actors. Furthermore safety needs to co-exist with other societal demands on the transportation system, e.g. efficient traffic flow and cost aspects. It is important to demonstrate cost/benefit. Cost effective business models become more important, especially when introducing solutions involving ICT (Intelligent Communication Technologies).

Activities in this area will generally have a longer time horizon before their effect can be clearly demonstrated, but they are considered crucial for the implementation of a sustainable road safety strategy in a country.

Pillar 1 in Decade of Action (Road safety management) takes an integrated vision as a basis for a safe system approach. Essential actions include:

- establishment of a national lead agency
- establishment of a national road safety plan with realistic safety targets and corresponding budgets

- setting-up monitoring systems for accident data and for other indicators of safety improvement.

Supporting material for activity implementation and establishment can be found in e.g. Handbook on cost/benefit of different traffic safety counter-measures (see section 4.3), Swedish Vision Zero (see section 4.2) and its methodology and "Safe Future" - the strategic research and innovation agenda for traffic and vehicle safety , see section 4.2.3.

Two specific recommendations are:

- **Public transportation** needs to be reliable, safe and in harmony with other traffic, requiring a systems mind-set. In general the numbers for injuries in public transportation vehicles are low compared to private means of transport. If demand for public transportation increases, so will the number of heavy vehicles in areas where more people will be pedestrians on their way to and from the transporting vehicle. It is highly recommended to take a systems approach and to consider these and other dynamic effects to secure an overall positive outcome of a shift towards public transport.
- **Leveraging ICT -** This relatively new area revolves around the increased connectivity of things and people enabled by cameras located in public spaces, access control systems, etc. as well as smartphones, and how they can be used to develop traffic safety promoting solutions and/or traffic-related "apps" (applications). "Apps" and solutions can give general traffic information that may have safety implications and can thus be used for planning and warning purposes. They can also provide data on what goes on in the closer vicinity. It is recommended that while exploring and developing ICT solutions, related risks are also taken into account- increased distraction, reliability and timeliness of information and data etc. and consider that it cannot be expected that indeed 100% of all road users are connected in the foreseeable future.

5.2 Safer Roads and Mobility

In order to reach true improvements in traffic safety all road users need to be taken into account, including the most vulnerable ones. Safe road design and maintenance need to be satisfactory from the road safety point of view of all road users. The condition and the arrangement of infrastructure, such as roads, bike paths, loading/un-loading areas etc. shall not in themselves induce risk of injury. Implementation and prioritization of operation and maintenance, and management of the infrastructure and its maintenance should be organized to meet traffic safety demands

Pillar 2 in Decade of Action (Safer roads & mobility) lists activities with the aim to improve the safety and protective quality of road networks for the benefit of all road users. The pillar includes e.g. the following essential actions:

- elimination of high risk roads by 2020
- safety impact assessments as part of all planning and development decisions
- speed management and speed sensitive design of the road network
- ensuring work zone safety
- set minimum safety ratings for new road investments that ensure the safety needs of all road users
- encouragement of education and R&D in the field of safe road infrastructure

Three specific recommendations are:

- **Separate roads or lanes** for special transport modes and oncoming traffic and in particular for vulnerable road users like pedestrians, cyclists or motorized two-wheelers - have been proven to be successful in many countries in view of safety and health aspects. When introducing separate roads it is also recommended to build in properties that encourage their use, such as easy access points. Also avoidance of falls and other single accidents should be considered upfront by e.g. selection of appropriate materials for the surface but also the surroundings.
- **Maintenance of roads -** Designs that facilitate or reduce the need for maintenance should be rewarded. It can include addressing e.g. lack of correct information to road users, or neglected actions as trimming of obscuring plants. Changes in environmental conditions (weather, light, temperature etc.) should be safely handled by the traffic environment. Indicators for monitoring and follow-up of the maintenance are recommended.
- **Intelligent Communication Technologies** – It is recommended to explore opportunities to utilize ICT for information and decision support also for the infrastructure and its maintenance. Already available information may be complemented by the ever increasing amount of directly or indirectly connected road users. Efficient operation of ICT, advanced driver support systems and connectivity services may raise requirements on the traffic environment.

5.3 Safe Vehicles

In a future where the Bali Vision has been reached the vehicles are of many different types – some of them transport goods, other people; they may be for private or public transportation, including also the vehicles of vulnerable road users (e.g. two-wheelers with or without power). Irrespective the vehicles need to be safe for their occupants as well as for surrounding road users. The crucial consumer and market demand to actually get well performing vehicles on the roads needs to be accelerated.

Vehicle aspects, in particular relating to cars, are the topic of *Decade of Action's Pillar 3 (Safer Vehicles)*. The pillar includes e.g. the following essential actions:

- Implementation of UN vehicle safety regulations and new car assessment programmes (NCAPs). Recommendations for inclusion of technologies such as ESC and ABS.
- discouragement of import and export of new or used cars that have inferior safety levels
- increased research into safety technologies designed to reduce risks to vulnerable road users
- encouragement of managers of governments and private sector fleets to purchase vehicles that offer advanced safety technologies and high levels of occupant protection

Numerous reports point out driver behaviour as the main cause of accidents, and driver distraction and inattention is a focused research area with many recent studies. Vehicle design has the potential to contribute to an enhanced behaviour, as well as help avoiding conflict situations through new accident avoidance technologies. If and when accidents still occur continued efforts will be needed to prevent and reduce injuries of different magnitude – whether caused inside, on or by different vehicles. It is worthwhile stressing that it is the broad mix of vehicles that need to be considered.

Three specific recommendations for ***Safe Vehicles*** therefore include:

- Introduction of **Collision avoidance technologies** – In addition to the technologies recommended by WHO (primarily ABS and ESC) emerging technologies should be introduced in particular automatic emergency braking (AEB) and required as soon as feasible in a particular traffic environment. This holds for passenger cars but also for trucks and buses.

Drunk-driving (and drug-driving) is a major problem in many countries. In addition to breath test controls, introduction of compulsory alcohol locks in vehicles can be considered.

- **Truck safety** – WHO recommendations concerning trucks focus on safe operation of trucks. But much more can and has to be done on the vehicles themselves, including (see also 4.5.4): visibility of other road users including introduction of blind spot detection technology, under-run protection at the front, rear and side and energy absorbing fronts for collisions with other road users (compatibility) and in particular for collisions with pedestrians and cyclists.
- **Motorcycle safety** – Next to helmet usage which is well covered in the WHO action plan important measures include: promotion of protective clothing, requirements for advanced braking systems on motorcycles and measures that improve the visibility of motorcycles like day-time running lights.

5.4 Safe road users

A human in the traffic environment can be considered an object with a certain tolerance to external impact from an accident. More importantly a human is also a decision making part of the traffic system, actively choosing how to behave – including conscious misbehaving. Addressing road users groups that are statistically overrepresented in the accident statistics is of key importance. These include, but are not limited to, motorcyclists, young drivers and older road users. Distracted road users are emerging as another group. Detailed knowledge and ability to identify the groups are required, and reinforces the before mentioned need of accurate accident data.

Activities aimed at developing comprehensive measures and programmes to improve road user behaviour can be found in *WHO's Pillar 4 (Safer road users)*. It includes the following essential actions:

- implementation (if not done yet) and enforcement of laws and/or standards concerning maximum speed, drunk-driving, and the usage of helmet, seatbelt and child restraints, combined with public awareness/education concerning these risk factors.
- introduction of policies and practices to reduce work-related road traffic injuries in the public, private and informal sectors
- establishment of Graduated Driver Licensing systems for novice drivers**.**

The importance of addressing *Child Safety* can be highlighted with one example from China. National and international experts gathered at the "Improving Child Safety Awareness & Law Enforcement International Conference" in Shanghai, China October 22-23, 2014, concluded that one of the main measures in increasing child restraint usage and hence the child protection in cars, is to enforce regulations for child restraint usage.

Three specific recommendations for ***Safe Road Users:***

- **Pedestrians** – The ambition should be that vulnerable road users can move safely inside as well as outside urban areas. The view of pedestrians as well as the pedestrian's perceived safety may vary significantly in different parts of the world. Nevertheless a person walking in traffic should not have to worry about falling, being injured, run over or assaulted. A dedicated approach can overcome some of the current deficiencies, such as lack of adequate data and coordinated actions – which, if existing today, often are fragmented.
- **Elderly persons** – This increasing age group should feel safe to move about in traffic and when using public transportation. Keeping a high degree of mobility also at higher age is essential for the individual's continued quality of life, and movements in traffic should be absent from worries for assault, harm or injury. Generally members of this heterogeneous

group are more fragile and spend more time in traffic as pedestrians and bicyclists than other age groups. This needs to be taken into account in e.g. public transportation and its associated stops, access routes and vehicles.

- **Bicyclists** – The changing patterns in bicycling seen in several countries are additional incentives to work towards a reduced number of accidents involving bicycles, including electrical bikes. The e-bikes allow much higher speeds than regular bikes, and since their number is assumed to grow, helmet wearing for e-bike riders should become compulsory in order to change the trend of increasing fatalities and injuries seen among pedal bicyclists. The successful introduction of helmet wearing in many countries has shown that the helmet not only to protect in accidents with vehicles but also in single accidents – further adding to the reasons for increased helmet wearing.

5.5 Post-crash response

WHO's Pillar 5 (Post Crash Response) proposes an increased responsiveness to post-crash emergencies and improvement of the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims. Essential actions included:

- the implementation of a single countrywide telephone number for emergencies
- development of hospital trauma care systems
- early rehabilitation and support to injured patients
- encouragement of research and development into improving post-crash response.

It should be noted that Post-crash involves different disciplines that may lack a shared basic understanding or that haven't yet established a deep collaboration (automotive, medical care, emergency services, etc.) and their interaction should be encouraged.

5.6 Concluding remarks

Improved road safety can only be reached when introduced measures and actions are applied, respected or observed. The need for persistent promotion of measures already at hand is obvious - Even when data clearly points out effects of different measures there are other studies showing that a high percentage of accidents and injuries are associated with the non-use or lack of enforcement of the measures. Bicycle helmets, belts, speed limits, optional safety equipment at vehicle purchases, are some examples.

Finally, it is recommended that when introducing any measure a "base-line" status is established and means to track progress and effectiveness are considered. Few, if any, of the recommendations mentioned in this paper can act in isolation – as mentioned repeatedly, enhanced road safety is the result of a persistent systems approach and collaboration towards a shared challenging goal.

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