COMMENTARY

Commentary: Status of road safety in Asia

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ABSTRACT

Objectives: The objective of this article is to assess the status of road safety in Asia and present accident and injury prevention strategies based on global road safety improvement experiences and discuss the way forward by indicating opportunities and countermeasures that could be implemented to achieve a new level of safety in Asia.

Methods: This study provides a review and analyses of data in the literature, including from the World Health Organization (WHO) and World Bank, and a review of lessons learned from best practices in high-income countries. In addition, an estimation of costs due to road transport injuries in Asia and review of future trends in road transport is provided.

Results: Data on the global and Asian road safety problem and status of prevention strategies in Asia as well as recommendations for future actions are discussed. The total number of deaths due to road accidents in the 24 Asian countries, encompassing 56% of the total world population, is 750,000 per year (statistics 2010). The total number of injuries is more than 50 million, of which 12% are hospital admissions. The loss to the economy in the 24 Asian countries is estimated to around US$800 billion or 3.6% of the gross domestic product (GDP).

Conclusions: This article clearly shows that road safety is causing large problems and high costs in Asia, with an enormous impact on the well-being of people, economy, and productivity. In many Asian low- and middle-income countries, the yearly number of fatalities and injuries is increasing. Vulnerable road users (pedestrians, cyclists, and motorcyclists combined) are particularly at risk. Road safety in Asia should be given rightful attention, including taking powerful, effective actions. This review stresses the need for reliable accident data, because there is considerable underreporting in the official statistics. Reliable accident data are imperative to determine evidence-based intervention strategies and monitor the success of these interventions and analyses. On the other hand, lack of good high-quality accident data should not be an excuse to postpone interventions. There are many opportunities for evidence-based transport safety improvements, including measures concerning the 5 key risk factors: speed, drunk driving, not wearing motorcycle helmets, not wearing seat belts, and not using child restraints in cars, as specified in the Decade of Action for Road Safety 2011–2020. In this commentary, a number of additional measures are proposed that are not covered in the Decade of Action Plan. These new measures include separate roads or lanes for pedestrians and cyclists; helmet wearing for e-bike riders; special attention to elderly persons in public transportation; introduction of emerging collision avoidance technologies, in particular automatic emergency braking (AEB) and alcohol locks; improved truck safety focusing on the other road user (including blind spot detection technology; underride protection at the front, rear, and side; and energy-absorbing fronts); and improvements in motorcycle safety concerning protective clothing, requirements for advanced braking systems, improved visibility of motorcycles by using daytime running lights, and better guardrails.

Introduction

Recent publications from the World Health Organization (WHO 2013) and the Institute for Health Metrics and Evaluation (IHME)–World Bank (2014) estimate that worldwide some 1.3 million people die yearly due to injuries in road accidents, and many more are injured, often with long-term disabilities as a consequence. This tragedy affects in particular those entering their most productive years (IHME/World Bank 2014; WHO 2013). 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 (IHME/World Bank 2014). For the 2015 fiscal year, low-income economies are defined by the World Bank as those with a gross national income per capita of $1,045 or less in 2013 and middle-income economies are those with a gross national income per capita of more than $1,045 but less than $12,746 (World Bank 2015). 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 (International Road Assessment Programme [iRAP] 2008).
The Asian Environmentally Sustainable Transport (EST) Initiative, which is a joint initiative of the United Nations Centre for Regional Development 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 multisectoral environment and transport issues (United Nations Centre for Regional Development 2010). Road safety is one of the core elements within the Asian EST initiative. Currently, the following 24 Asian countries, representing 56% of the world population, are participating in the Asian EST initiative: Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, People’s Republic of China, Indonesia, India, Japan, Republic of Korea, Lao PDR, Malaysia, The Maldives, Mongolia, Myanmar, Nepal, the Philippines, Pakistan, the Russian Federation, Singapore, Sri Lanka, Thailand, Timor-Leste, and Vietnam.

This article aims to review and summarize the most recent and relevant information on the global safety problem. Particular attention will be given to the Asian EST countries and accident and injury prevention strategies based on experience and effectiveness in developed countries will be presented. Status of implementation and indication for new opportunities to prevent road accident death in Asia will also be discussed.

This article is based on a report (Wismans et al. 2014) prepared for the 8th Regional EST Forum in Asia in Colombo, November 19–21, 2014, with the theme “Next Generation Solutions for Clean Air and Sustainable Transport—Towards a Livable Society in Asia.” The methodology used for this study included a review and analyses of data in literature, among others from the WHO and the World Bank; review of lessons learned from best practices in high-income countries; estimation of costs due to road transport injuries in Asia; and review of future trends in road transport.

**The road safety problem**

In 2004, the WHO and the World Bank jointly launched the *World Report on Road Traffic Injury Prevention* (Peden et al. 2004). 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 and noted that in many low- and middle-income countries, systematic efforts to collect road traffic data are not well developed yet. In order to assist countries in setting up good accident data systems, the WHO, together with some of its partners, developed a road safety manual concerning accident databases (WHO 2010) that contains detailed background on how to set up new accident database systems, strategies for improving data quality and strengthening the performance of systems already in place, as well as country-specific examples.

Since the launch of the *World Report on Road Traffic Injury Prevention* (Peden et al. 2004), 2 global status reports on road safety have been published by the WHO (2009, 2013). In these reports, data that were collected with the help of different sectors and stakeholders in each country are presented. For details on the methodology for collecting the data, refer to WHO (2013). The accident data included in the 2013 report concern the year 2010. For 2015, a third 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 2014) are based on the *Global Burden of Diseases, Injuries, and Risk Factors Study 2010* (GBD 2010; see: Lozano et al. 2012, Vos et al. 2012, Murray et al. 2012 and Salamon et al. 2012). The data are for the same year (2010) as the WHO (2013) status report. 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.

**Global fatalities and injuries**

The WHO (2013) study estimates about 1.24 million road fatalities in the world annually in 2010. The IHME/World Bank (2014) estimates are slightly higher: almost 1.33 million deaths due to motorized transport.

Deaths due to road accidents are just the tip of the iceberg. Nonfatal injuries are much more difficult to record and measure than fatal injuries. The reasons for this include difficulties in defining the severity of injuries and availability of good hospital data linked to police data (see IHME/World Bank 2014; IRTAD-OECD/ITF 2010; WHO 2013). This is particularly true for pedestrians and cyclists, who in many cases are completely unreported.

The GBD 2010 data analyzed in the IHME/World Bank (2014) study represent the first attempt to quantify data on nonfatal injury on a global level. For the year 2010, the number of injured persons worldwide due to road accidents was estimated to be 78.2 million persons needing medical care, of which 9.2 million requiring a hospital admission. 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" (IHME/World Bank 2014; p. 44). 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. The number of injuries reported in the IHME/World Bank (2014) study are higher and more precise than the earlier injury data reported by the WHO in various reports (20–50 million).

**Fatalities and injuries in Asia**

Table A1 (see online supplement) summarizes the number of deaths caused by road accidents in 2010 in the Asian EST countries derived from different sources. The 2010 population of each country is included (WHO 2013). Also shown are the number of nonfatal injuries (hospital admissions and total number of injuries) based on IHME/World Bank (2014).

The total number of estimated deaths by WHO (2013) and IHME/World Bank (2014), respectively, has the same order of magnitude—around 750,000—but large differences within some individual countries can be seen between these 2 sources: up to a factor 2 or more in countries like Afghanistan, Bangladesh, and Pakistan. When comparing the WHO and IHME/World Bank data with the official country data, the estimated total number
of deaths for the 24 Asian EST countries is more than twice the value from official sources, indicating high underreporting. This in particular appears to be the case in Afghanistan, Bangladesh, Pakistan, Myanmar, India, and China. In China, for example, 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 (IHME/World Bank 2014). 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 (so only one quarter of all road accident deaths in the DSP-based data are included in the official Chinese country statistics).

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 two thirds, of all injuries worldwide occur in Asian EST countries, whereas the region’s total population is 56% of the world population (IHME/World Bank 2014).

From the IHME/World Bank (2014) data, the total number of deaths (in percentages) in the Asian EST region for the various transport modes has been calculated. Pedestrians are the largest single category, with 35% of all deaths, followed by vehicle occupants, with 30%. Vulnerable road users (pedestrians, cyclists, and motorcyclists combined) make up 60% of the deaths due to road accidents.

Road safety and economic impact

In addition to the invaluable human tragedy, traffic accidents are a huge loss for the economy. These costs can be divided into direct economic costs, indirect economic costs, and value of life per se (Elvik 2000).

The direct economic costs are more or less visible, as medical costs, legal and emergency service costs, and property damage costs. Medical treatment will for some patients continue over many years, in the worst cases over their whole lifetime, and it is necessary to estimate the present value of future medical treatments. These costs are a visible burden to the economy but constitute in general only around 10% of the total accident cost (Department of Transport 2012).

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 labor cost, wages, and additional labor costs paid by his employer. The losses of an accident will continue over time up to retirement and will grow with a growing economy over time. However, the weight of the later years will be smaller because a discount rate will be used in the calculations. To account for the lost life span due to premature mortality, the number of years of life lost is measured as the difference between expected lifetime and actual age when the accident occurred. Years of life lost will thus measure the number of lost productive years if it is adjusted for local retirement age. For the Asian EST countries these costs have been calculated to be US$81 billion or 0.4% of gross domestic product (GDP) in 2010 for fatalities only, as described in detail by Wismans et al. (2014).

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 labor market observations (Viscusi and Aldy 2003) or responses to questionnaires (Jones-Lee 1976). A vast literature on methodology and metastudies exists (de Blaey et al. 2003; Miller 2000; Viscusi and Aldy 2003), concluding that although the methodology is not flawless, it is more appropriate than the alternatives. For the Asian EST countries these costs have been calculated to be US$250 billion or 1.1% of GDP in 2010 for fatalities only based on a VSL of 70 × GDP per capita as described in detail by Wismans et al. (2014).

The cost of serious injuries is based on a value of serious injury of 17 × GDP per capita (iRAP 2008), which results in a total cost of US$485 billion. Adding the cost for fatalities and the cost for serious injuries, the value of prevention to the economy in the Asian EST countries is estimated to around US$800 billion or 3.6% of GDP for accidents in 2010 only (see Wismans et al. [2014] for details).

In addition to these economic costs, traffic accidents are also a serious workplace hazard and may represent 30–50% of workplace fatalities depending on the region and whether or not commuting is included (Adirazola-Delgado et al. 2010). 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 salespeople), workers on the road (for instance, road maintenance crews), and commuting to work. Note that many of these workers are also the only breadwinner in a family.

Road injury prevention strategies and achievements in Asia

Probably the first systematic approach concerning accident and injury prevention strategies was the so-called Haddon matrix (Haddon 1968). It caused a shift from an almost exclusive focus on trying to improve driver behavior to a more comprehensive approach. The Haddon matrix identifies 3 phases—pre-event, event, and post-event—as sequential phases within a crash event as well as 3 components: human (behavior and tolerance), vehicle, and infrastructure (environment). This approach has 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 (Thomas et al. 2013).

New approaches like the “Vision Zero” in Sweden (Breen et al. 2008; Johansson 2009) and the “Safe System” approach (OECD/ITF 2008) view the traffic system more holistically. A full Safe System approach to road trauma requires that the crash energy in an accident is low enough to prevent (serious) injuries, recognizes 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 (OECD/ITF 2008).

Other important elements are formulating road safety strategies,
High-income countries have shown a continuous decline in death rates in the past 2 decades. In Europe, the number of road fatalities in 1990, which was around 75,000, dropped more than half, to 35,000, in 2009 (European Commission 2010). In the 2011 White Paper—Roadmap to a Single European Transport Area (European Commission 2011), the European Union 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, education and promotion of use of safety equipment, and, in particular, attention to vulnerable road users (pedestrians, cyclists, and motorists) through safer infrastructure and new vehicle technologies (European Commission 2011).

The achievements in road safety improvement in Europe and in many other high-income countries have in particular also been achieved by implementation of requirements for vehicle safety, including the regulations developed by the United Nations Economic Commission for Europe World Forum for Harmonization of Vehicle Regulations and the introduction of consumer test rating programs (New Car Assessment Programs, NCAPs). See Wismans et al. (2014) for an introduction and overview of United Nations (UN) regulations and NCAP programs worldwide, including the role of Global NCAP. The UN regulations should be seen as a set of minimal performance requirements. They are applied in many high-income countries, but implementation in other countries is still limited. In an NCAP, the protection offered by a vehicle or a 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 and to encourage industry to develop safer designs. 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 (Kullgren et al. 2010; Strandrot et al. 2011, 2014). Further studies into the cost-effectiveness of the introduction of consumer testing programs are recommended in particular in low- and middle-income countries.

### Decade of action for road safety 2011–2020

The United Nations Road Safety Collaboration (UNRSC) was established in 2004, recognizing the need for the UN system to support efforts to address the global road safety crisis. The WHO was invited to coordinate the road safety issues within the UN system (WHO 2011). The first milestone was the launch, in cooperation with the World Bank, the World Report on Road Traffic Injury Prevention (Peden et al. 2004).

In 2010 The United Nations General Assembly declared the decade 2011-2020 as the Decade of Action for Road Safety (United Nations 2010). The main objective of the plan was to stabilize global road accident fatalities until 2020 and then reduce the forecasted levels of global road fatalities by increasing road safety improvement activities at national, regional, and global levels.

Based on the Safe System approach, the Commission for Global Road safety defined 5 pillars for a road safety policy framework, which were used later in the Global Plan for the Decade of Action for Road Safety 2011–2020 (Commission for Global Road Safety 2009). Table 1 shows these 5 pillars from the Global Plan together with important activities within each pillar.

Furthermore, within the Plan for the Decade of Action for Road Safety, 5 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, and not using child restraints in cars. Background on the introduction and effectiveness of measures concerning these 5 risk factors can be found in the following 4 “best practice guides” developed by WHO and its partners: (1) speed management, (2) drinking and driving, (3) helmet use, and (4) use of seatbelts and child restraints (UNRSC 2015). A systematic overview of the efficiency of measures concerning these 5

| Pillars | Important activities |
|---------|---------------------|
| 1: Road safety management | Establishment of a national lead agency Establishment of a national road safety plan with safety targets and budgets Setting up monitoring systems for accident data and other indicators of safety improvement. |
| 2: Safer roads and mobility | 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 research and development in the field of safe road infrastructure |
| 3: Safe vehicles | Implementation of UN vehicle safety regulations and NCAPs Recommendations for inclusion of technologies such as ESC and ABS. Encouragement of use of safety equipment, and, in particular, attention to vulnerable road users (pedestrians, cyclists, and motorists) through safer infrastructure and new vehicle technologies |
| 4: Safe road users | Implementation (if not done yet) and enforcement of laws and/or standards concerning maximum speed, drunk driving, and the usage of helmets, seat belts, 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 Encouragement of managers of governments and private sector fleets to purchase vehicles that offer advanced safety technologies and high levels of occupant protection |
| 5: Postcrash response | Development of hospital trauma care systems Early rehabilitation and support to injured patients Encouragement of research and development into improving postcrash response |

### Table 1. Summary of important actions within the 5 pillars of the global plan for the decade of action for road safety (WHO 2011).
risk factors, based on an analysis of 117 studies from the international literature, can be found in TØI (2012). According to this study, a reduction in the speed limit with 10 km/h from an initial limit of 90, 80, or 70 km/h reduces the number of fatalities by 14% and severe injuries by 9%. The relative risk of being under the influence of alcohol compared to a sober driver is summarized in Table 2, showing that even very low blood alcohol content (BAC) levels result in an increased risk by a factor 2. The best estimate of the effect of helmet usage is a reduction in fatal accidents of 44% and severe injuries of 49%. For wearing seat belts, the probability of a fatal outcome is reduced by 40–50% in the front seat of the car and by 25% in the rear seat. The effect on reduction in child fatalities, if a child seat is used properly, is 55% for forward-facing seats and 71% for rearward-facing seats.

Social acceptance of measures, considering the variety in economic and geographical differences of Asian countries, is important. For instance, in the case of wearing helmets for riders in one of the hottest locations in the world, not only material properties of the helmet in high-temperature environments have to be addressed but how user-friendly and comfortable helmets are for riders. For example, in The Transportation Research and Injury Prevention Programme at the Indian Institute of Technology (Delhi, India), research on helmet use in a warm climate has been carried out. Different solutions have been developed, including more open models and the use of alternative, more affordable materials. Furthermore, to spur social recognition of traffic safety, continuous education of the younger generation in particular should receive high priority.

### Status of road safety measures in Asia

The WHO (2013) provides an overview of the road safety measures, including implementation of measures concerning the 5 risk factors and implementation of safety laws/standards in the 24 Asian EST countries. A number of the findings in this report are presented in Table A2 (see online supplement) and summarized below.

### Speed

All countries have some kind of maximum speed laws like maximum speeds in city centers. The effectiveness of enforcement of speed laws was rated by respondents on a scale from 0 to 10, where 0 and above is good. Only South Korea rated enforcement as an 8 and 4 countries rated it as a 7 (Cambodia, Japan, Singapore, and Vietnam). Countries like Afghanistan, Bangladesh, India, Pakistan, the Philippines, and Thailand, however, showed a low score of 3.

### Drunk driving

Laws concerning drunk driving exist in all countries except Afghanistan and the Maldives. In 5 countries, no BAC 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 to 10 (see Table A2) with high (8 and higher) ratings in Brunei, China, Japan, and Singapore and low ratings (3 and below) in 9 of the Asian EST countries, including India.

### Helmets

All countries except Afghanistan have helmet laws for motorcyclists and most countries control the quality of a helmet by a helmet standard, except Bangladesh, Laos, the Maldives, Mongolia, Nepal, and Timor-Leste. Without adequate laws, the risk of counterfeit helmets without sufficient protection increases. The helmets use rate is available for 11 countries (WHO 2013) and appears to be high (75% and more wearing rate) in Indonesia, Laos, Malaysia, the Philippines, Sri Lanka, and Vietnam.

### Seat belts

The use of seat belts in the front seat is required in all Asian EST countries except Afghanistan and Myanmar. Only 13 countries require seat belts to be worn in the back seat. The effectiveness of enforcement of seat belt use was rated high (8 and higher) in Indonesia, the Philippines, Singapore, and South Korea and low (3 and below) in 7 countries, among others in China and India, with a rating of 2. Actual figures are also available for about 10 countries (WHO 2013). They are high (more than 75% wearing rate) for drivers in Japan, Malaysia, the Philippines, Russia, South Korea, and Sri Lanka and low in India (27% use rate for drivers) and Pakistan (only 4% for drivers). For Thailand, the seat belt use rate is 61% for drivers and for China no data are available in the WHO (2013) report.

### Child restraint systems

Child restraints are required in 8 countries. No information is available from the WHO (2013) report on the effectiveness and enforcement of child restraint laws in the Asian EST countries.

### National road safety programs

Most countries have national road safety programs, except the Maldives, Mongolia, Nepal, and Sri Lanka. Furthermore, 13 countries have specified national targets on reduction of death due to road accidents. Only Japan, South Korea, and the Philippines have also set targets for reduction of nonfatal injuries (WHO 2013).

### UN regulations

Most low- and middle-income Asian EST countries have not implemented the UN regulations. As a result, there are many cars produced and sold in these countries that are substandard in comparison with the UN’s minimum safety requirements. According to Global NCAP (2014), of 65 million new passenger cars built last year, one third would not pass the UN regulations.

| BAC (%)      | 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         |
for front and side crash tests (UN Regs. 94 and 95) and do not have antilock brake systems (ABS) and electronic stability control (ESC) systems fitted.

**NCAP**

NCAP programs have been implemented in Japan and South Korea for quite some time. More recently they have also been introduced in China (C-NCAP) and Malaysia, Singapore, and the Philippines (Asian NCAP). India is considering including an NCAP program (BNVSAP, Bharat New Vehicle Safety Assessment Programme). The Global New Car Assessment Programme (Global NCAP) was launched in 2011 to share best practices and support NCAPs setting up new test programs. ASEAN NCAP was set up by the Malaysian Institute of Road Safety Research with support of Global NCAP. Note that NCAP test programs worldwide do not always have the same test methods and assessment criteria.

**Examples of good practices**

There are many good examples of successful road safety projects. Most of them share at least 4 characteristics:

- a challenging goal,
- recognition of the multistakeholder involvement needed,
- the importance of having a common understanding of the problem at hand, and
- 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 to put efficient social change into practice via legislation, and business, which can catalyze implementation and contribute a focused efficiency of action. The need is expressed well, for example, by the World Bank in its review of road safety activities in China (World Bank 2008). For an overview of examples of good practices and practical guidelines to develop road safety projects, see the publications developed jointly by multiple partner agencies of the UN Road Safety Collaboration on the UNRSC website (UNRSC 2015). One specific example concerns the iRAP (2015), which assesses roads (including the maintenance condition) all over the world and aims to significantly reduce road casualties by improving the safety of road infrastructure. Its activities include inspecting high-risk roads and developing star ratings, safer roads investment plans, and risk maps. Rating of a road means that a protocol-based safety assessment is made resulting in assigning the road design 1 (worst) to 5 (best) stars.

**Shift in transport paradigm**

The global car and road system will continue to develop. 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. A large part of travel in certain areas is made on public transport and by nonmotorized means of mobility. These modes will have to be further developed, modernized, designed, regulated, managed, and controlled by authorities in order to meet the safety requirements and to be more secure. In many countries in Southeast Asia it is often the case that informal public transport, footpaths, and roads are not designed or maintained accordingly, hence impeding walkability and access for low-income families. Street lights are often missing; cars and heavy vehicles drive too fast, etc. Therefore, a greater responsibility for making nonmotorized and/or informal means of mobility safe will be part of the next generation of transport policies.

Goods transport is an important cause of unsafe conditions because growing cities have an increased requirement for goods distribution and waste management. Research shows that introducing new logistics planning resulting in more efficient and less intrusive transport operations significantly increases safety and, at the same time, decreases congestion and CO₂ emissions.

The increasing numbers of travelers in the systems of transport and on roads imply a range of new and old issues that have to be addressed by 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, are needed to improve safety together with behavioral and attitudinal changes to assume a shared responsibility for the enormous amount of traveling in what is called the Asian Century. The transport behaviors of road users from all socioeconomic 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.

**Future safety technologies**

Among the trends in the fast development of technology, there are 2 trends that will influence the research roadmaps and future vehicles, especially in high-income countries:

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

**More sustainable and lighter vehicle**

New propulsion system (like electric vehicles) in conjunction with weight and size reduction will lead to new vehicle architectures that pose new challenges concerning vehicle safety, such as protection of occupants in crashes with significantly heavier vehicles. The electrification trend is also affecting pedal cycle design. Bicycles are increasingly becoming partially electrified driving where the driver may be out of the loop at the end.

**Future trends**

The transport of people and goods in the world will undergo many changes the next 20–30 years due to increases in urbanization and increased environmental concerns, changes in use of transport modes and mobility needs, shortage of natural resources, strong application of Intelligent Transportation Systems solutions, changing views on private car ownership etc. Two important linked trends and changes will be discussed here: The shift in transport paradigm and future safety technologies.
Automated driving
The automotive community has achieved significant progress in the development of automated vehicles in conjunction with fast developments in the field of 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 how to secure a net safety benefit from automated traffic and whether developing countries can benefit from these developments. Different levels of automated driving can be distinguished. Several organizations have proposed definitions for the levels of automation in automated driving like NHTSA (2013). The levels vary from 0 (no automation) to 4 (fully self-driving automation). Currently several systems are already commercially available, such as adaptive cruise control, lane-keeping assist, and autonomous emergency braking (AEB), which are all examples of level 1 automation; that is, the stage of driver assistance. Some of these systems would offer significant benefit in developing countries due to their safety potential. This is particularly 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 worldwide, 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 behavioral, legal, social, and technological aspects. Automated driving is expected to have significant safety benefits, but although its ultimate aim is a 100% reduction of accidents, there certainly will be some crashes and injuries remaining.

The way forward in Asia
How countries have approached auto mobility is not only about building roads and providing fuel. It also includes responsibility for adverse effects. The political system will have to assume responsibility and develop protective measures because experience shows that market forces will not develop such measures on their own. The various political levels (provinces, federal states, cities, municipalities, and so on) have to take responsibility and establish institutions that effectively engage in traffic safety issues. Such ambitions are in line with the definition of sustainable transport.

Progress in the area of road safety in high-income countries was made possible because of important efforts in capacity building, research, and the development of knowledge in the area of traffic safety. Studies of local conditions and the reasons why accidents take place made it possible to develop ways to reduce them. However, without a long-term commitment to improve conditions on the road, political will, policy, and planning, it would have been impossible to achieve safer roads. There need to be institutions and human resources together with a budget that pays for the work; otherwise, such development does not take place. It has taken decades to build capacity and implement policy and planning in developed countries. The challenges to improve road safety in developing countries are even much larger. This is due, among others, to the absence of adequate infrastructure, unplanned urbanization taking place, lack of a legal regulatory framework, and a strong increase in motorisation.

Vision Zero has gained major support in highly motorized countries. The basic concepts behind Vision Zero have global validity. In every development of the road transport system the target can be to absorb human errors. Key is to control energy transfer to the human body to safe levels. Speeds and designs should have this in focus. Another cornerstone of Vision Zero is the shared responsibility. Any organization influencing the design and use of the road transport system can contribute to road safety. The management system standard ISO 39001 (ISO 2012) can be an important guide for many organizations. A Safe System is the evident target for developing countries as well for already motorized countries.

Although many Asian countries have made great progress, the potential for improved traffic safety is high. If all countries were to give high priority to implementing the most relevant and effective activities in the Global Plan for the Decade of Action for Road Safety, substantial further improvements could be made. This in particular holds for addressing the 5 risk factors included in the Global Plan.

UNRSC is planning to update the Global Plan for the Decade of Action in 2015. For an overview of a complete list of recommendations for new activities in the Global Plan, see Wismans et al. (2014). Here we shall highlight a few of the new topics relevant for the Asian EST countries and taking advantage of recent technological developments and research findings.

Pedestrians and cyclists
The ambition should be that vulnerable road users can move safely inside as well as outside urban areas. Separate roads or lanes have been proven to be successful in many countries. The views 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. Furthermore, in many countries, a strong increase in the usage of e-bikes (electrically supported bikes) can be observed, allowing higher speeds than regular bikes. Helmet use for e-bike riders should be considered 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 protects in accidents with other vehicles but also in single bicycle accidents.

Elderly persons
Keeping a high degree of mobility at an older 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 growing and 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, for example, public transportation and its associated stops, access routes, and vehicles.

Collision avoidance technologies
In addition to the technologies recommended in the Global Plan (primarily ABS and ESC), emerging technologies should
be considered, in particular AEB and alcohol locks, which offer interesting opportunities in developing countries. This holds for passenger cars as well as trucks, buses, and motorcycles. It should be realized, however, that implementation of such accident avoidance and other future safety technologies depends on the regional situation in each country. In other words, the local situation should be carefully analyzed before the introduction of such new technologies.

**Truck safety**

The Global Plan recommendations concerning trucks focus on safe operation of trucks only. Much more can and has to be done on the vehicles themselves, including visibility of other road users; 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 Vulnerable Road Users (VRU) collisions.

**Motorcycle safety**

The Global Plan focus is on helmets only. However, much more can be done; for example, promotion of protective clothing, requirements for advanced braking systems on motorcycles, measures that improve the visibility of motorcycles like daytime running lights (Yuan 2000), and well-designed guardrails that help mitigate the effect of an impact rather than making it more severe (APROSYS 2009).

**Conclusions**

This article clearly shows that road safety is causing large problems and high costs in the Asian EST countries with an enormous impact on the well-being of people, the economy, and productivity. In several of the Asian EST low- and middle-income countries, the yearly number of fatalities and injuries is increasing, whereas in many high-income countries worldwide these numbers are decreasing. Vulnerable road users (pedestrians, cyclists, and motorcyclists combined) are particularly at risk.

The above figures and the material throughout the article justify that road safety in Asia 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. Still, lack of good high-quality accident data should not be an excuse to postpone interventions. There are many opportunities as shown in this article.

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 point out the effects of different measures, there are other studies showing that a high percentage of accidents and injuries are associated with the nonuse or lack of enforcement of the measures. Bicycle helmets, seat belts, speed limits, and optional safety equipment at vehicle purchases are some examples.

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**References**

Adriazola-Delgado et al. Michelin Challenge Bibendum. Achieving Zero Work-Related Road Deaths Road Safety Task Force; 2010. Available at: http://www.challengebibendum.com/publication/White-Paper-For-Safe-Roads-in-2050

APROSYS (Advanced PROtection SYStems). Final Report for the Work on Motorcyclist Accidents (SP4). Molinero, Ciduat, 2009. Available at: http://docplayer.net/6143131-Ap-90-0004-final-report-for-the-work-on-motorcyclist-accidents-sp4-project-no-tp6-plr-506503-aprosys.html

Breen J, Howard E, Bliss T. An Independent Review of Road Safety in Sweden. Swedish Road Administration; 2008. Available at: https://online4.ineko.se/trafikverket/Product/Detail/44643

Commission for Global Road Safety. Make Roads Safe - a decade of action for road safety. 2009. Available at: http://www.fiafoundation.org/media/44212/decade-of-action-report-2009.pdf

de Blaey J, Florax RJ, Rietveld P, Verhoef E. The value of statistical life: a meta-analysis. Accid Anal Prev. 2003;35:973–986.

Department of Transport. Reported Road Causalities in Great Britain. 2012. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244913/trccp-2012-02.pdf.

Elvik R. How much do road accidents cost the national economy? Accid Anal Prev. 2000;32:849–851.

European Commission. Towards a European Road Safety Area: Policy Orientations on Road Safety 2011–2020. Brussels, Belgium: Author; 2010.

European Commission. White Paper—Roadmap to a Single European Transport Area—Towards a Competitive and Resource Efficient Transport System. Brussels, Belgium: Author; 2011.

Global NACP. Global NACP Fleet Safety Guide and Safer Car Purchasing Policy 2014–2015. 2014. Available at: http://www.globalncap.org/wp-content/uploads/2013/07/gncap_brochure_lr.pdf.

Haddon W Jr. The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. Am J Public Health. 1968;58:1431–1438.

Institute for Health Metrics and Evaluation/World Bank. Transport for Health: The Global Burden of Disease from Motorized Road Transport. Seattle, WA, and Washington, DC: Author; 2014.

International Road Assessment Programme. The True Cost of Road Crashes—Valuing Life and the Cost of a Serious Injury. 2008. Available at: http://www.irap.net/en/about-irap-3/research-and-technical-papers.

International Road Assessment Programme. 2015. Available at: http://www.irap.net/en/about-irap-2/safety-inspections.

IRTA-D-OECD/ITF. Reporting on Serious Road Traffic Casualties—Combining and Using Different Data Sources to Improve Understanding of Non-fatal Road Traffic Crashes. International Traffic Safety Data and Analysis Group (IRTAD), 2010. Available at: http://www.internationaltransportforum.org/irtadpublic/pdf/Road-Casualties-Web.pdf.

ISO 39001, Road traffic safety (RTS) management systems - Requirements with guidance for use. 2012.

Johansson R. Vision Zero—implementing a policy for traffic safety. Saf Sci. 2009;47:826–831.

Jones-Lee MW. The Value of Life. An Economic Analysis. Chicago, IL: University of Chicago Press; 1976.

Kullgren A, Lie A, Tingvall C. Comparison between Euro NCAP test results and real-world crash data. Traffic Inj Prev. 2010;11:587–593.

Lozano RL, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet. 2012;380:2095–2128.

Miller TR. Variations between countries in values of statistical life. J Transp Econ Policy. 2000;34:169–188.

Murray CJL, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the
Global Burden of Disease Study 2010. *The Lancet*. 2012;380:2197–2223.

NHTSA. U.S. Department of Transportation releases policy on automated vehicle development [press release]. NHTSA; May 30, 2013. Available at: http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development

OECD/ITF. Towards Zero—Ambitious Road Safety Targets and the Safe System Approach. 2008. Available at: http://www.internationaltransportforum.org/Pub/pdf/09CDsr/PDF_EN/TowardsZero.pdf

Peden M, Scurfield R, Sleet D, et al. *World Report on Road Traffic Injury Prevention*. Geneva, Switzerland: World Health Organization; 2004.

Salomon J, et al. Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. *The Lancet*. 2012;380:2129–2143.

Strandroth J, Rizzi M, Sternlund S, Lie A, Tingvall C. The correlation between pedestrian injury severity in real-life crashes and Euro NCAP pedestrian test results. *Traffic Inj Prev*. 2011;12:604–613.

Strandroth J, Sternlund S, Lie A, et al. Correlation between Euro NCAP pedestrian test results and injury severity in real-life crashes with pedestrians and bicyclists in Sweden. *Stapp Car Crash J*. 2014;58:213–231.

Thomas P, Morris A, Talbot R, Fagerlind H. Identifying the causes of road crashes in Europe. Paper presented at: 57th AAAM Annual Conference, September 22–25, 2013.

TOI (Institute of Transport Economics). *Handbook of Road Safety Measures* [in Norwegian]. Oslo, Norway: Author; 2012. Available at: http://tsh.toi.no/files/trafikksikkerhetshandboken.pdf

United Nations Centre for Regional Development. *Environmentally Sustainable Transport for Asian Cities: A Sourcebook*. Rev ed. Nagoya, Japan: Author; 2010.

United Nations Resolution 64/255, Improving global road safety, 74th plenary meeting 2 March 2010.

United Nations Road Safety Collaboration. 2015. http://www.who.int/roadtrafficpublications/en/

Viscusi WK, Aldy JA. The value of a statistical life: a critical review of market estimates throughout the world. *J Risk Uncertain*. 2003;27:5–76.

Vos T, et al. Years lived with disability (YLDS) for 1,160 sequelae of 289 diseases and injuries, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2012;380:2163.2196.

Wismans J, Skogsmo I, Nilsson-Ehle A, Lie A, Thynell M, Lindberg G. Implications of road safety in national productivity and human development in Asia. Paper presented at: Eighth Regional EST Forum in Asia; November 19 to 21, 2014; Colombo, Sri Lanka. Available at: http://www.uncrd.or.jp/content/documents/22698EST-P4_Wismans.pdf.

World Bank. *China Road Traffic Safety—The Achievements, the Challenges, and the Way Ahead*. Beijing, China: China and Mongolia Sustainable Development Unit (EASCS), East Asia and Pacific Region; 2008.

World Bank. 2015. Available at: http://data.worldbank.org/about/country-and-lending-groups.

World Health Organization. *Global Status Report on Road Safety: Time for Action*. Geneva, Switzerland: Author; 2009.

World Health Organization. *Data Systems, a Road Safety Manual for Decision-makers and Practitioners*. Geneva, Switzerland: Author; 2010.

World Health Organization. *Global Plan for the Decade of Action for Road Safety, 2011–2020*. Geneva, Switzerland: Author; 2011. Available at: www.who.int/roadsafety/decade_of_action/plan/plan_english.pdf

World Health Organization. *Global Status Report on Road Safety 2013, Supporting a Decade of action*. Geneva, Switzerland: Author; 2013.

Yuan W. The effectiveness of the “ride-bright” legislation for motorcycles in Singapore. *Accid Anal Prev*. 2000;32:559–563.