Our roads, which are meant to take us places, often become venues of loss and sources of sorrow. Friends for Life, India, appreciates and supports the initiative WHO is taking to make the world a safer, more responsible place in which to live.

Anish Verghese Koshy, President, Friends for Life, Bangalore, India

We, the surviving relatives of the victims of road accidents, appreciate the initiative of WHO and the publication of this report. It is wrong to place the responsibility for causing and preventing road crashes on the driver only; we need to look at the vehicle and the road as well.

Ben-Zion Kryger, Chairman, Yad-Haniktafim, Israel

There are not many roads, there is a single road that extends across the length and breadth of our vast planet. Each of us is responsible for a segment of that road. The road safety decisions that we make or do not make, ultimately have the power to affect the lives of people everywhere. We are one road – one world.

Rochelle Sobel, President, Association for Safe International Road Travel, United States of America

The human suffering for victims and their families of road traffic–related injuries is incalculable. There are endless repercussions: families break up; high counselling costs for the bereaved relatives; no income for a family if a breadwinner is lost; and thousands of rands to care for injured and paralysed people. Drive Alive greatly welcomes this report and strongly supports its recommendations.

Moira Winslow, Chairman, Drive Alive, South Africa

WHO has decided to tackle the root causes of road accidents, a global scourge characteristic of our technological era, whose list of victims insidiously grows longer day by day. How many people die or are injured? How many families have found themselves mourning, surrounded by indifference that is all too common, as if this state of affairs were an unavoidable tribute society has to pay for the right to travel? May this bold report by WHO, with the assistance of official organizations and voluntary associations, lead to greater and genuine awareness, to effective decisions and to deeper concern on the part of road users for the lives of others.

Jacques Duhayon, Administrator, Association de Parents pour la Protection des Enfants sur les Routes, Belgium

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World report on road traffic injury prevention

SUMMARY

ROAD SAFETY IS NO ACCIDENT

World Health Organization

THE WORLD BANK

The World Health Organization was established in 1948 as a specialized agency of the United Nations serving as the directing and coordinating authority for international health matters and public health. One of WHO's constitutional functions is to provide objective and reliable information and advice in the field of human health, a responsibility that it fulfils in part through its extensive programme of publications.

The Organization seeks through its publications to support national health strategies and address the most pressing public health concerns of populations around the world. To respond to the needs of Member States at all levels of development, WHO publishes practical manuals, handbooks and training material for specific categories of health workers; internationally applicable guidelines and standards; reviews and analyses of health policies, programmes and research; and state-of-the-art consensus reports that offer technical advice and recommendations for decision-makers. These books are closely tied to the Organization's priority activities, encompassing disease prevention and control, the development of equitable health systems based on primary health care, and health promotion for individuals and communities. Progress towards better health for all also demands the global dissemination and exchange of information that draws on the knowledge and experience of all WHO's Member countries and the collaboration of world leaders in public health and the biomedical sciences.

To ensure the widest possible availability of authoritative information and guidance on health matters, WHO secures the broad international distribution of its publications and encourages their translation and adaptation. By helping to promote and protect health and prevent and control disease throughout the world, WHO's books contribute to achieving the Organization's principal objective–the attainment by all people of the highest possible level of health.

The European Federation of Road Traffic Victims is deeply concerned about the millions of deaths, severely disabled victims and often forgotten survivors of road traffic crashes as well as the huge psychological, social and economic impact of these incidents worldwide. We heartily welcome this report and strongly support the call for an effective response.

Marcel Haegi, President, European Federation of Road Traffic Victims, Switzerland

Road accidents are a never-ending drama. They are the leading cause of mortality among young people in industrialized countries. In other words, they are a health emergency to which governments must find a response, and all the more so because they know what the remedies are: prevention, deterrence and making the automobile industry face up to its responsibilities. This report is a contribution towards the efforts of those who have decided, whether or not after a personal tragedy, to come to grips with this avoidable slaughter.

Geneviéve Jurgensen, Founder and Spokesperson, League against Road Violence, France

Many deaths and injuries from road crashes are completely preventable, especially those caused by alcohol or drug-impaired drivers. WHO has done important work by focusing attention on road violence as a growing worldwide public health problem. This report will be a valuable resource for Mothers Against Drunk Driving and its allies in working to stop impaired driving and in supporting the victims of this crime.

Dean Wilkerson, Executive Director, Mothers Against Drunk Driving, United States of America

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Foreword

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Every day thousands of people are killed and injured on our roads. Men, women or children walking, biking or riding to school or work, playing in the streets or setting out on long trips, will never return home, leaving behind shattered families and communities. Millions of people each year will spend long weeks in hospital after severe crashes and many will never be able to live, work or play as they used to do. Current efforts to address road safety are minimal in comparison to this growing human suffering.

The World Health Organization and the World Bank have jointly produced this *World report on road traffic injury prevention*. Its purpose is to present a comprehensive overview of what is known about the magnitude, risk factors and impact of road traffic injuries, and about ways to prevent and lessen the impact of road crashes. The document is the outcome of a collaborative effort by institutions and individuals. Coordinated by the World Health Organization and the World Bank, over 100 experts, from all continents and different sectors – including transport, engineering, health, police, education and civil society – have worked to produce the report.

Road traffic injuries are a growing public health issue, disproportionately affecting vulnerable groups of road users, including the poor. More than half the people killed in traffic crashes are young adults aged between 15 and 44 years – often the breadwinners in a family. Furthermore, road traffic injuries cost low-income and middle-income countries between 1% and 2% of their gross national product – more than the total development aid received by these countries.

But road traffic crashes and injuries are preventable. In high-income countries, an established set of interventions have contributed to significant reductions in the incidence and impact of road traffic injuries. These include the enforcement of legislation to control speed and alcohol consumption, mandating the use of seatbelts and crash helmets, and the safer design and use of roads and vehicles. Reduction in road traffic injuries can contribute to the attainment of the Millennium Development Goals that aim to halve extreme poverty and significantly reduce child mortality.

Road traffic injury prevention must be incorporated into a broad range of activities, such as the development and management of road infrastructure, the provision of safer vehicles, law enforcement, mobility planning, the provision of health and hospital services, child welfare services, and urban and environmental planning. The health sector is an important partner in this process. Its roles are to strengthen the evidence base, provide appropriate pre-hospital and hospital care and rehabilitation, conduct advocacy, and contribute to the implementation and evaluation of interventions.

The time to act is now. Road safety is no accident. It requires strong political will and concerted, sustained efforts across a range of sectors. Acting now will save lives. We urge governments, as well as other sectors of society, to embrace and implement the key recommendations of this report.

LEE Jong-wook
Director-General
World Health Organization

James D Wolfensohn
President
World Bank Group

Preface

Over 3000 Kenyans are killed on our roads every year, most of them between the ages of 15 and 44 years. The cost to our economy from these accidents is in excess of US$ 50 million exclusive of the actual loss of life. The Kenyan government appreciates that road traffic injuries are a major public health problem amenable to prevention.

In 2003, the newly formed Government of the National Alliance Rainbow Coalition, took up the road safety challenge. It is focusing on specific measures to curtail the prevalent disregard of traffic regulations and mandating speed limiters in public service vehicles.

Along with the above measures the Government has also launched a six-month Road Safety Campaign and declared war on corruption, which contributes directly and indirectly to the country's unacceptably high levels of road traffic accidents.

I urge all nations to implement the recommendations of the *World report on road traffic injury prevention* as a guide to promoting road safety in their countries. With this tool in hand, I look forward to working with my colleagues in health, transport, education and other sectors to more fully address this major public health problem.

Mwai Kibaki, President, Republic of Kenya

In 2004, World Health Day, organized by the World Health Organization, will for the first time be devoted to Road Safety. Every year, according to the statistics, 1.2 million people are known to die in road accidents worldwide. Millions of others sustain injuries, with some suffering permanent disabilities. No country is spared this toll in lives and suffering, which strikes the young particularly. Enormous human potential is being destroyed, with also grave social and economic consequences. Road safety is thus a major public health issue throughout the world.

World Health Day will be officially launched in Paris on 7 April 2004. France is honoured. It sees this as recognition of the major efforts made by the French population as a whole, which mobilized to reduce the death and destruction it faces on the roads. These efforts will only achieve results if they are supported by a genuine refusal to accept road accidents fatalistically and a determination to overcome all-too-frequent indifference and resignation. The mobilization of the French Government and the relevant institutions, particularly civic organizations, together with a strong accident prevention and monitoring policy, reduced traffic fatalities in France by 20%, from 7242 in 2002 to 5732 in 2003. Much remains to be done, but one thing is already clear: it is by changing mentalities that we will, together, manage to win this collective and individual struggle for life.

Jacques Chirac, President, France

Globally deaths and injuries resulting from road traffic crashes are a major and growing public health problem. Viet Nam has not been spared. In the year 2002, the global mortality rate due to traffic accidents was 19 per 100 000 population while in Viet Nam the figure was 27 per 100 000 population. Road traffic collisions on the nation's roads claim five times more lives now than they did ten years ago. In 2003 a total of 20 774 incidents were reported, leading to 12 864 deaths, 20 704 injuries and thousands of billions of Viet Nam Dong in costs.

A main contributor to road crashes in Viet Nam is the rapid increase in the number of vehicles, particularly motorcycles, which increase by 10% every year. Nearly half of the motorcycle riders are not licensed, and three quarters don't comply with traffic laws. Also, the development of roads and other transport infrastructure has not been able to keep pace with rapid economic growth.

To reduce deaths and injuries, protect property and contribute to sustainable development, the Government of Viet Nam established the National Committee on Traffic Safety in 1995. In 2001 the Government promulgated the National Policy on Accidents and Injury Prevention with the target of reducing traffic deaths to 9 per 10 000 vehicles. Government initiatives to reduce traffic accidents include issuing new traffic regulations and strengthening traffic law enforcement. In 2003, the number of traffic accidents was reduced by 27.2% over the previous year, while the deaths and injury rates declined by 8.1% and 34.8% respectively.

The Government of Viet Nam will implement more stringent measures to reduce road traffic injuries through health promotion campaigns, consolidation of the injury surveillance system, and mobilization of various sectors at all levels and the whole society. The Government of Viet Nam welcomes the World Health Organization/World Bank *World report on road traffic injury prevention*, and is committed to implementing its recommendations to the fullest extent possible.

H.E. Mr Phan Van Khai, Prime Minister, Socialist Republic of Viet Nam

In Thailand road accidents are considered one of the top three public health problems in the country. Despite the Government's best efforts, there are sadly over 13 000 deaths and more than one million injuries each year as the result of road accidents, with several hundred thousand people disabled. An overwhelming majority of the deaths and injuries involve motorcyclists, cyclists and pedestrians.

The Royal Thai Government regards this problem to be of great urgency and has accorded it high priority in the national agenda. We are also aware of the fact that effective and sustainable prevention of such injuries can only be achieved through concerted multisectoral collaboration.

To deal with this crucial problem, the Government has established a Road Safety Operations Centre encompassing the different sectors of the country and comprising the government agencies concerned, nongovernmental organizations and civil society. The Centre has undertaken many injury prevention initiatives, including a "Don't Drink and Drive" campaign as well as a campaign to promote motorcyclists to wear safety helmets and to engage in safe driving practices. In this regard, we are well aware that such a campaign must involve not only public relations and education but also stringent law enforcement measures.

The problem of road traffic injuries is indeed a highly serious one, but it is also a problem that can be dealt with and prevented through concerted action among all the parties concerned. Through the leadership and strong commitment of the Government, we are confident that we will be successful in our efforts and we hope that others will be as well.

Thaksin Shinawatra, Prime Minister, Thailand

We are pleased that the Sultanate of Oman, with other countries, has brought up the issue of road safety to the United Nations General Assembly and played a major role in raising global awareness to the growing impact of deadly road traffic injuries, especially in the developing world.

The magnitude of the problem, encouraged the United Nations General Assembly to adopt a special resolution (No 58/9) and the World Health Organization to declare the year 2004 as the year of road safety.

In taking these two important steps, both organizations started the world battle against trauma caused by road accidents, and we hope that all sectors of our societies will cooperate to achieve this noble humanitarian objective.

The world report on road traffic injury prevention is no doubt a compelling reading document. We congratulate the World Health Organization and the World Bank for producing such a magnificent presentation.

Qaboos bin Said, Sultan of Oman

Land transportation systems have become a crucial component of modernity. By speeding up communications and the transport of goods and people, they have generated a revolution in contemporary economic and social relations.

However, incorporating new technology has not come about without cost: environmental contamination, urban stress and deteriorating air quality are directly linked to modern land transport systems. Above all, transportation is increasingly associated with the rise in road accidents and premature deaths, as well as physical and psychological handicaps. Losses are not limited to reduced worker productivity and trauma affecting a victim's private life. Equally significant are the rising costs in health services and the added burden on public finances.

In developing countries the situation is made worse by rapid and unplanned urbanization. The absence of adequate infrastructure in our cities, together with the lack of a legal regulatory framework, make the exponential rise in the number of road accidents all the more worrying. The statistics show that in Brazil, 30 000 people die every year in road accidents. Of these, 44% are between 20 and 39 years of age, and 82% are men.

As in other Latin American countries, there is a growing awareness in Brazil as to the urgency of reversing this trend. The Brazilian Government, through the Ministry of Cities, has put considerable effort into developing and implementing road security, education campaigns and programmes that emphasize citizen involvement. As part of this endeavour Brazil recently adopted a new road traffic code that has brought down the annual number of road deaths by about 5000. This is a welcome development that should spur us to even further progress. The challenges are enormous and must not be side stepped. This is why road security will remain a priority for my Government.

The publication of this report is therefore extremely timely. The data and analysis that it brings to light will provide valuable material for a systematic and in-depth debate on an issue that affects the health of all. Of even greater significance is the fact that the report will help reinforce our conviction that adequate preventive measures can have a dramatic impact. The decision to dedicate the 2004 World Health Day to Road Safety points to the international community's determination to ensure that modern means of land transportation are increasingly a force for development and the well-being of our peoples.

Luis Inácio Lula da Silva, President, Federative Republic of Brazil

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The World Health Organization, the World Bank and the Editorial Committee would like to pay a special tribute to Patricia Waller, who passed away on 15 August 2003. She was a member of the technical committee for chapter 1 but sadly became too ill to participate. Her many contributions to the promotion of road safety in the context of public health are acknowledged. She was a friend and mentor to many.

The report also benefited from the contributions of a number of other people. In particular, acknowledgement is made to Jeanne Breen and Angela Seay for writing the report under very tight time constraints, to Tony Kahane for editing the final text, to Stuart Adams for writing the summary and David Breuer for editing the summary. Thanks are also due to the following: Caroline Allsopp and Marie Fitzsimmons, for their invaluable editorial support; Anthony Bliss for technical support on transport-related matters; Meleckidzedeck Khayesi and Tamitza Toroyan, for assistance with the day-to-day management and coordination of the project; Kara McGee and Niels Tomijima, for statistical assistance; Susan Kaplan and Ann Morgan, for proofreading; Tushita Bosonet and Sue Hobbs, for graphic design and layout; Liza Furnival for indexing; Keith Wynn for production; Desiree Kogevinas, Laura Sminkey and Sabine van Tuyll van Serooskerken, for communications; Wouter Nachtergaele for assistance with references; Kevin Nantulya for research assistance; and Simone Colairo, Pascale Lanvers-Casasola, Angela Swetloff-Coff, for administrative support.

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The fundamentals

Introduction

Road traffic injuries are a major but neglected public health challenge that requires concerted efforts for effective and sustainable prevention. Of all the systems with which people have to deal every day, road traffic systems are the most complex and the most dangerous. Worldwide, an estimated 1.2 million people are killed in road crashes each year and as many as 50 million are injured. Projections indicate that these figures will increase by about 65% over the next 20 years unless there is new commitment to prevention. Nevertheless, the tragedy behind these figures attracts less mass media attention than other, less frequent types of tragedy.

The *World report on road traffic injury prevention*[1] is the first major report being jointly issued by the World Health Organization (WHO) and the World Bank on this subject. It underscores their concern that unsafe road traffic systems are seriously harming global public health and development. It contends that the level of road traffic injury is unacceptable and that it is largely avoidable.

The report has three aims.

- To create greater levels of awareness, commitment and informed decision-making at all levels – government, industry, international agencies and nongovernmental organizations – so that strategies scientifically proven to be effective in preventing road injuries can be implemented. Any effective response to the global challenge of reducing road traffic casualties will require all these levels to mobilize great effort.
- To contribute to a change in thinking about the nature of the problem of road traffic injuries and what constitutes successful prevention. The perception that road traffic injury is the price to be paid for achieving mobility and economic development needs to be replaced by a more holistic idea that emphasizes prevention through action at all levels of the road traffic system.
- To help strengthen institutions and to create effective partnerships to deliver safer road traffic systems. Such partnerships should exist horizontally between different sectors of government and vertically between different levels of government, as well as between governments and nongovernmental organizations. At the government level, this means establishing close collaboration between sectors, including public health, transport, finance, law enforcement and other sectors concerned.

This summary of the *World report on road traffic injury prevention* is primarily intended for people responsible for road safety policies and programmes at the national level and those most closely in touch with road safety problems and needs at the local level. The views expressed and the conclusions drawn are taken from the main report and the many studies to which that report refers.

A public health concern

Every day around the world, more than 3000 people die from road traffic injury. Low-income and middle-income countries account for about 85% of the deaths and for 90% of the annual disability-adjusted life years (DALYs) lost because of road traffic injury.

Projections show that, between 2000 and 2020,

[1] Peden M. et al., eds. *The world report on road traffic injury prevention.* Geneva, World Health Organization, 2004.

road traffic deaths will decline by about 30% in high-income countries but increase substantially in low-income and middle-income countries. Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease and injury (Table 1) (*1*).

TABLE 1

Change in rank order of DALYs for the 10 leading causes of the global burden of disease

1990		2020	
Rank	Disease or injury	Rank	Disease or injury
1	Lower respiratory infections	1	Ischaemic heart disease
2	Diarrhoeal diseases	2	Unipolar major depression
3	Perinatal conditions	3	Road traffic injuries
4	Unipolar major depression	4	Cerebrovascular disease
5	Ischaemic heart disease	5	Chronic obstructive pulmonary disease
6	Cerebrovascular disease	6	Lower respiratory infections
7	Tuberculosis	7	Tuberculosis
8	Measles	8	War
9	Road traffic injuries	9	Diarrhoeal diseases
10	Congenital abnormalities	10	HIV

DALY: Disability-adjusted life year. A health-gap measure that combines information on the number of years lost from premature death with the loss of health from disability.
Source: reference *1*.

The social and economic costs of road traffic injuries

Everyone killed, injured or disabled by a road traffic crash has a network of others, including family and friends, who are deeply affected. Globally, millions of people are coping with the death or disability of family members from road traffic injury. It would be impossible to attach a value to each case of human sacrifice and suffering, add up the values and produce a figure that captures the global social cost of road crashes and injuries.

The economic cost of road crashes and injuries is estimated to be 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries. The global cost is estimated to be US$ 518 billion per year. Low-income and middle-income countries account for US$ 65 billion, more than they receive in development assistance (*2*).

Road traffic injuries place a heavy burden, not only on global and national economies but also household finances. Many families are driven deeply into poverty by the loss of breadwinners and the added burden of caring for members disabled by road traffic injuries.

By contrast, very little money is invested in preventing road crashes and injuries. Table 2 compares the funds spent on research and development focused on several health concerns, including road safety. Comparatively little is spent on implementation, even though many interventions that would prevent crashes and injuries are well known, well tested, cost-effective and publicly acceptable.

Changing fundamental perceptions

Since the last major WHO world report on road safety issued over 40 years ago (*4*) there has been a major change in the perception, understanding and practice of road injury prevention among traffic safety professionals around the world. Figure 1 sets out the guiding principles of this shift of paradigms.

The predictability and preventability of road crash injury

Historically, motor vehicle "accidents" have been viewed as random events that happen to others (*5*) and as an inevitable outcome of road transport. The term "accident", in particular, can give the impres-

TABLE 2

Estimated global research and development funding for selected topics

Disease or injury	US$ millions	1990 DALYs ranking	2020 DALYs ranking
HIV/AIDS	919–985	2	10
Malaria	60	8	—
Diarrhoeal diseases	32	4	9
Road traffic crashes	24–33	9	3
Tuberculosis	19–33	—	7

Source: reference *3*.

FIGURE 1

The road safety paradigm shift

ROAD INJURY PREVENTION AND CONTROL – THE NEW UNDERSTANDING
■ Road crash injury is largely preventable and predictable; it is a human-made problem amenable to rational analysis and countermeasure
■ Road safety is a multisectoral issue and a public health issue – all sectors, including health, need to be fully engaged in responsibility, activity and advocacy for road crash injury prevention
■ Common driving errors and common pedestrian behaviour should not lead to death and serious injury – the traffic system should help users to cope with increasingly demanding conditions
■ The vulnerability of the human body should be a limiting design parameter for the traffic system and speed management is central
■ Road crash injury is a social equity issue – equal protection to all road users should be aimed for since non-motor vehicle users bear a disproportionate share of road injury and risk
■ Technology transfer from high-income to low-income countries needs to fit local conditions and should address research-based local needs
■ Local knowledge needs to inform the implementation of local solutions

sion of inevitability and unpredictability – an event that cannot be managed. This is not the case. Road traffic crashes are events that are amenable to rational analysis and remedial action.

In the 1960s and early 1970s many highly-motorized countries began to achieve large reductions in casualties through outcome-oriented and science-based approaches. This response was stimulated by campaigners including Ralph Nader in the United States of America (*6*) and given intellectual strength by scientists such as William Haddon Jr (*7*).

The need for good data and a scientific approach

Data on the incidence and types of crashes as well as a detailed understanding of the circumstances that lead to crashes is required to guide safety policy. Knowledge of how injuries are caused and of what type they are is a valuable instrument for identifying interventions and monitoring the effectiveness of interventions. However, in many low-income and middle-income countries, systematic efforts to collect road traffic data are not well developed and underreporting of deaths and serious injuries is common. The health sector has an important role to play in establishing data systems on injuries and the effectiveness of interventions, and the communication of these data to a wider audience.

Road safety as a public health issue

Traditionally, road safety has been assumed to be the responsibility of the transport sector. In the early 1960s many developed countries set up traffic safety agencies, usually located within a government's transport department. In general, however, the public health sector was slow to become involved (*8, 9*).

But road traffic injuries are indeed a major public health issue, and not just an offshoot of vehicular mobility. The health sector would greatly benefit from better road injury prevention in terms of fewer hospital admissions and a reduced severity of injuries. It would also be to the health sector's gain if – with safer conditions on the roads guaranteed for pedestrians and cyclists – more people were to adopt the healthier lifestyle of walking or cycling, without fearing for their safety.

The public health approach to road traffic injury prevention is based on science. It draws on knowledge from medicine, biomechanics, epidemiology, sociology, behavioural science, criminology, education, economics, engineering and other disciplines.

While the health sector is only one of many bodies involved in road safety, it has important roles to play. These include:

- discovering, through injury surveillance and surveys, as much as possible about all aspects of road crash injury – by systematically collecting data on the magnitude, scope, characteristics and consequences of road traffic crashes;
- researching the causes of traffic crashes and injuries, and in doing so trying to determine:
  - causes and correlates of road crash injury,
  - factors that increase or decrease risk,
  - factors that might be modifiable through interventions;
- exploring ways to prevent and reduce the severity of injuries in road crashes by designing,

implementing, monitoring and evaluating appropriate interventions;
- helping to implement, across a range of settings, interventions that appear promising, especially in the area of human behaviour, disseminating information on the outcomes, and evaluating the cost-effectiveness of these programmes;
- working to persuade policy-makers and decision-makers of the necessity to address injuries in general as a major issue, and of the importance of adopting improved approaches to road traffic safety;
- translating effective science-based information into policies and practices that protect pedestrians, cyclists and the occupants of vehicles;
- promoting capacity building in all these areas, particularly in the gathering of information and in research.

Cross-sectoral collaboration is essential here, and this is something the public health sector is in a good position to promote.

Road safety as a social equity issue

Studies show that motor vehicle crashes have a disproportionate impact on the poor and vulnerable in society (*10, 11*). Poorer people comprise the majority of casualties and lack ongoing support in the event of long-term injury. They also have limited access to post-crash emergency care (*12*). In addition, in many developing countries, the costs of prolonged medical care, the loss of the family bread winner, the cost of a funeral, and the loss of income due to disability can push families into poverty (*13*).

A large proportion of the road crash victims in low-income and middle-income countries are vulnerable road users such as pedestrians and cyclists. They benefit least from policies designed for motorized travel, but bear a disproportionate share of the disadvantages of motorization in terms of injury, pollution and the separation of communities.

Equal protection for all road users should be a guiding principle to avoid an unfair burden of injury and death for poorer people and vulnerable road users (*10, 14*). This issue of equity is a central one for reducing the global burden of road crash death and injury.

Systems that accommodate human error

The traditional view in road safety has been that road crashes are usually the sole responsibility of individual road users despite the fact that many other factors beyond their control may have come into play, such as the poor design of roads or vehicles. But human error does not always lead to disastrous consequences. Human behaviour is governed not only by the individual's knowledge and skills, but also by the environment in which the behaviour takes place (*15*). Indirect influences, such as the design and layout of the road, the nature of the vehicle, and traffic laws and their enforcement affect behaviour in important ways. For this reason, the use of information and publicity on their own is generally unsuccessful in reducing road traffic collisions (*8, 16–18*).

Systems that account for the vulnerability of the human body

The uncertainty of human behaviour in a complex traffic environment means that it is unrealistic to expect that all crashes can be prevented. However, if greater attention in designing the transport system were given to the tolerance of the human body to injury, there could be substantial benefits. Examples include reducing speed in urban areas, separating cars and pedestrians by providing pavements, improving the design of car and bus fronts to protect pedestrians, and a well-designed and crash-protective interface between the road infrastructure and vehicles.

Technology transfer from high-income countries

Transport systems developed in high-income countries may not fit well with the safety needs of low-income and middle-income countries for a variety of reasons, including the differences in traffic mix (*19–21*). In low-income countries, walking, cycling, motorcycling and the use of public transport are the predominant transport modes. In developed countries, car ownership is high, and most road users are vehicle occupants.

Technology transfer, therefore, needs to be appropriate for the mix of different vehicle types and the patterns of road use (*22*). The priority in developing countries therefore should be the import and

adaptation of proven and promising methods from developed nations, and a pooling of information as to their effectiveness among other low-income countries (*23*).

The new model

Globally there is a need to improve the safety of the traffic system for users, and to reduce current inequalities in the risk of incurring road crash injuries.

A systems approach

In the United States, some 30 years ago, William Haddon Jr described road transport as an ill-designed "man-machine" system needing comprehensive systemic treatment (*7*). He produced what is now known as the Haddon Matrix, illustrating the interaction of three factors – human, vehicle and environment – during three phases of a crash event: pre-crash, crash and post-crash. The resulting nine-cell Haddon matrix models the dynamic system, with each cell of the matrix allowing opportunities for intervention to reduce road crash injury (see Figure 2). This work led to substantial advances in the understanding of the behavioural, road-related and vehicle-related factors that affect the number and severity of casualties in road traffic.

Building on Haddon's insights, the "systems" approach seeks to identify and rectify the major sources of error or design weakness that contribute to fatal and severe injury crashes, as well as to mitigate the severity and consequences of injury by:

- reducing exposure to risk;
- preventing road traffic crashes from occurring;
- reducing the severity of injury in the event of a crash;
- reducing the consequences of injury through improved post-collision care.

Evidence from some highly-motorized countries shows that this integrated approach to road safety produces a marked decline in road deaths and serious injuries (*8, 24, 25*) but that the practical realization of the systems approach remains the most important challenge for road safety policy-makers and professionals.

Developing institutional capacity

The development of traffic safety policy involves a wide range of participants representing a diverse group of interests (see Figure 3). The structure and management systems may vary. In European Union countries, for example, national governments manage many aspects of road safety, but the European Union regulates motor vehicle safety. In the United States, both the federal and state governments are responsible for road safety.

Bogotá, the capital of Colombia, has a population of 7 million and provides an excellent example of road safety management. National and local authorities, universities and citizens work together on managing road safety and have achieved dramatic results.

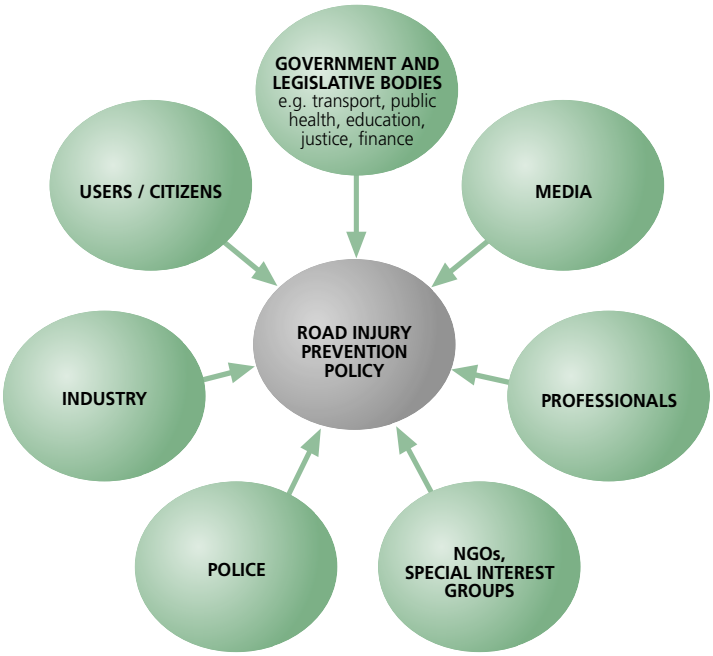
FIGURE 2

The Haddon Matrix

		FACTORS		
PHASE		HUMAN	VEHICLES AND EQUIPMENT	ENVIRONMENT
Pre-crash	Crash prevention	Information Attitudes Impairment Police enforcement	Roadworthiness Lighting Braking Handling Speed management	Road design and road layout Speed limits Pedestrian facilities
Crash	Injury prevention during the crash	Use of restraints Impairment	Occupant restraints Other safety devices Crash-protective design	Crash-protective roadside objects
Post-crash	Life sustaining	First-aid skill Access to medics	Ease of access Fire risk	Rescue facilities Congestion

FIGURE 3

The key organizations influencing policy development



The role of government

Historically, governmental responsibilities for traffic safety fall within the transport ministry with other government departments such as police, justice, health, planning and education having some responsibility for key areas. Experience of several countries indicates that effective strategies for reducing traffic injury have a greater chance of being applied if there is a separate government agency with the power and budget to plan and implement its programme (*8*). Two examples of such agencies are the Swedish National Road Administration (SNRA) and the United States National Highway Traffic Safety Administration (NHTSA). Although stand-alone agencies are likely to increase the priority given to road safety, they are not a substitute for strong political support and actions from other agencies (*26*).

If the establishment of a stand-alone agency is not possible, then an alternative is to strengthen the existing road safety unit, giving it greater powers, responsibility and authority within the government transport ministry (*8*).

Parliamentary Committees

Informed and committed politicians are essential to achieving government commitment to road safety, since they authorize policies, programmes and budgets. They also play central roles in developing road safety legislation.

Two examples of this commitment include:

— the Parliamentary Standing Committee on Road Safety in the Australian state of New South Wales which, in the early 1980s, was responsible for the introduction and full implementation of random breath testing, which led to a 20% reduction in deaths (*27*);

— the Parliamentary Advisory Council for Transport Safety in the United Kingdom was responsible for the introduction of legislation for front seat-belt use in the 1980s, followed some years later by the introduction of speed humps and the use of rear seat-belts (*28*).

Research

Impartial research and development on road safety is an essential element of any effective road safety programme.

Independent institutes that contribute to understanding road safety issues include the Dutch Institute for Road Safety Research, TRL Ltd (formerly known as the Transport Research Laboratory) in the United Kingdom and the road safety research units at universities in Hanover, Germany and Adelaide and Melbourne, Australia. The United States has many including the North Carolina Highway Safety Research Center, the University of Michigan Transportation Research Institute and the National Center for Injury Prevention and Control at the Centers for Disease Control and Prevention.

The Transportation Research and Injury Prevention Programme at the Institute of Technology in New Delhi, India and the Centre for Industrial and

Scientific Research and Development in South Africa have both contributed to identifying interventions that can protect vulnerable road users, with special attention to interventions that low-income and middle-income countries can afford.

The most practical course of action for low-income and middle-income countries is to import and adapt proven and promising road safety technology from other countries. Doing this requires having the capacity to conduct research into their own road traffic systems and to identify which of the known technologies may be appropriate and what adaptations may be necessary. In addition, unique national and local road traffic situations are likely to require the development of new technologies.

Involvement of industry

Industry shares responsibility for road safety by designing and selling vehicles and other products, by using road traffic systems to deliver its products and by employing people who use roads. Recognizing this responsibility, industry has contributed to improving road safety. For example, Finland's insurers' fund investigates every fatal road traffic injury in the country and provides the resulting data to the Government of Finland and others with an interest in road safety. The Insurance Institute for Highway Safety in the United States provides data on the crash performance of new cars and other road safety issues to government agencies and independent research institutes.

Nongovernmental organizations

Nongovernmental organizations promote road safety by publicizing the problem of road traffic injury, identifying effective solutions, challenging ineffective policies and forming coalitions to lobby for improved road safety (*29*).

The Trauma Committee of the Royal Australasian College of Surgeons advocates the best possible post-crash care for injured people, proper training in handling trauma cases for health professionals and gathering and reporting clinical data to enhance the understanding of injuries (*8*). Mothers Against Drunk Driving in the United States has successfully lobbied for the enactment of hundreds of laws to combat driving while under the influence of alcohol. The European Transport Safety Council, a coalition of nongovernmental organizations, has had remarkable influence on the Road Safety and Technology Unit of the European Commission's Directorate-General for Energy and Transport and on the European Parliament (*28*).

Some nongovernmental organizations in low-income and middle-income countries have difficulty in raising funds for their efforts to campaign for road safety (*26*). However, several active nongovernmental organizations promote road safety in these countries: for example, Asociación Familiares y Víctimas de Accidentes del Tránsito [Association of Families and Victims of Traffic Accidents] (Argentina), Friends for Life (India), Association for Safe International Road Travel (Kenya and Turkey), Youth Association for Social Awareness (Lebanon) and Drive Alive (South Africa).

Achieving better performance

Sharing responsibility

Road safety is best achieved when all the key groups identified earlier (Figure 3) share a culture of road safety (*25, 30*).

When there is a culture of road safety, the providers and enforcers of road traffic systems (vehicle manufacturers, road traffic planners, road safety engineers, police, educators, health professionals and insurers) take responsibility for ensuring that their products and services meet the highest possible standards for road safety. Road users take responsibility by complying with laws, informing themselves, engaging in safe road behaviour and engaging in discussion and debate about road safety issues, whether individually or through nongovernmental organizations.

Responsibility requires accountability, and this necessitates ways of measuring performance objectively.

In 1997, Sweden's parliament approved Vision Zero, a new road safety programme in which the providers, enforcers and users of Sweden's road traffic system work in partnership, setting targets and other performance standards. The ultimate goal of

Vision Zero is a road traffic system with zero fatalities or severe injuries through road crashes. It has public health as its underlying premise (*31*).

Vision Zero has a long-term strategy in which road safety is improved gradually until, over time, the vision is achieved. It advocates shared responsibility and flexibility so that the allocation of responsibility can change as science and experience reveal the optimum role for the motor vehicle industry, road traffic planners, road safety engineers, law enforcers, health professionals, educators and road users.

For example, if the inherent safety of motor vehicles and roads can no longer be improved much, more emphasis may have to be placed on reducing speed. Conversely, if reducing speed any further is no longer acceptable, more emphasis may have to be placed on improving the safety of vehicles and roads.

The Dutch "sustainable safety" is another example of shared responsibility (*32*). Launched in 1998, this strategy aims to reduce road traffic deaths by 50% and injuries by 40% by the year 2010.

Setting targets

Several studies (*33, 34*) have shown that setting targets for reducing the incidence of road traffic injury can improve road safety programmes by motivating everyone involved to make optimal use of their resources. Further, ambitious long-term targets are more effective than modest short-term ones (*35*) (Table 3).

A prerequisite for setting targets is good baseline data on road traffic injury, which means that an injury surveillance system or some other means of providing fairly complete and accurate information on the incidence of road traffic injury must be in place.

Targets encourage people to identify all possible interventions, to rank them according to the impact they are proven to have on the incidence of injury and to implement the ones that are most effective. Each provider and enforcer of road safety can set its own internal targets and monitor and assess its own performance.

To achieve targets, road safety planners need to concern themselves with a wide variety of factors that influence safety (*36, 37*). One factor they have to consider is that the objective of road safety often conflicts with other objectives, including mobility and environmental conservation. They need to identify possible barriers to implementing road safety measures and determine how these barriers might be overcome (*38*).

In New Zealand, the road safety programme has four levels of target.

- The overall target is to reduce the social and economic costs of road crashes and injuries.

TABLE 3

Examples of current fatality reduction targets in use[a]

Country or area	Base year for target	Year in which target is to be realized	Target reduction in the number of road traffic fatalities
Australia	1997	2005	–10%
Austria	1998–2000	2010	–50%
Canada	1991–1996	2008–2010	–30%
Denmark	1998	2012	–40%
European Union	2000	2010	–50%
Finland	2000	2010	–37%
		2025	–75%
France	1997	2002	–50%
Greece	2000	2005	–20%
		2015	–40%
Ireland	1997	2002	–20%
Italy	1998–2000	2010	–40%
Malaysia	2001	2010	< 3 deaths/10 000 vehicles
Netherlands	1998	2010	–30%
New Zealand	1999	2010	–42%
Poland	1997–1999	2010	–43%
Saudi Arabia	2000	2015	–30%
Sweden	1996	2007	–50%
United Kingdom	1994–1998	2010	–40%
United States	1996	2008	–20%

[a] It should be noted that some of these targets also include reductions in serious injury and are supplemented by other targets, e.g. to reduce the numbers of casualties among children.

Sources: references *33, 36*.

- The second level of target requires specific reductions in the numbers of road traffic fatalities and severe injuries.
- The third level consists of performance indicators related to reducing speed, reducing the incidence of driving while under the influence of alcohol and increasing the use of seat-belts.
- The fourth level is concerned with institutional output, including the number of police patrol hours and the kilometres of high-risk crash sites treated to reduce risk (*37, 39*).

Building partnerships

The state of Victoria, Australia has developed a partnership between those responsible for road safety and those involved in compensation for injury. The Transport Accidents Commission compensates road crash survivors through a no-fault insurance system funded by premiums levied as part of annual vehicle registration charges. The Commission invests heavily in improving road safety, knowing that its investment will be more than offset by savings in the compensation it pays out. Three government ministers – responsible for transport, justice and insurance – jointly set the policy and coordinate the programme.

The province of KwaZulu-Natal, in South Africa has transferred and adapted the Victoria state model (*40*).

The United Kingdom Department for Transport encourages local partnerships in which the department and local authorities, police, courts and sometimes health authorities work together on enforcing speed limits and recovering the costs of this. Over the first two years, pilot studies launched in 2000 have reduced the incidence of road crash by 35% and the incidence of fatal and serious injury to pedestrians by 56%. The savings on administering services to road crash survivors have freed up about £20 million to be invested in other ways. The economic benefit to society is estimated to be about £112 million (*41*).

The New Car Assessment Programme (NCAP) was established in the United States in 1978. Under the programme, manufacturers, buyers and government cooperate, subjecting new car models to a range of crash tests and rating their performance with a "star" system. There is now an Australian NCAP and a European one called EuroNCAP. The partners in EuroNCAP include national transport departments, automobile clubs, the European Commission and, on behalf of car buyers, International Consumer Research and Testing. In Europe, research (*42*) has shown that, in car-to-car collisions, cars rated with three or four stars are about 30% safer than ones with two stars or fewer.

European automobile clubs are now working on developing star rating systems for roads, so that road builders, like car manufacturers, are encouraged to improve the safety of their products.

The global impact

Global, regional and country estimates

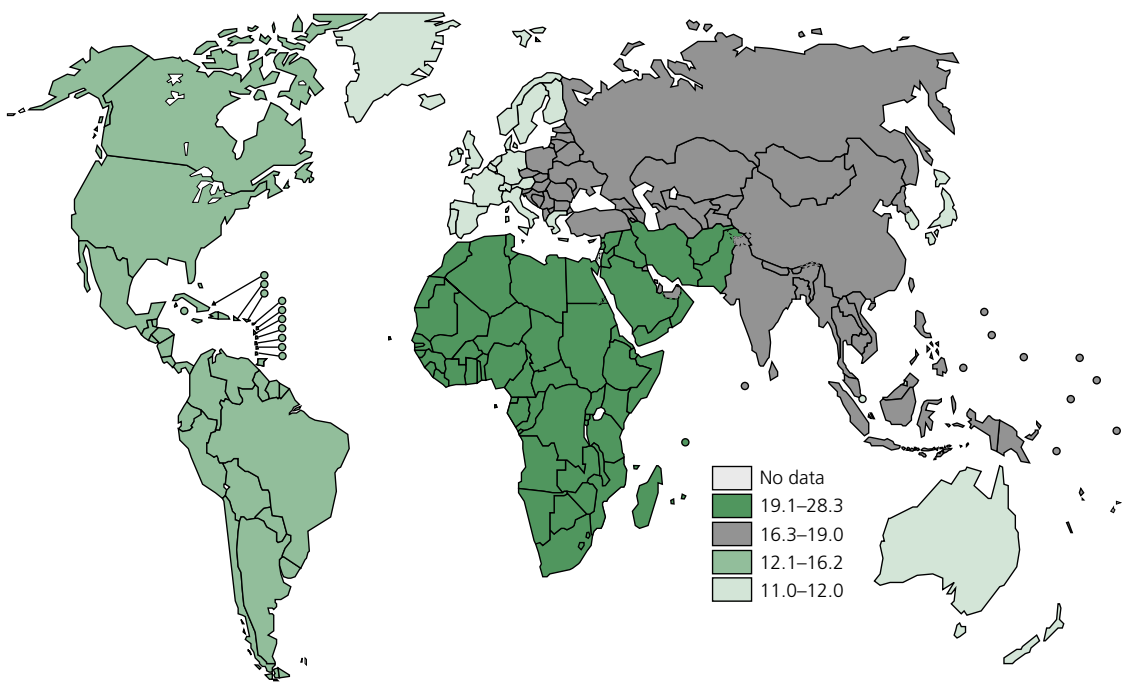
Long before cars were invented, road traffic injuries occurred involving carriages, carts, animals and people. The numbers grew exponentially as cars, buses, trucks and other motor vehicles were introduced and became ever more common. A cyclist in New York City was the first recorded case of injury involving a motor vehicle on 30 May 1896, and a London pedestrian was the first recorded motor vehicle death on 17 August of the same year (*43*). The cumulative total of road traffic deaths had reached an estimated 25 million by 1997 (*44*).

In 2002, an estimated 1.18 million people died from road traffic crashes: an average of 3242 deaths per day. Road traffic injuries accounted for 2.1% of all global deaths, making them the eleventh leading cause of global deaths.

In addition to deaths, an estimated 20 million to 50 million people are injured in road crashes each year (*2, 45*). In 2002, an estimated 38.4 million DALYs were lost because of road crashes, or 2.6% of all DALYs lost. This made road traffic injuries the

FIGURE 4

Road traffic injury mortality rates (per 100 000 population) in WHO regions, 2002



Source: WHO Global Burden of Disease project, 2002, Version 1.

TABLE 4

Predicted road traffic fatalities by region (in thousands), adjusted for underreporting, 1990–2020

Region[a]	Number of countries	1990	2000	2010	2020	Change (%) 2000–2020	Fatality rate (deaths/ 100 000 persons)	
							2000	2020
East Asia and Pacific	15	112	188	278	337	79	10.9	16.8
East Europe and Central Asia	9	30	32	36	38	19	19.0	21.2
Latin America and Caribbean	31	90	122	154	180	48	26.1	31.0
Middle East and North Africa	13	41	56	73	94	68	19.2	22.3
South Asia	7	87	135	212	330	144	10.2	18.9
Sub-Saharan Africa	46	59	80	109	144	80	12.3	14.9
Sub-total	121	419	613	862	1 124	83	13.3	19.0
High-income countries	35	123	110	95	80	–27	11.8	7.8
Total	156	542	723	957	1 204	67	13.0	17.4

[a] Data are displayed according to the regional classifications of the World Bank.

Source: reproduced from reference *48*, with minor amendments, with the permission of the authors.

ninth leading contributor to the global burden of disease and injury.

The rates of road traffic death vary considerably between regions and between countries within regions (Figure 4). In general, rates are higher in low-income and middle-income countries than in high-income countries. Altogether, low-income and middle-income countries accounted for 90% of all road traffic deaths in 2002.

Global, regional and country trends

Road traffic death rates have decreased in high-income countries since the 1960s and 1970s, although countries' rates vary greatly even within the same region. For example, in North America, from 1975 to 1998, the road traffic fatality rate per 100 000 population declined by 27% in the United States but by 63% in Canada.

Meanwhile, rates in low-income and middle-income countries have increased substantially (*10, 46, 47*). Again, countries vary widely. In Asia, from 1975 to 1998, road traffic fatality rates rose by 44% in Malaysia but by 243% in China (*48*).

Two major studies predict that the trend towards increase in low-income and middle-income countries will continue, unless deliberate action changes it. As a result, the annual numbers of road traffic deaths globally will rise sharply over the next two decades.

The first study, the WHO Global Burden of Disease study (*1*), predicts the following changes from 1990 to 2020.

- Road traffic injuries will rise in rank to sixth place as a major cause of death worldwide.
- Road traffic injuries will rise to become the third leading cause of DALYs lost.
- Road traffic injuries will become the second leading cause of DALYs lost for low-income and middle-income countries.
- Road traffic deaths will increase worldwide, from 0.99 million to 2.34 million (representing 3.4% of all deaths).
- Road traffic deaths will increase on average by over 80% in low-income and middle-income countries and decline by almost 30% in high-income countries.
- DALYs lost will increase worldwide from 34.3 million to 71.2 million (representing 5.1% of the global burden of disease).

Table 4 shows the results of the second study, a World Bank study on traffic fatalities and economic growth (*48*). In high-income countries, the annual number of road traffic deaths is projected to decrease by 27% from 2000 to 2020. In the six regions where low-income and middle-income countries are concentrated, the annual number of road traffic deaths is projected to increase by 83%. The projected percentage increases from 2000 to 2020 are very similar in these two studies.

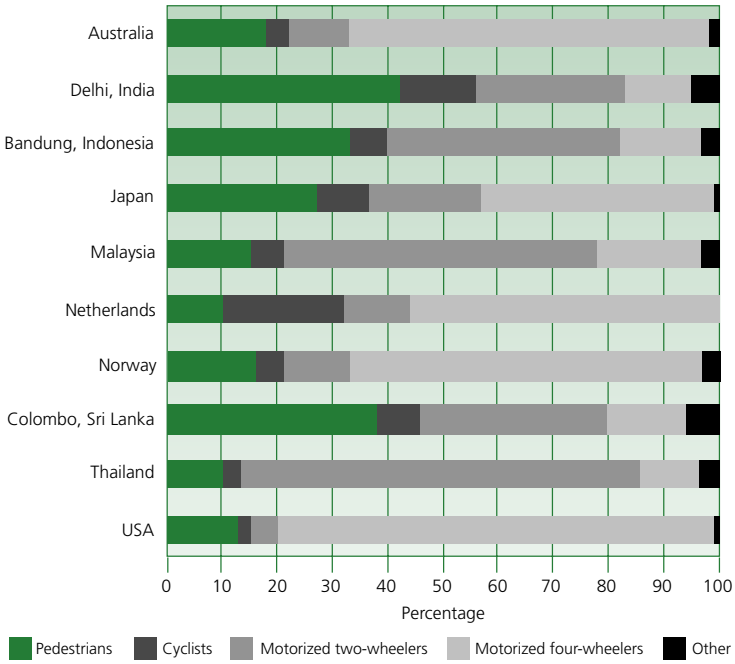
Profile of the people affected by road traffic injuries

Figure 5 shows the distribution of road traffic deaths by type of road user in selected countries. Pedestrians, cyclists and moped and motorcycle riders are the most vulnerable road users (*49*). In low-income and middle-income countries, they account for large portions of road traffic and most road traffic deaths (*49, 50*). In high-income countries, car owners and drivers account for a large majority of road users and the majority of road traffic deaths. Nevertheless, even there, pedestrians, cyclists and moped and motorcycle riders have a much higher risk of death per kilometre travelled.

Figure 6 shows the distribution of global road traffic deaths by sex and age. In all age groups, males account for more deaths than females. In 2002, the road traffic death rates were 27.6 per 100 000 males and 10.4 per 100 000 females. Males accounted for 73% of deaths and 70% of all DALYs lost because of road traffic injury.

FIGURE 5

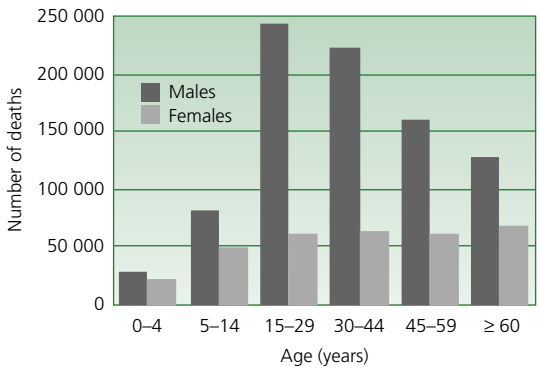
Road users killed in various modes of transport as a proportion of all road traffic deaths



Source: reference *51*.

FIGURE 6

Road traffic deaths by sex and age group, world, 2002



Source: WHO Global Burden of Disease project, 2002, Version 1.

In 2002, people aged 15–44 years accounted for more than half of all road traffic deaths globally. They also accounted for about 60% of all DALYs lost because of road traffic injury (*52*). In high-income countries, people aged 15–29 years had the highest death rates per 100 000 population, but in low-income and middle-income countries people 60 years and older had the highest rates. In low-income and middle-income countries children have much higher rates of road traffic death than in high-income countries.

In 2002, people 60 years and older accounted for more than 193 000 road traffic deaths. Their death rates per 100 000 population were the highest of all age categories in low-income and middle-income countries. When involved in a motor vehicle crash, elderly people are more likely to be killed or seriously disabled than younger people because they are generally less resilient.

United Nations population projections indicate that people 60 years and older will account for ever-greater portions of all countries' populations

over the next 30 years. The vulnerability of elderly people to road traffic death and serious injury will be of increasing concern globally.

Socioeconomic status and location

Several studies (*50, 53–57*) have shown that people from less-privileged socioeconomic groups are at greater risk of injury from all causes, including road crashes. In the case of road crashes, the explanation may lie in their greater exposure to risk (*56*). A 2002 study in Kenya (*50*), for example, found that 27% of commuters with no formal education travelled on foot, 55% used buses or minibuses and only 8% used private cars. By contrast, 81% of people with a secondary-level education travelled in private cars, 19% used buses and none walked.

Where people live can also influence their exposure to road traffic risk. In general, people living in urban areas are at greater risk of being involved in road crashes, but people living in rural areas are more likely to be killed or seriously injured if they are involved in crashes. One reason is that motor vehicles tend to travel faster in rural areas. In many low-income and middle-income countries, many people are exposed to new risks when new highways are built through their communities (*49*).

Other health, social and economic costs

Estimating the costs of road crashes and injuries can help countries to understand the seriousness of the problem of road crashes and injuries and to understand the benefits of investing in measures to prevent road crashes and injuries. An assessment should take into account both the direct and indirect costs. At minimum, the direct costs should include those of providing health care and rehabilitation, and the indirect costs should include the value of lost household services and lost earnings for survivors, caregivers and families.

Many high-income countries produce annual estimates of the costs of road crashes and injuries that take into account lost earnings, health care costs and the costs of property damage, administration (such as the costs of police, courts and insurance companies) and travel delays. Health care and rehabilitation costs can be prohibitively expensive in cases of serious injury. Further, little effort is usually made to attach a cost to psychological stress and suffering experienced by survivors and their families.

Estimating the costs in low-income and middle-income countries is more difficult because good data on road crashes and injuries are lacking. Nevertheless, a survey of the literature yielded a few studies that shed light on the costs of road crashes and injuries for these countries.

Health and social costs

Data from the WHO Global Burden of Disease study in 2002 show that, of those injured severely enough to require attention from a health facility, almost one quarter had traumatic brain injury and one tenth had open wounds. Fractured bones accounted for most other injuries. Studies show that road traffic crashes are the leading cause of traumatic brain injury in both high-income and low-income and middle-income countries (*58–63*).

A comprehensive survey of numerous studies (*64*) found that road traffic injuries accounted for 30–86% of trauma admissions in some low-income and middle-income countries. The mean length of hospital stay reported in 15 studies for inpatients with road traffic injuries was 20 days. People with road traffic injuries accounted for 13–31% of all injury-related attendees and 48% of bed occupancy in surgical wards and were the most frequent users of operating theatres and intensive care units. The increased workload in radiology departments and increased demand for physiotherapy and rehabilitation services were largely attributed to road traffic injuries (*64*).

Many low-income and middle-income countries cannot provide all the health care services that people sustaining road traffic injuries would get in high-income countries. A recent study in Kenya, for example, found that only 10% of all health facilities could handle more than 10 injured people at a time. The least-prepared facilities were the public health units most frequently used by poor people. Many of these lacked essential equipment and supplies for handling trauma cases, including oxygen, plaster of Paris, blood, dressings, antiseptics, local and general anaesthetics and blood pressure machines. Mission

and private hospitals, on the other hand, usually had all these (*50*).

A recent study (*65*) found that people sustained 5.27 million nonfatal injuries in 2000 in the United States as a result of road crashes, with 87% of the injuries considered minor. The cost of treating all these injuries was US$ 31.7 billion, placing a tremendous burden on public health care services and the finances of road traffic casualties and their families. The serious injuries, including brain and spinal cord injuries, cost an average of US$ 332 457 per injury.

Regardless of the costs of health care and rehabilitation, injured people bear additional costs. Permanent disability, such as paraplegia, quadriplegia, loss of eyesight or brain damage, can deprive an individual of the ability to achieve even minor goals and can result in dependence on others for financial support and routine physical care. Less serious injuries can result in chronic physical pain and limit the injured person's physical activity for lengthy periods. Serious burns, contusions or lacerations can lead to emotional trauma associated with permanent disfigurement (*66*).

In the European Union every year, more than 40 000 people are killed and more than 150 000 are disabled for life by road crashes. Nearly 200 000 families are newly bereaved or left with disabled family members (*67*). Coping with a disabled family member often requires that at least one family member take time away from other activities, including employment, so that families lose income (*68*). A 1993 study found that 90% of the families of people dying from road traffic crashes and 85% of the families of disabled road traffic survivors reported a significant decline in their quality of life. Many survivors and members of their families suffered from headaches, sleeping problems, general health problems and nightmares and reported no significant improvement in these conditions three years after crashes had taken place (*69, 70*). In addition, a follow-up study found that road traffic survivors and their families were dissatisfied with criminal proceedings, insurance and civil claims and the information and support they had received to help them cope.

In all countries, the loss of income earners and the costs of funerals and prolonged care for disabled people can push families into poverty. Children are often hardest hit. In Mexico, the loss of parents in road traffic crashes is the second leading cause of children becoming orphaned (*13*).

Economic costs

Cost to countries

The Transport Research Laboratory (now TRL Ltd) examined data on road traffic injuries from 21 low, middle and high-income countries and produced crude estimates that road traffic injuries cost low-income countries an average of 1% of their gross national product (GNP) versus 1.5% for middle-income countries and 2% for high-income countries (*2*).

Applying these averages to GNP in 1997, TRL Ltd estimated that road traffic injuries cost US$ 518 billion globally and that high-income countries accounted for US$ 453 billion of this. Low-income and middle-income countries accounted for US$ 65 billion of this, more than they received in development assistance (Table 5). TRL Ltd emphasized that the estimates were crude and that countries varied widely. For example, evidence suggested

TABLE 5

Road crash costs by region

Region[a]	GNP, 1997 (US $ billion)	Estimated annual crash costs	
		As percentage of GNP	Costs (US $ billion)
Africa	370	1	3.7
Asia	2 454	1	24.5
Latin America and Caribbean	1 890	1	18.9
Middle East	495	1.5	7.4
Central and eastern Europe	659	1.5	9.9
Subtotal	5 615		64.5
Highly motorized countries[b]	22 665	2	453.3
Total			517.8

[a] Data are displayed according to the regional classifications of the TRL Ltd, United Kingdom.

[b] Australia, Japan, New Zealand, North America, and the western European countries.

Source: reproduced from reference *2* with the permission of the author.

that the costs were 0.3% of GNP in Viet Nam but almost 5% of GNP in Malawi.

Other studies focusing on particular regions or countries have produced estimates as follows.

- Road traffic injuries cost European Union countries €180 billion annually, twice the annual budget for all activities in these countries (*33, 71*).
- The cost in the United States is US$ 230.6 billion annually, or 2.3% of GNP (*65*).
- Various studies done in the 1990s produced estimates of 0.5% of gross domestic product (GDP) in the United Kingdom, 0.9% in Sweden, 2.8% in Italy and an average of 1.4% of GDP in 11 high-income countries (*72*).
- In 2000, road traffic injuries cost Bangladesh US$ 745 million, 1.6% of GNP (*73*).
- In 2000, they cost South Africa US$ 2 billion (*74*).
- In Uganda, road crashes, injuries and fatalities cost US$ 101 million per year or 2.3% of GNP (*75*).
- In eastern Europe in 1998, road traffic injuries cost Estonia US$ 66.6 million to US$ 80.6 million, Latvia US$ 162.7 million to US$ 194.7 million and Lithuania US$ 230.5 million to US$ 267.5 million (*66*).
- In China in 1999, road traffic injuries caused the loss of 12.6 million potentially productive life years, with an estimated value of US$ 12.5 billion, almost four times the country's annual health budget (*76*).

Cost to families

As discussed earlier, people 15–44 years old account for more than half of all road traffic deaths, and 73% of the people killed are male. People of that age are in their most productive earning years, so their families suffer financially when they are killed or disabled. A recent study in Bangladesh (*73*) found that 21% of road traffic deaths occurred to household heads among non-poor people versus 32% among poor people. Three quarters of all poor families who had lost a member to road traffic death reported a decrease in their standard of living, and 61% reported that they had had to borrow money to cover expenses following their loss.

Families who lose the earning capacity of members disabled by road traffic injuries and who are burdened with the added cost of caring for these members may end up selling most of their assets and getting trapped in long-term indebtedness.

Need for reliable information

Only 75 countries report annual data on road traffic injuries. The others have no national health information systems that can produce such data.

Many of the global estimates given here are derived from the WHO Mortality Database, the WHO Global Burden of Disease version 1 database for 2002, the TRL Ltd data (*2*) and a World Bank study on traffic fatalities and economic growth (*48*). The WHO Mortality Database filled in gaps by producing country estimates based on small samples. The WHO Global Burden of Disease project produced estimates for 2002 by projecting 1990 estimates. The TRL Ltd and World Bank data relied on police reports and adjusted for lack of such reports from some countries and for differences in definitions used in the available reports. This means that the estimates from these sources should be considered approximate or indicative, even though they may be the best available. Other studies mentioned in the previous discussion often used similar means for producing their estimates and projections.

Accurate data are essential for prioritizing public health issues, monitoring trends and assessing intervention programmes. Many countries have inadequate information systems on road traffic injury, making it difficult to realize the full nature of the problem and thus gain the attention that is required from policy-makers and decision-makers. There are a number of areas where road traffic injury data are often problematic, and these include:

- sources of data – for example, whether data are from police or health sources;
- the types of data collected;
- inappropriate use of indicators;
- non-standardization of data;
- definitional issues related to traffic deaths and injuries;

— underreporting;
— poor harmonization and linkages between different sources of data.

The lack of reliable data is most critical at the national and local levels, where the data are needed as a sound basis for road safety planning and decision-making. The *World report on road traffic injury prevention* discusses this subject in full and provides guidance. Other useful resources available from WHO are *Injury surveillance guidelines* (*77*) and *Guidelines for conducting community surveys on injuries and violence* (*78*).

Risk factors and interventions

Introduction

In road traffic, risk is a function of four elements. The first is the exposure – the amount of movement, or travel, within the system by different users or a given population density. The second is the underlying probability of a crash, given a particular exposure. The third is the probability of injury, given a crash. The fourth element is the outcome of injury. Risk can be explained by human error, kinetic energy, tolerance of the human body and post-crash care (*15, 79*).

Road traffic injury should be considered alongside heart disease, cancer and stroke as a public health problem that responds well to intervention that can prevent much of it from occurring (*80*).

The known interventions were discovered through research and development conducted mainly in high-income countries. Further research and development will result in new and better interventions and ways of adapting known interventions to new circumstances. All countries can benefit by transferring and adapting road safety technology that has been proven in a few countries.

The interplay of risk factors and interventions in a road traffic system is so complex that presenting them in neat risk–intervention pairings is impossible without being highly repetitive and simplistic. The following section organizes material according to categories of intervention, although the interventions within each category often address more than one category of risk. The way roads are laid out and designed, for example, can reduce the exposure to traffic of vulnerable road users, reduce the probability that crash and injury occur when these users are exposed and reduce the severity of injury if it occurs.

Managing exposure with land-use and transport policy

Exposure to risk of road traffic injury

Exposure to risk means exposure to road traffic resulting from the need to use roads and from the volumes and mixes of traffic on the roads. Without new safety measures, all road users may be exposed to ever greater risk as the volumes of traffic increase, especially when different types of motor vehicle, some travelling at high speeds, share roads with each other and with pedestrians and cyclists.

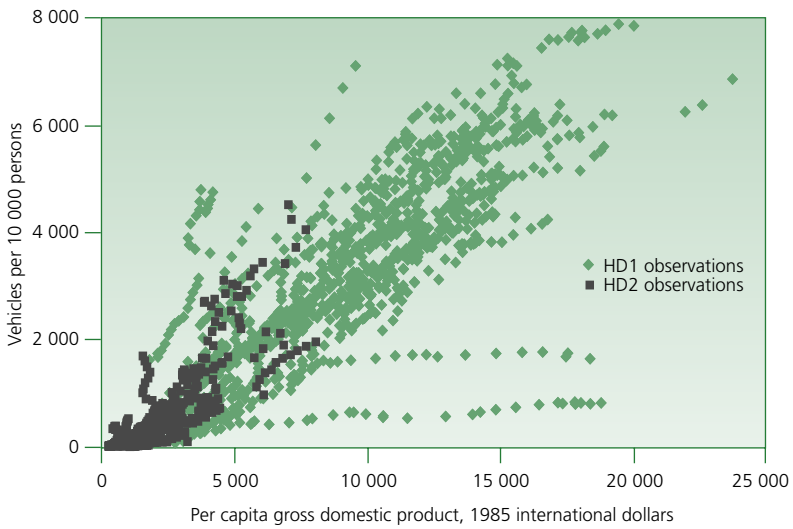
Figure 7 shows how the number of motor vehicles per 10 000 people rises in relation to GDP per capita. In the 30 member countries of the Organisation for Economic Co-operation and Development, the number of motor vehicles is projected to increase by up to 62% between 2003 and 2012 to 705 million (*48*). In China, the number of motor vehicles quadrupled between 1990 and 2002 to more than 55 million and in Thailand, between 1987 and 1997, there was an almost four-fold increase in the number of registered motor vehicles, from 4.9 million to 17.7 million (*81*).

Despite rapid motorization in China and other low-income and middle-income countries, most families in these countries are unlikely to own a car or other motorized four-wheeler within the next 25 years (*19*). Nevertheless, as pedestrians, cyclists, riders of motorized two-wheelers and public transport passengers, they may be ever more exposed to motorized four-wheelers on their roads.

Projections indicate that, compared with other countries, Asian countries will experience the greatest growth in the numbers of motor vehicles for the foreseeable future, but most of the growth will be in motorized two-wheelers and three-wheelers, such as motorized rickshaws and jitneys (*19*). In

FIGURE 7

Motorization rate versus income[a]



[a] HDI is the United Nations Human Development Index. Countries with an HDI more than 0.8 are labelled as HD1 while those with a value less than 0.8 are denoted as HD2.

Source: reproduced from reference 48, with minor editorial amendments, with the permission of the authors.

Viet Nam, for example, such vehicles already account for 95% of all motor vehicles. The number of motorcycles in Viet Nam grew by 29% in 2001, and this growth was associated with a 37% increase in the number of road traffic deaths (*82*).

Buses and trucks are also common modes of transport in low-income and middle-income countries. They pose risks both to their occupants and to others. In Delhi, they are involved in almost two thirds of crashes involving vulnerable road users, who account for 75% of all road traffic deaths (*19*).

Reducing exposure through land-use and transport planning

Eliminating the need or desire to travel is not possible, but the length and intensity of exposure to types of road traffic that put people at risk can be reduced (*30*).

Requiring safety impact assessment before planning decisions are made

Proposed policies and projects are often assessed for safety but not often for their effects on the safety of an entire road traffic system. Although such assessment is not common, the Netherlands has some experience with this (*83*).

Promoting efficient patterns of land use

A community's pattern of land use affects the number and lengths of trips people make and their choice of route and travel mode (*84*). Smart-growth policies, for example, favour compact, higher-density development with mixed uses so that the places where people live, work, go to school, shop and find opportunities for recreation and entertainment are close together. They may choose to walk, cycle or use public transport rather than use private cars (*85*).

Providing shorter, safer routes for vulnerable road users

Most pedestrians and cyclists take shorter and easier paths, even if this is less safe (*86*). Studies in Brazil, Mexico and Uganda found that pedestrians would rather cross a dangerous road than go out of their way to take pedestrian bridges (*13, 23, 87*). A road traffic system should ensure that the shorter routes are also the safer ones for vulnerable road users. Motor vehicle traffic should be channelled as much as possible along other routes in areas where pedestrians and cyclists are common (*88*). For example, through-traffic that neither originates in nor is destined for residential neighbourhoods should be routed away from these neighbourhoods (*89*). In addition, local traffic should be calmed to speeds that are less risky for vulnerable road users.

Discouraging unnecessary trips

Measures to reduce the numbers of motor vehicles, especially in areas where vulnerable road users are

common, can reduce the risk of injury. Policies to ban or discourage private cars from entering city centres or university campuses (such as by requiring special licences, charging entry fees or making parking scarce) and to ban freight trucks and tourist coaches in certain zones during certain hours can be effective. Other possibilities include encouraging telecommuting or e-working.

Encouraging the use of safer modes of travel

Of the four main modes of travel – road, rail, air and marine – travel by road puts people at the greatest risk of injury per kilometre travelled by far (*90, 91*). Table 6 shows the results of a recent study (*90*) comparing the risks of travel in the European Union countries by the four main modes and by different means of road travel.

The study found that, compared with a person in a car, a person on a motorized two-wheeler is 20 times more likely to be killed for each kilometre travelled; a person on foot 9 times more likely; and a person on a bicycle 8 times more likely. A person in a car, however, is 10 times more likely to be killed than a passenger in a bus or coach and 20 times more likely to be killed than a passenger in a train (*90*).

Providing convenient and affordable public transport, by rail and/or bus and coach, can reduce the distance travelled using higher-risk modes. A trip using public transport usually has a walking or cycling component. Although that component may bear relatively high risk, pedestrians and cyclists pose less risk to other road users than do motor vehicles (*85*). National transport policy in many high-income countries now encourages the combination of public transport with improved safety of pedestrian and cycling routes (*15*).

Strategies to encourage use of public transport include routes, stops, schedules and ticketing systems that make it convenient and easy. Providing affordable fares (including free travel or preferred fares for students), safe and secure park-and-ride facilities, taxi stands, bicycle storage areas, pedestrian approaches, waiting areas and attractive vehicle interiors are also important. In addition, disincentives may be implemented to using other modes of travel, including higher fuel taxes and some of the means already mentioned for discouraging unnecessary trips by private car (*85*).

In high-income countries, integrating land-use, road traffic and public transport policies could reduce per capita car travel by an estimated 20–49% (*85*). Meanwhile, in many low-income and middle-income countries, public transport services are unregulated and provide inadequate safety both for their occupants and for road users outside the vehicles. Improving the safety and overall quality of these services will be important strategies for them.

TABLE 6

Deaths per 100 million passenger-kilometres versus passenger-travel hours in European Union countries for the period 2001–2002

	Deaths per 100 million passenger-kilometres[a]	Deaths per 100 million passenger-travel hours[b]
Roads (total)	0.95	28
Powered two-wheelers	13.8	440
Foot	6.4	75
Cycle	5.4	25
Car	0.7	25
Bus and coach	0.07	2
Ferry	0.25	16
Air (civil aviation)	0.035	8
Rail	0.035	2

[a] Passenger-kilometres is the total distance covered by all the individuals travelling on that mode.

[b] Passenger-travel hours is the total time spent by all the individuals travelling on that mode.

Source: reproduced from reference *90*, with minor editorial amendments, with the permission of the publisher.

Minimizing exposure to high-risk road traffic scenarios

Restricting access to parts of the road network

Preventing pedestrians and cyclists and, sometimes, slow-moving farm and construction vehicles from accessing high-speed motorways is a well-established road safety measure. So is preventing motor vehicles from accessing pedestrian zones.

Giving priority to higher-occupancy vehicles

Giving high-occupancy vehicles (such as buses or cars with two or more occupants) priority, with their own lanes, can reduce the use of motor vehicles.

Restricting the power-to-weight ratios of motorized two-wheelers

In the United Kingdom in the early 1980s, the maximum engine size of a motorcycle that learners could ride was reduced from 250 cc to 125 cc, and the maximum power output was limited to 9 kW. The result was a 25% reduction in the number of road traffic injuries among young riders. Among more experienced riders, those on larger, more powerful motorcycles had significantly higher rates of crash and injury (*92*).

Regulating motor vehicle use by young riders and drivers

Globally, road traffic injuries are a leading cause of death among young people who drive cars or ride motorized two-wheelers (*52*). The death rates are especially high among teenagers and males (*92, 93*).

A study of patterns of road traffic injury in Australia, Japan, Malaysia and Singapore (*94*) found that the road users at highest risk of injury were motorcyclists with provisional licences, followed by those in their first year of riding. Another study (*93*) found that drivers of all types of vehicle were at greatest risk during their first year of driving.

Contributing factors include: unfamiliarity with vehicles, which are often borrowed; thrill-seeking and overconfidence; less tolerance of alcohol compared with older people; and excess or inappropriate speed. The late-night risk is three times the daytime risk for 16-year-old drivers and four times for 20- to 44-year-olds (*93*). One case–control study (*95*) found that one third of all crashes involving young drivers might have been prevented if they had been restricted to driving with no more than one passenger.

Malaysia has significantly reduced rates of motorcycle crash by increasing the legal riding age from 16 years to 18 years (*96*). In 1987, New Zealand pioneered the graduated driver licence system for all motor vehicles; Australia, Canada and the United States have followed since.

A graduated driver licence system provides stepwise access to a full driving licence (*97*). The original New Zealand system applied to all new drivers aged 15–24 years. Step one was a 6-month supervised driver permit obtained by passing written and oral tests. Step two was an 18-month restricted permit that allowed no driving from 22:00 to 05:00, no passengers under 20 years and a blood alcohol concentration (BAC) limit of 0.03 grams per decilitre (g/dl). Step 3, a full licence, required a practical driving test at the end of step 2. Evaluation showed that the graduated driver licence had contributed to an 8% reduction in crashes involving serious injury among young novice drivers (*98*). Australia achieved a reduction of over one third, largely by reducing the permitted BAC to 0.01 g/dl (*99*).

Planning and designing roads for safety

Risk of injury from poor planning and design

In many Asian cities, at least seven categories of motorized and non-motorized vehicle plus pedestrians and cyclists share the roads (*21*). Differences in kinetic energy – between heavy vehicles travelling at high speeds and light vehicles travelling at low speeds – put the occupants of many motor vehicles at high risk of injury.

In all countries, road networks are laid out and most roads are designed largely from the perspective of motor vehicle users (*100*). From the perspective of pedestrians and cyclists, mixing them with motor vehicles capable of travelling at high speeds is the most important road safety problem (*13, 15, 19*). Pedestrians and cyclists are relatively safe only on roads where motor vehicles are travelling at less than 30 km/h (*101*) and, even there, only if they are separated from motor vehicles, with their own sidewalks, paths or lanes. From the perspective of pedestrians and cyclists, crossing at junctions is the second most important road safety problem. In urban areas, most fatal or serious crashes involving bicycles occur at junctions (*99*).

Safety-conscious design of roads

A road network planned for safety has a hierarchy of roads, with several levels or classifications of road, each intended to serve a certain function (*102*).

In 1998, the Netherlands launched a programme of reclassifying its roads and then modifying them

so that every road would have a clear, unambiguous function. An earlier study (*103*) predicted that this clarification of function for all roads could reduce by more than one third the average number of road traffic injuries per vehicle–kilometre travelled.

Design to suit road function

Each road should be designed according to its particular function in the road network. A key characteristic of a well-designed road is that it makes compliance with the intended speed limit a natural choice for drivers.

- Higher-speed roads (motorways, expressways and multi-lane divided highways) should have: restricted access; horizontal and vertical curves of large radius; crashworthy shoulders; median barriers; and grade-separated junctions with entry and exit ramps. If such features are present, these are the safest of all roads (*104*). Many low-income and middle-income countries should also have separate lanes for motorized two-wheelers.
- Rural roads should have: periodic lanes for overtaking and for turning across oncoming traffic; median barriers to prevent overtaking in hazardous stretches; lighting at junctions; roundabouts; advisory speed limit signs before sharp bends; regular signs to remind of speed limits; rumble strips; and roadside hazards such as trees and utility poles removed.
- Transitional roads connecting higher-speed roads with lower-speed roads or moving from higher- to lower-speed stretches (such as rural roads entering villages) should have signs and other design features to encourage drivers to slow down in good time. Rumble strips, speed bumps, visual warnings in the pavement and roundabouts are possibilities. In Ghana, the use of rumble strips reduced crashes by 35% and deaths by 55% in certain locations (*105*).
- Residential access roads should have speed limits of no more than 30 km/h and design features that calm traffic.

Design for pedestrians and cyclists

The safety of pedestrians and cyclists can be achieved through area-wide road safety management that includes the following (*19, 99*).

- Networks of segregated or separate pedestrian and bicycle routes connecting to a public transport system are the ideal (*106*). Such a network might consist of sections of footpath or cycle path separate from roads plus sections running alongside roads, with particular attention paid to safe crossings at junctions. Pedestrians have twice the risk of injury where pedestrians are not separated or segregated from motor vehicle traffic (*107*). Studies in Denmark (*108*) have shown that providing segregated bicycle tracks or lanes alongside urban roads reduced deaths among cyclists by 35%.
- Traffic-calming measures discourage motorized traffic from travelling at speeds that put pedestrians and cyclists at high risk. They include road narrowing, roundabouts, rumble strips and speed bumps.

Widespread experience with area-wide road safety management in Europe shows that it can reduce crashes and injuries by 15–80% (*109, 110*). The town of Baden, Austria launched a management plan in 1988 that has resulted in about 75% of its road network being restricted to speeds of 30 km/h or less and an integrated system of public transport with pedestrian and bicycle routes. The rate of road casualties has declined by 60% (*111*).

Low-income and middle-income countries have experimented little with area-wide road safety management, but some road safety experts believe that this should be a priority for urban areas in all countries (*49*).

Design for motor vehicle drivers, riders and passengers

According to research in Australia and several European Union countries, collisions between vehicles and solid roadside objects contribute to 18–42% of all fatal crashes (*112, 113*). Such collisions frequently involve young drivers, excess or inappropriate speed, the use of alcohol, driver fatigue or restricted visibility. Roads and roadsides should be designed

and maintained to minimize the opportunities for serious effects when vehicles veer off course.

- Keeping roadsides clear of trees, boulders, steel and concrete pillars and posts and similar rigid roadside objects is especially important on roads where vehicles travel at high speeds.
- Collapsible lighting columns and signs, mounted on shear bolts or made of yielding material and designed for electrical safety, are recommended.
- Safety barriers can be used to contain motor vehicles within lanes, preventing head-on or side collisions, and to prevent them from leaving roads. These barriers should be designed to deflect or contain vehicles while doing no serious harm to occupants (*114*). Denmark, Sweden, Switzerland and the United Kingdom favour flexible cable barriers (rather than rigid concrete or semi-rigid steel), sometimes to prevent dangerous overtaking on single-carriageway roads. Used on dual-carriageway roads (with no pedestrians or bicycles) to prevent motor vehicles from crossing over and crashing into traffic going in the opposite direction, they have been found to reduce fatal and serious injuries by 45–50% (*115*).
- Crash cushions slow and cushion motor vehicles before they strike rigid roadside objects such as bridge pillars, safety barrier ends and utility poles. They have reduced fatal and serious injuries resulting from impact by up to 75% in the United States (*116*) and by 67% or more in the United Kingdom (*117*).

Safety audits

Road safety audits are generally carried out at up to five stages of a new road project: feasibility study, draft design, detailed design, pre-opening and a few months after opening. They should be done by experienced teams that are independent from the project teams (*118–121*).

Most countries do not carry out such audits, but those that do, such as Malaysia, can provide guidelines. Cost–benefit analyses of safety audits have found them to be highly effective, with the money invested early returning substantial savings later. A study in Denmark (*122*) found first-year returns of well over 100% on 13 projects. Transit New Zealand (*123*) has estimated a potential cost–benefit ratio of 1 to 20. Together with area-wide safety impact assessments before proposals for projects are improved, safety audits can help to optimize the safety of the whole road network.

Remedial action at high-risk crash sites

Road crashes are not evenly distributed throughout a road network. They occur in clusters at single sites, along particular sections of road or scattered across whole residential neighbourhoods (*57*). Even where area-wide impact assessment and road safety audits are carried out, experience may show that certain sites, sections or areas are hazardous and need improvement. Possibilities include: adding skid-resistant surfaces, improving lighting, providing central refuges or islands for pedestrians, adding signs or markings, improving junctions with signals or roundabouts and adding pedestrian bridges.

Safety defects may also arise through poor maintenance: for example, road surfaces and signs are deteriorated and roadside lights do not function.

The improvements needed to make an entire road network or a hazardous site safer often cost little but can result in huge benefits in terms of reduced incidence of road crash and injury. Nevertheless, a 1996 survey of 12 European Union countries (*124*) found that only seven reported having formal policies on remedial action at high-risk sites, only three did evaluations as a matter of course and only three had separate budgets for remedial action. A study in Kenya found about 145 hazardous locations on the country's main road network (*125*).

Monitoring the entire road traffic system, identifying problems as they emerge and correcting them are all important measures for ensuring road safety.

Providing visible, crashworthy, smart vehicles

Risk of injury from poor vehicle design and maintenance

Vehicle design can have considerable influence on crash injuries. Its contribution to crashes, through

vehicle defects is generally between 3% and 5%. A recent European Commission report (*126*) stated that, if all cars in the European Union were designed to be equal in standard to the best car available in each class, an estimated 50% of all fatal and disabling injuries could be prevented. Meanwhile, many low-income and middle-income countries do not set and enforce standards as high as the ones in the European Union.

From a car occupant's perspective, a major problem is the mismatch in size and weight between the vehicles involved in a crash. The rates of death and serious injury are many times higher in car-to-truck collisions than in car-to-car collisions (*127, 128*). Other problems are: failure of the passenger compartment to provide a protective shell; lack of features to stop occupants from being ejected from the car; and lack of other safety features, such as high-mounted stop lamps in the rear.

Pedestrians involved in crashes more often sustain multiple injuries resulting in death or disability than do car occupants (*129*). In Europe, 66% of fatally injured pedestrians are struck by the fronts of cars, 11% by other parts of cars and 23% by other types of motor vehicle (*130*). In low-income and middle-income countries, other types of motor vehicle are more often involved. In Ghana, 37.8% of pedestrian traffic deaths involve cars, but the cars are often taxis; 31.8% buses or minibuses; 18.6% heavy trucks; 7.6% light trucks; 2.1% motorcycles; 0.8% bicycles; and 1.3% other (*105*).

In Thailand, hospital records show that 75–80% of road traffic injuries and 70–90% of road traffic deaths are among users of motorized two-wheeled vehicles (*63*). In all countries, such road users tend to sustain multiple injuries to the head, chest and legs. Head injuries contribute to most deaths and leg injuries to most cases of long-term disability (*131*).

In low-income and middle-income countries, buses, minibuses and trucks – including open-backed trucks for transporting passengers – are frequently involved in crashes and often do not meet the standards of crashworthiness demanded in high-income countries. Typically, their passengers are not provided with seat-belts and, in the case of open-backed trucks, they are thrown from vehicles (*132*). Other problems include lack of emergency exits, glass-breakers and fire extinguishers on public transport vehicles.

Though periodic vehicle inspections have not been found useful in reducing injury crashes, inspections and checks for overloading and safety-related maintenance for larger commercial vehicles and buses could be important for vehicles more than 12 years old (*19*).

Improving the visibility of vehicles and vulnerable road users

Seeing and being seen are fundamental prerequisites for the safety of all road users. Inadequate visibility plays a key role in three kinds of crash (*133*): at night, motor vehicles running into the rears or sides of slowly moving or stationary motor vehicles, bicycles or pedestrians located ahead on the roadway; during the day, angled or head-on collisions; and at all times, rear-end collisions in fog.

There are ways of improving visibility.

- Daytime running lights for cars, though not required in many countries, reduce the incidence of daytime crashes by 10–15% (*86, 134, 135*). One study (*136*) found a reduction of 12% in crashes, 20% in injuries and 25% in deaths.
- Daytime running lights for motorized two-wheelers are equally effective. In the state of Victoria, Australia, not being sufficiently visible was a factor in 65% of crashes between cars and motorized two-wheelers and the sole cause in 21% of them (*137*). Studies have found that daytime running lights reduced the crash rate of motorcycles by 10–29% in Malaysia (*99, 138, 139*); by 13% in the United States (*140*); by 15% in Singapore (*141*); and by 10% in Europe (*99*).
- High-mounted stop lamps in cars reduce rear-end collisions by 15–50% (*86*).
- Lighting on trucks and their trailers is often inadequate. Research in Germany (*142*) found that nearly 5% of severe car-to-truck collisions are caused by the poor visibility of trucks or their trailers at night, so car drivers fail to see trucks turning off roads, turning around or driving ahead of them.

- Front, rear and wheel reflectors and lights on bicycles are required in many high-income countries. A study in the Netherlands (*143*) found that 30% of bicycle crashes occur at night or in twilight and could be avoided if bicycle lights were used.
- Colourful clothing, accessories and vehicle parts can make pedestrians, riders and non-motorized vehicles more visible. Reflective vests are often used in high-income countries, but their cost and unsuitability for hot weather may make them impractical for many low-income and middle-income countries. Alternatives include bright yellow or orange clothing or accessories. Similar colours on non-motorized vehicles (such as on bicycle frames or the wheels and rear ends of rickshaws) can make them more visible (*19*).

Improving the crashworthiness of motor vehicles

A recent study in the United Kingdom (*144*) concluded that a combination of improving vehicles, roads, laws and law enforcement could reduce the number of fatal or serious road traffic crashes by 33%. Improving vehicles alone would yield the best results: a 15.4% reduction. A recent New Zealand study (*145*) came to a similar conclusion.

High-income countries tend to share the results of such studies through such forums as the International Technical Conferences on the Enhanced Safety of Vehicles (*146*). Although their national and regional authorities (such as the European Union) set and enforce standards, they are moving towards common standards, both to ensure safety and to facilitate free trade. Many low-income and middle-income countries do not adopt the same high standards, however, with the result that their new vehicles do not incorporate the latest advances in engineering (*64*).

In addition, high proportions of the motor vehicles in low-income and middle-income countries are obsolete or deteriorated to the point at which they would not be tolerated in high-income countries. A recent study (*147*) found that occupants in cars manufactured before 1984 have about three times the risk of crash injury of occupants of recently manufactured cars.

Protecting pedestrians and cyclists with improved vehicle fronts

In collisions with cars, the most frequent causes of pedestrian injury are impact between: the pedestrian's head and the car bonnet or windscreen frame; a pedestrian's pelvis or abdomen and the bonnet edge; a child pedestrian's abdomen or chest and the bonnet edge; and the legs and the car bumper (*148, 149*). Lower-limb trauma is the most common type of pedestrian injury, and head trauma is the most common cause of death. Tests show that, in general, new cars do not protect pedestrians (*150, 151*) and no country requires the fronts of motor vehicles to have crashworthy design to minimize injury to pedestrians (*51*).

Since the 1970s, there have been studies on the shape and stiffness of motor vehicle fronts and how they impact pedestrians and cyclists; engineers have known for some time how to modify the fronts so they do less harm (*148, 152–154*). The European Enhanced Vehicle-safety Committee has devised performance tests for vehicle fronts. If motor vehicles were required to pass these tests, the annual numbers of deaths and serious injuries to pedestrians and cyclists in Europe could decline by an estimated 20% (*126, 130, 154, 155*). Meanwhile, EuroNCAP and the Australian NCAP have been applying these tests to new cars for several years and have found only one model of car that meets 80% of the protection demanded, at an estimated additional manufacturing cost of € 10 (*156*). Some European countries are expected to approve laws requiring safer car fronts soon (*126, 157*). The EC (*126*) estimates that designs that meet the 4 EEVC tests could save up to 2000 lives annually in the European Union.

In low-income and middle-income countries, similar laws are urgently needed to improve the fronts of buses, trucks, pick-ups, vans and the unique vehicles found in some cities (*128, 158, 159*). In New Delhi, India, about two thirds of crashes involve buses or trucks (*19*), but many of the people killed or seriously injured are neither passengers nor drivers but vulnerable road users

outside the vehicles (*159*). Several studies (*19, 128, 158–160*) have identified safer bus and truck fronts as an urgent need.

Protecting motor vehicle occupants

To protect occupants, a motor vehicle should be designed so the passenger compartment maintains its integrity (does not collapse) in a crash and has no elements that could cause injury. There should be restraints so that occupants do not eject from the vehicle or tumble about inside it, injuring themselves and other occupants. In addition, vehicles should be designed to minimize the impact in crashes with other vehicles of different mass, as in collisions between sports utility vehicles and smaller cars, between cars and motorcycles and so on.

The vast majority of car crashes in high-income countries are offset frontal crashes (frontal impact with partial front-end overlap) (*146*). High-income countries therefore generally require that new models be tested to ensure that passenger compartments maintain their integrity and that occupant restraints are effective in such crashes (*161, 162*). Although side-impact crashes are less common, they result in more death and serious injury per crash. Engineers are working on ways to ensure the integrity of passenger compartments and to restrain occupants appropriately in such crashes. Providing better padding and side airbags are possible improvements (*162, 163*).

As discussed later, using seat-belts reduces the risk of serious and fatal injury by 40–60%. Most high-income countries require cars and light trucks to have seat-belts that meet certain technical standards and, increasingly, to have audible alarms to remind drivers and passengers to use them. Anecdotal evidence suggests that half or more of the motor vehicles in low-income and middle-income countries may lack functioning seat-belts (*23*).

Air bags have been estimated to reduce driver and front passenger deaths by 8–14% in all types of crashes (*164–166*) and by 22–29% in frontal crashes (*164–167*). The combination of seat-belts plus air bags has reduced driver and front passenger deaths by an estimated 68% (*164*). In the United States, many children have been fatally or severely injured while seated in rear-facing child safety seats when there were also air bags (*168–170*). Concern about this hazard has caused some European countries to require warning labels in cars and automatic sensors to detect the presence of child restraints and automatically disable the airbag.

Improving vehicle-to-vehicle compatibility

Because of concern about deaths and serious injuries among car occupants when cars crash with sports utility vehicles and other light trucks, the United States National Highway Traffic Safety Administration (*171*) has made vehicle compatibility one of its highest priorities.

In Europe, efforts are being made to improve car-to-car compatibility in front-to-front and side-to-front crashes (*130*). The fronts of many new cars are capable of absorbing their own kinetic energy in crashes, but no country has legislation requiring that cars be capable of absorbing the kinetic energy of different models of car. Thus, stronger, more massive cars crush weaker, less massive ones in crashes (*162*).

Of greater concern in most low-income and middle-income countries are car-to-truck and car-to-bus collisions (*128*). High-income countries have addressed some of this concern by requiring rear and side under-run guards on trucks, preventing under-running by cars and, at the sides, by bicycles. Providing energy-absorbing front, rear and side under-run protection can reduce deaths by an estimated 12% in crashes involving trucks and lighter vehicles (*172*).

Improving bicycle design

Bicycles show large differences in component strength and the reliability of brakes and lighting. About three quarters of crashes involving cyclists in the Netherlands involve feet being trapped in the wheel spokes, and 60% of cycles have no protection system to prevent this (*19, 143*).

Designing smart vehicles

New technologies are opening new opportunities for road safety. Some of the more promising recent developments are:

- Smart, audible seat-belt reminders that detect whether or not belts are in use in each occupied seat and emit increasingly aggressive warning signals until belts are fastened (*162*). In Sweden, for example, 35% of all new cars sold are equipped with these (*173*). Although Sweden already has high rates of seat-belt use, these reminders could boost the rate to an estimated 97% and contribute to a 20% reduction in deaths among car occupants (*174*).
- Intelligent speed adaptation is a system by which the vehicle determines the speed limit for a road. Current versions use a digital road map onto which speed limits have been coded. Intervention levels can be set to advisory (informing the driver of limits and violations), voluntary (the system is linked to the controls but the driver can enable or disable the link) or mandatory (the driver cannot override the system's control). The system could reduce fatal crashes by an estimated 18–25% at the advisory level, 19–32% at the voluntary level and 37–59% at the mandatory level (*175*). Experimental trials in Sweden indicate high driver acceptance of such a system in urban areas (*173*).
- Alcohol-ignition interlock systems detect alcohol on the breath of drivers, preventing them from starting their motor vehicles. Many states in the United States and some provinces in Canada now have laws requiring that such systems be installed in cars owned by repeat violators of laws pertaining to driving while under the influence of alcohol. In Sweden, two major manufacturers are offering the systems as standard equipment in trucks, and more than 1500 trucks now have them installed (*173*).
- Electronic stability programmes can help maintain the stability of a car in adverse weather conditions, preventing skidding and loss of control on wet roads and ice. Electronic stability programmes are being offered only in luxury vehicles, but recent tests in Sweden indicate that they could reduce crashes related to ice and snow by 32–38% (*176*).

Setting road safety rules and securing compliance

Risk of injury from lack of rules and enforcement

Driving at excess or inappropriate speeds, while under the influence of alcohol, while sleepy or fatigued and without protective gear (such as seat-belts, child restraints and helmets) for all vehicle occupants are major contributors to road crashes, deaths and serious injuries. Laws alone are not enough to discourage these errors. Enforced compliance is the key. In the European Union, improving enforcement of current laws could reduce the number of road traffic deaths and serious injuries by an estimated 50% (*177*).

An extensive review of international experience with enforcement (*178*) concluded as follows.

- Creating a meaningful deterrent is critical.
- Enforcement levels need to be high and maintained so the perceived risk of apprehension is high.
- Apprehension must be followed by swift administration of penalties.
- Automated enforcement – such as cameras to catch speeders – is most effective.
- Public education without enforcement has negligible effect but, combined with enforcement, increases compliance with laws.

Setting and enforcing speed limits

Risk posed by speed

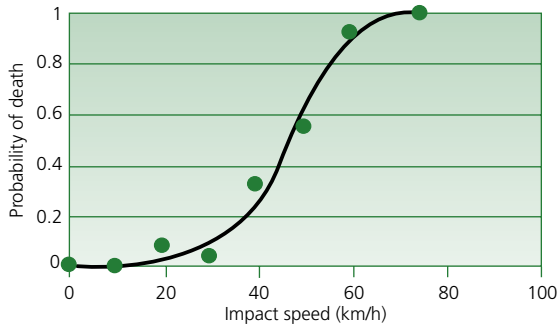
The higher the speed, the shorter the time a driver has to stop and avoid a crash. The higher the speed, the more severe the impact is when a crash occurs. The probability that a crash will result in injury is proportional to the square of the speed; for serious injury, proportional to the cube of the speed; and for fatal injury, proportional to the fourth power of the speed (*179*).

Vulnerable road users, outside motor vehicles, are at especially high risk of injury from speeding motor vehicles. The probability of a pedestrian dying as a result of a car crash increases exponentially as the speed of the car increases (Figure 8).

Older pedestrians are more vulnerable than younger ones. The probability that a pedestrian

FIGURE 8

Pedestrian fatality risk as a function of the impact speed of a car



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aged 65 years or more will be killed by a car going 75 km/h is more than 60% versus 20% for a pedestrian younger than age 15 years (*181*).

Speed limits

Speed limits that road users perceive as realistic and those that are self-enforcing have the greatest chance for achieving compliance. The layout of road networks and the design of roads, as discussed earlier, can make drivers uncomfortable with exceeding speed limits.

Speed cameras or radar can catch drivers who are exceeding speed limits. A recent analysis of experience in several countries (*86*) found that instruments that automatically catch drivers reduced road traffic deaths and serious injuries by 14%, whereas enforcement by police officers achieved a 6% reduction. Publicizing the presence of speed cameras or radar has been found to increase compliance with speed laws and to reduce the incidence of crash and injury substantially (*41, 182–184*).

Nevertheless, an earlier study in Tasmania, Australia, found that the long-term placement of stationary police vehicles on each of three high-risk stretches of a rural road achieved an average 3.6 km/h reduction in speed and a 58% reduction in crashes resulting in death or serious injury (*184*).

Speed-limiting devices built into vehicles are also effective. Speed-limiting governors in heavy goods vehicles could reduce the incidence of road traffic injury by an estimated 2% (*185*). Requiring speed governors in buses, minibuses and trucks travelling on the rural roads of low-income and middle-income countries could contribute even more (*105*).

Setting and enforcing alcohol limits

Risk posed by alcohol

Like speed, alcohol consumption increases the probability both that a crash will occur and that death or serious injury will result.

Making comparisons is difficult because legal BAC limits and enforcement vary so much from country to country. Nevertheless, several studies indicate the extent of driving while under the influence of alcohol. A review of surveys done in European Union countries (*186*) found that 1–3% of drivers were under the influence depending on the country. Surveys in Croatia found that over 4% of drivers were intoxicated (*187*). A study in Ghana (*188*) found that the BAC of more than 7% of drivers exceeded 0.08 g/dl.

A survey of studies in low-income and middle-income countries found that blood alcohol was present in 33–69% of fatally injured drivers and in 8–29% of drivers involved in crashes but not fatally injured (*189*). Studies in South Africa (*190*) found that alcohol was a factor in 47% of driver deaths and 27% of crashes in which drivers were not killed; excess alcohol was present in 52% of the people with trauma involved in road crashes (*191*). In New Delhi, India, a study (*192*) found that one third of motorized two-wheeler riders taken to hospital admitted to riding under the influence of alcohol.

Pedestrians, too, put themselves at greater risk of road traffic injury when they consume too much alcohol. A survey of studies in Australia (*193*) found that the BAC of 20–30% of pedestrians dying in road crashes exceeded 0.15 g/dl. A study in South Africa (*190*) found that alcohol was involved in more than 61% of pedestrian fatalities. A recent study in the United Kingdom (*194*) concluded that 48% of pedestrians killed in road traffic collisions had been drinking.

Blood alcohol concentration limits

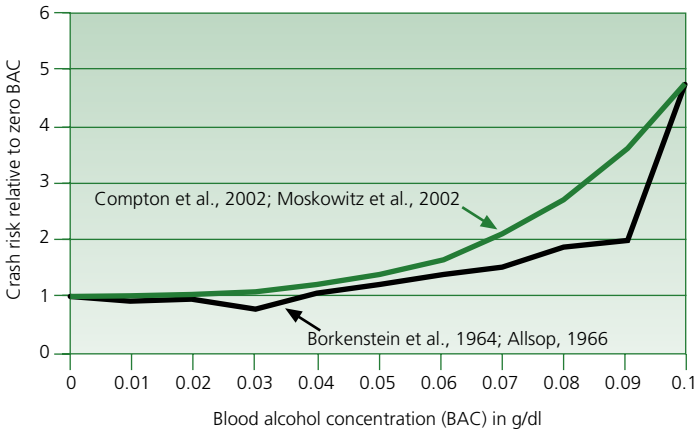
In 1964, the Grand Rapids study (*195*) showed how the crash risk increased with the amount of alcohol

consumed by drivers and provided the basis for the 0.08 g/dl BAC still accepted as the limit in many countries. Subsequent studies (*196–198*) have found that even lower levels increase the risk of crash (Figure 9).

Upper BAC limits of 0.05 g/dl for mature drivers of four-wheeled vehicles are now common in Europe. In the United States, the states set their own limits; they vary from 0.08 to 0.10 g/dl. A review of the experience in 16 states (*202*) found that the states with the lower limit had 7% fewer alcohol-related vehicle crashes. Uganda's limit is 0.15 g/dl.

FIGURE 9

Relative risk of driver involvement in police-reported crashes



Source: references *195, 199–201.*

Many European countries and many states in the United States set a BAC limit of 0.02 g/dl for young drivers (generally under 21 years in the United States) and for all riders of motorized two-wheelers. Some set the lower limit for all newly licensed drivers. A review of published studies (*202*) found that limits of between 0 and 0.02 g/dl can reduce the rate of crashes for young or novice drivers by 4–24%.

Enforcing blood alcohol concentration limits and publicizing enforcement

Research (*203–205*) has shown that the perceived risk of being caught is considerably more effective than the severity of the penalty in discouraging driving while under the influence of alcohol. Nevertheless, both the perception of the risk of being caught and the actual likelihood are low in most countries. A recent survey in Thailand (*206*) found that more than 80% of respondents considered their chances of being stopped by the police for BAC testing very low, but more than 90% agreed that enforcing BAC limits was beneficial.

Breath-testing devices that provide objective evidence of BAC are the most effective enforcement tool. Although they are used in most high-income countries, they are not used in most low-income and middle-income countries. In any case, the deterrent effect of breath testing depends on the laws governing their use (*178*). Police powers vary among jurisdictions. Some allow the police to stop only obviously impaired drivers. Some allow roadblocks or sobriety checkpoints and testing only of those suspected of impairment. Others allow stopping drivers at random and testing everyone stopped.

Widespread random breath testing – applied to at least 1 in 10 drivers every year – achieves the highest compliance with laws setting BAC limits. Enforcement should be unpredictable as to time and place, so drivers cannot avoid being tested. Three states in Australia have reduced their rates of alcohol-related road traffic deaths by 36–42% with intensive random breath testing covering anywhere from one third to three quarters of drivers (*178*).

Enforcement is most effective at reducing the frequency of driving with BAC exceeding legal limits if it is accompanied by mass media campaigns that increase public perception of the risk of being caught, reduce public acceptance of drinking and driving and increase public acceptance of enforcement (*207*).

In general, harsh penalties such as imprisonment, despite being tried in several high-income countries, have not been found to deter people from driving after drinking (*205*). More effective is swift and certain punishment such as disqualification from driving after failing a breath test or refusing to submit to a test (*208*). There is also evidence

that requiring high-risk offenders (those with BAC exceeding 0.15 g/dl) to take driver rehabilitation courses can reduce the rate of repeat offences (*186, 209*).

Medicinal and recreational drugs

The effects of drugs on driving performance and crash involvement are much less well understood than those of alcohol, largely because so many different drugs are used in varying doses and combinations, all with differing effects on different individuals. Drivers with medical conditions, for example, may drive more safely when taking certain medicinal drugs than when not taking them (*210*). There is no strong evidence that the use of medicinal drugs and driving constitutes a significant road crash risk.

However, there is evidence for the increasing use among drivers of many psychoactive drugs, both medicinal and recreational, often in conjunction with alcohol (*211, 212*). Research on this subject is urgently needed. Meanwhile, recent studies in France and the United Kingdom (*213, 214*) have found reduced driver capability when cannabis and alcohol are used in combination and a higher prevalence of the combination in drivers involved in road crashes than in other drivers.

Addressing the problem of driver fatigue

A recent study in New Zealand (*215*) found that the incidence of road crashes could be reduced by up to 19% if people did not drive: 1) while feeling sleepy, 2) after sleeping for less than five hours in the previous 24 hours or 3) between 02:00 and 05:00.

An earlier study in the United States (*216*) identified three groups of drivers at high risk of being involved in crashes while fatigued: young people, especially men aged 16–29 years; shift workers who work at night or have long, irregular working hours; and people with untreated sleep apnoea or narcolepsy.

Another study (*217*) identified all of these and other factors contributing to fatigue and crash involvement, including driving long distances, under pressure, on monotonous roads, on unfamiliar roads, after consuming alcohol, in extreme weather, during hours when normally asleep, after poor-quality sleep and during periods of the day (such as in the afternoon) when the driver normally feels drowsy.

Several studies have found fatigue to be especially frequent among commercial drivers. Surveys in low-income and middle-income countries (*55, 218, 219*) have revealed that transport company owners frequently force their drivers to work long hours, to work when exhausted and to drive at excessive speeds. Studies in the United States (*220*) have found that fatigue was a factor in 30% of fatal crashes involving heavy commercial vehicles and in 52% of all single-vehicle crashes involving trucks. In the latter case, 18% of the drivers admitted having fallen asleep.

Many high-income countries have laws restricting the number of hours commercial drivers can drive at a stretch, but the effectiveness of such restrictions, by themselves, is questionable. Evidence suggests that the time of day when commercial driving takes place is more pertinent and, also, that changing shifts of work can result in increased sleep debt and difficulties in adapting to circadian rhythms (*221*). Research (*222*) suggests that laws should be guided by the following considerations: the risk of being involved in crashes doubles after 11 hours of driving; the risk of fatigue-related crashes is 10 times greater at night than during the day; and adequate time and facilities should be provided to allow breaks for rest, meals and naps.

Reducing the risk of junction crashes

Junction crashes are a leading source of road traffic injury. Improving junction layout and design – for example, replacing signal-controlled junctions with roundabouts – can reduce the risk of junction crashes. A highly cost-effective measure is to install cameras that take photographs of vehicles going through traffic lights when signals are red.

In Australia, installing red-light cameras reduced the total number of road crashes by 7% and 32% at treated sites (*223*). In Oxnard, California, installing red-light cameras yielded a 29% reduction in crashes with injury and a 68% reduction in front-into-side crashes with injury at treated sites (*224*).

Requiring seat-belts and child restraints

Seat-belts

Mandatory seat-belt use has been one of the greatest success stories of road injury prevention and has saved many lives. Seat-belts were introduced as optional features in new cars in the 1960s. They soon proved so successful at reducing the incidence of fatal and serious injury that, in 1971, the state of Victoria, Australia, led the way in passing laws to require their presence and use in all cars. By the end of that year, the rate of occupant deaths in car crashes had declined by 18% (*27*). Other countries followed suit and have since found that improved enforcement and compliance can achieve even better results.

Several studies (*164, 225*) on the benefits of seat-belts for drivers and front-seat passengers have found that seat-belts can reduce the risk of all injuries by 40–50%; of serious injuries by 43–65%; and of fatal injuries by 40–60%. Table 7 shows their effectiveness in various types of crash. They are, for example, highly effective in frontal crashes, which are the most common kind of crash and often result in serious head injuries (*227*). Their effectiveness for people in front seats is reduced if passengers in rear seats are not also wearing seat-belts or if there are unrestrained objects, such as luggage, in rear seats.

TABLE 7

Injury reduction effects of seat-belts for various types of car crash

Crash type	Proportion of all crashes (%)	Driver seat-belt effectiveness in different crash types (%)
Frontal	59	43
Struck side	14	27
Non-struck side	9	39
Rear	5	49
Roll-over	14	77

Source: reproduced from reference *226* with the permission of the publisher.

Rates of seat-belt use vary from country to country, depending on the existence and enforcement of laws. A survey in Kenya (*55*) found that only 1% of car occupants injured in crashes were wearing seat-belts. A recent study in Argentina (*228*) found that 26% of drivers and front-seat passengers used seat-belts in Buenos Aires and 58% on national highways. A study of European Union countries in the mid-1990s (*225*) found front-seat use of seat-belts of 52–92% and rear-seat use of 9–80%. Use of seat-belts in front seats in the United States rose from 58% in 1994 to 75% in 2002 (*229*). Following a national campaign of police enforcement and increased fines in the Republic of Korea, rates of seat-belt use among drivers rose to 98% in 2001 (*230*).

Experience has shown that selective traffic enforcement programmes work best to increase compliance with seat-belt laws. These involve well-publicized, highly visible and intensive enforcement over particular periods, several times per year (*231, 232*). In provinces in France and the Netherlands, compliance with seat-belt laws increased by about 10–15% within one year of implementing such a programme (*233*). In Saskatchewan, Canada, 72% of drivers and 67% of passengers complied with seat-belt laws in 1987 (Figure 10). Implementation of a selective traffic enforcement programme had produced 90% compliance by 1993 (*234, 235*). Another effective approach involves incentives, in which people found wearing seat-belts are eligible for prizes in much the same way they might be in a lottery (*233, 236*).

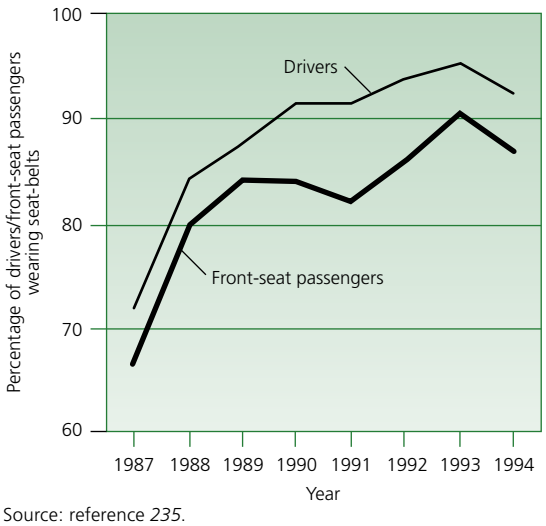
Child restraints

Child restraints work in the same way as seat-belts. A study in the United States (*237*) found that child restraints reduce the death rates in car crashes by 71% among infants and by 54% among young children.

Various models are appropriate for children of different ages. For infants aged 0–15 months weighing up to 13 kg, forward-facing child restraints reduce all injuries by 34% and severe injuries by 60%, but rear-facing child restraints reduce all injuries by 76% and severe injuries by 90% (*225*). Rear-facing restraints optimally distribute any force of impact over infants' backs and heads. As discussed previously, placing such seats in front of air bags is dangerous unless the air bag mechanism can automatically detect such a seat and switch it off.

FIGURE 10

Use of seat-belts by car drivers/front-seat passengers in Saskatchewan, Canada, 1987–1994



Source: reference *235*.

For children aged 9–18 months weighing 9–18 kg, forward-facing child restraints are appropriate. For older children, up to age 11 years, booster cushions of appropriate thickness can be used in conjunction with regular seat-belts (*238*).

Although current models of child restraints are effective, there is room for improvement. A study in Sweden found that 50% of fatal car crash injuries among children under 3 years resulted from side impact, in which current models of child restraints are less effective (*239*). EuroNCAP has found that current restraints do not fully constrain the movement of children's heads.

Child restraints are common in high-income countries – usage rates are 90% in Australia and 86% in the United States – but rare in low-income and middle-income countries. Cost is an issue even in high-income countries, where child restraint loan programmes are common. Under these programmes, for a small fee or no charge, parents can borrow infant seats from maternity hospitals. A further benefit of such schemes is their educational value, with the opportunity to advise parents on the value of the infant seats and how to use them.

In the absence of child restraints, parents should be advised not to carry children on their laps, where children are likely to be crushed in crashes.

Requiring helmets on two-wheelers

Head injuries are the main cause of death among the riders of all two-wheelers. Helmets protect very effectively against such injuries.

Motorized two-wheelers

Among moped and motorcycle riders, head injuries account for about 75% of deaths in Europe (*240*) and 55–88% in Malaysia (*241*). One study (*242*) found that riders without helmets were three times more likely to sustain head injuries than those with helmets. Another (*243*) found that helmets reduced fatal and serious head injuries by 20–45%.

A study in India (*192*) found that motorcyclists benefited from any type of helmet with padding, whereas a study in the United States (*244*) found that the non-standard helmets used by half of all motorcyclists produced more frequent head injuries than not wearing a helmet at all. Most high-income countries set standards, and a recent study (*240*) reviewed these for their effectiveness. In low-income and middle-income countries, developing standards that are sensitive to local manufacturing capabilities, cost and comfort for local climates is most practical. For example, the Asia Injury Prevention Foundation has developed a lightweight tropical helmet suitable for Viet Nam, and helmets suitable for children are now being developed in Malaysia (*241*).

Less than 10% of motorcyclists wear helmets in most countries that do not require the use of helmets by law (*245*). Although helmets have generally been widely worn in most high-income countries, there is some evidence of a decline. In the United States, helmet use fell from 71% in 2000 to 58% in 2002 (*229*).

Bicycles

Wearing helmets among child cyclists involved in crashes reduced their incidence of head injury by 63% and of loss of consciousness by 86% (*246, 247*).

Although Australia, New Zealand, Sweden, the United States and several other countries have laws requiring that cyclists wear helmets, the worldwide proportion of bicycle helmet use is low. A concern is that requiring helmets could discourage people from participating in healthy cycling, even though there

is abundant evidence that bicycle helmets prevent thousands of deaths and serious injuries every year. In the state of Victoria, Australia, a new law requiring helmets in 1990 increased the use of helmets from 31% to 75% within one year and was associated with a 51% reduction in head injuries to cyclists (*248*).

Banning drivers from using hand-held mobile phones

Over the past 20 years, hand-held mobile telephones have emerged as a road safety problem. In the United States, for example, the number of such phones increased from 500 000 in 1985 to more than 120 million in 2002. Research (*249, 250*) has shown that the reaction time of drivers increases by 0.5 to 1.5 seconds when they are talking on hand-held phones, and drivers have difficulty maintaining the correct positions in their lanes, maintaining appropriate speeds and judging and accepting safe gaps in traffic. Some evidence indicates that drivers who use hand-held phones face a risk of crash four times higher than risk faced by other drivers, imperiling themselves and other road users (*251*).

Hands-free phones can also distract drivers, but the current evidence suggests that hand-held phones pose a greater problem (*252*). Almost half of drivers now use mobile telephones to call for help in emergencies, so banning their presence in cars might not be desirable, but about 35 countries, representing all of the world's regions, now ban the use of hand-held mobile phones by the operator of the vehicle while driving (*252*).

Educating and informing the public

In isolation, public education and information campaigns do not deliver tangible, sustained reductions in road traffic deaths and serious injuries (*8, 18, 253–255*). For this reason, early efforts at public education and information have left many people feeling sceptical as to their value. As mentioned previously, however, public education and information campaigns have proven to be highly effective when they accompany laws and law enforcement.

Public education and information can clearly improve knowledge about the rules of the road and increase compliance. They can tell people which vehicles are safer and thereby influence their purchases. They can also create a climate of concern about road safety and increase public acceptance of effective interventions.

Delivering care after crashes

The aims of care after crashes are to avoid preventable death and disability, to limit the severity and suffering caused by the injury and to ensure optimal functioning of the crash survivors and reintegration into the community. A chain of opportunities to accomplish these aims involves bystanders at the scene of the crash; emergency rescue; access to the emergency care system; and trauma care and rehabilitation.

Improving care before reaching a hospital

A review of studies in Europe (*256*) concluded that about 50% of road traffic deaths occur within a few minutes at the scene of the crash or on the way to a hospital, 15% at the hospital within 4 hours of the crash and 35% after 4 hours. A study comparing road traffic deaths across a range of countries (*257*) found that the vast majority of deaths in low-income and middle-income countries occur before reaching the hospital (Table 8). The same study also found that the probability of dying before reaching the hospital increases as the socioeconomic status of the victim decreases.

Studies worldwide (*258, 259*) have shown that death could be prevented in many cases in which people died before reaching a hospital. Many complications resulting in disability could also be prevented pre-hospital.

TABLE 8

Proportion of road deaths by setting in three cities

Setting	Kumasi, Ghana (%)	Monterrey, Mexico (%)	Seattle, USA (%)
Pre-hospital	81	72	59
Emergency room	5	21	18
Hospital ward	14	7	23

Source: reference *257*.

Response by bystanders

The people arriving first at the scene of a crash can play important roles in preventing more serious con-

sequences by: calling emergency services; putting out fires; securing the scene to prevent further collisions or harm to other bystanders and rescuers; and applying first aid. Bystanders trained in first aid could prevent, for example, many deaths that result from airway obstruction or external haemorrhage (*259*).

In low-income countries and some middle-income countries, rescue by ambulance is rare and bystanders are the main means of access to health care. In Ghana, most injured people who reach a hospital do so by commercial vehicle. A recent project gave basic first-aid training to commercial vehicle drivers in the hope that it might help decrease pre-hospital mortality (*257, 260*). Although the impact of that project is not yet known, another possible model is a project that gave: 1) basic first-aid training (a two-day course) to 5000 people likely to be first on the scene in landmine-infested areas of Cambodia and northern Iraq; and 2) 450 hours of paramedic training to a select few. With basic supplies but no ambulances, the project reduced mortality from 40% to 9% (*261*).

Access to emergency services

In most high-income countries, the large volume of road traffic and the large number of mobile phones usually permit the early alerting of emergency services about a crash. There is usually a well-publicized emergency number to call, but the number varies from country to country. An internationally agreed number would be an improvement.

Many low-income countries have few emergency services delivered at the scene of road crashes. Bystanders, relatives or commercial vehicles evacuate injured people from the scene and transport them to a hospital. A study in Kenya (*50*) found that the police evacuate only 5.5% of crash survivors and hospital ambulances 2.9%.

Some African countries are starting to provide basic ambulance services in urban areas (*262*). Various studies, however, provide a basis to question whether emergency services similar to those provided in high-income countries are a priority when money is scarce and the need is so great for expenditure on other elements of health care. Basic first-aid training to groups, such as commercial vehicle drivers, who are most likely to be among the first at crash scenes, may be a more appropriate use of scarce resources (*262*).

Care by emergency services

Police and firefighters often arrive at the crash scene before emergency medical personnel. Police officers and firefighters should be equipped and trained to rescue people from a variety of emergency situations (such as fire, immersion in water and entrapment in a twisted vehicle) and to provide basic first aid (*256*).

Another concern is that emergency vehicles are highly prone to becoming involved in crashes, since they tend to travel at high speeds and weave in and out of traffic. Road safety laws, including ones requiring appropriate restraints for vehicle occupants, should also apply to them.

Improving hospital care

In high-income countries, a chain of well-trained practitioners typically provide trauma treatment in hospitals. There is room for improvement but, in general, trauma treatment has become significantly better over the past 30 years. The Advanced Trauma Life Support course of the American College of Surgeons is widely acknowledged to be the optimal standard for training in high-income countries (*256, 263*). The College and similar national and international organizations also provide guidelines and recommendations on staffing, equipment, supplies and organization.

In low-income and middle-income countries, many people have no access to hospitals through public health schemes or private insurance (*13, 55*). A study in Ghana (*258*) found that only 38% of the people seriously injured in crashes received hospital care in rural areas and only 60% in urban areas. If treatment is available at all, it is often provided by staff lacking specialized training in handling trauma cases (*256, 257*). A study of 11 rural hospitals in Ghana (*258*) found that they were staffed by general practitioners with no trauma training.

Low-income and middle-income countries also lack qualified surgeons. In the late 1980s, the

United States had 50 surgeons per 100 000 population versus only 7 per 100 000 in Latin America and 0.5 per 100 000 in Africa (*264*).

Lack of qualified medical specialists often leads to long delays between arrival at a hospital and the start of emergency surgery and treatment. A 1997 study in Ghana (*258*) found an average delay of 12 hours at the main hospital in Kumasi and that low-cost but essential equipment was missing from 11 hospitals because of poor organization, not the cost. A survey in Kenya (*50*) found that only 40% of health facilities had key supplies available.

Very little has been documented about effective programmes to address these issues, but there is some evidence of success (*262*). In Trinidad, for example, instituting the Advanced Trauma Life Support course for doctors and the Pre-Hospital Trauma Life Support course for paramedics, together with improved emergency equipment, reduced trauma mortality significantly, both pre-hospital and in hospital (*265*). Meanwhile, WHO and the International Society of Surgery are collaborating on the Essential Trauma Care Project, which aims to improve the planning and organization of trauma care worldwide (*266*).

Improving rehabilitation

In high-income countries, a variety of specialists provide rehabilitation: physical therapists, occupational therapists, prosthetists (prosthetics specialists), neuropsychologists, psychological counsellors and speech therapists. Services and equipment are often provided in homes. These services are known to make important contributions to reducing disability, although the best practices have yet to be defined (*256*). Not surprisingly, such services are in short supply in low-income and middle-income countries. They need to expand the capacity of their health care systems, in general, and decide which rehabilitation services are to be given high priority.

Doing research

All the known interventions that reduce the risk of road traffic crash and injury have resulted from scientific research and development, most of it conducted in high-income countries. Some priorities for discovering new and better interventions or adapting known ones include:

- conducting trials to test known interventions and determine whether they are appropriate and how they might be adapted to low-income and middle-income countries;
- developing road networks, with hierarchies of roads and road designs appropriate for low-income and middle-income countries and specifically developing design standards and guidelines for intercity roads carrying mixed traffic;
- developing safer fronts for all four-wheeled vehicles, so that they do less harm to vulnerable road users;
- developing standards for the crashworthiness of motorcycles and for lighter, better-ventilated helmets;
- developing better methods for evaluating the effectiveness of packages of interventions and determining which mixes of intervention are most effective;
- developing low-cost ways to improve post-crash care in low-income and middle-income countries, including improving understanding and treatment of head and whiplash injuries; and
- developing better strategies in high-income countries for managing exposure to risk and addressing the incompatibility between smaller, lighter vehicles and larger, heavier ones.

Conclusions and recommendations

Road traffic crashes occur on all continents, in every country of the world. Every year they take the lives of more than a million people and incapacitate many millions more. Pedestrians, users of non-motorized vehicles – including bicycles, rickshaws and carts – and motorcyclists in low-income and middle-income countries carry a large proportion of the global burden of road traffic death and serious injury. The elderly, children and the disabled are particularly vulnerable.

Despite the growing burden of road traffic injuries, road safety has received insufficient attention at both the international and national levels. The reasons include lack of general awareness and specific information on the scale of the problem, on the health, social and economic costs of road traffic crashes, and on the interventions that can prevent crashes or reduce the harm they cause.

Another reason is that the problem of road traffic crashes and injuries does not "belong" to any specific agency, either at national or international levels. Instead, responsibility for dealing with the various aspects of the problem – including the design of vehicles, the design of road networks and roads, urban and rural planning, the introduction and enforcement of road safety legislation, and care and treatment of crash victims – is divided among many different sectors and groups. There has usually been no leader to ensure that they coordinate their efforts and address the problem as a whole. In this environment, it is not surprising that political will has frequently been lacking to develop and implement effective road safety policies and programmes.

Main messages from the report

This report, the first joint report between WHO and the World Bank on the topic, presents the current knowledge about road traffic injuries and the actions that need to be taken in order to tackle the problem. The following are some of the report's key messages.

- Any road traffic system is highly complex and hazardous to human health. Elements of the system include motor vehicles, roads and road users and their physical, social and economic environments. Making a road traffic system less hazardous requires a "systems approach" – understanding the system as a whole and the interaction between its elements, and identifying where there is potential for intervention. In particular, it requires recognition that the human body is highly vulnerable to injury and that humans make mistakes. A safe road traffic system is one that accommodates and compensates for human vulnerability and fallibility.
- Road traffic injuries are a huge public health and development problem, killing almost 1.2 million people a year and injuring or disabling between 20 million and 50 million more. Both WHO and World Bank data show that, without appropriate action, these injuries will rise dramatically by the year 2020, particularly in rapidly-motorizing countries. Not only is 90% of the current burden borne by low-income and middle-income countries, but the increase in casualty rates will be greatest in these countries. Although data on the costs of road traffic crashes are sparse, particularly from low-income and middle-income countries, it is clear that the economic impact of these injuries on individuals, families, communities and nations is enormous, costing countries between 1% and 2% of their gross national product. In addition, there is the heavy and tragic burden

on those directly affected, both physically and psychologically – as well as on their families, friends and communities. Health facilities and their often meagre budgets are greatly overstretched in dealing with survivors of road traffic crashes.

- Many countries have no injury surveillance systems that generate reliable data on road traffic crashes and injuries. Indicators, especially for non-fatal outcomes, may not be standardized, making comparisons difficult. There are frequently discrepancies between data – for example, between police and health-related sources. Furthermore, widespread underreporting of road traffic fatalities and injuries – both in health and police data – limits the usefulness of existing data sources. Reliable data are needed to provide a solid foundation for road safety planning and decision-making. Establishing simple, cost-effective injury surveillance systems is an important step towards improving road safety. However, the lack of reliable data should not impede immediate action. Much can be achieved by adapting and applying proven safety practices.
- A number of factors affecting the probability of a road traffic injury need to be considered within the systems approach. The various types of risk related to road traffic injury, and the factors influencing these risks, are:
  - For *exposure to risk*, the determinants include economic and demographic factors, level of motorization, modes of travel, the volume of unnecessary trips and land use planning practices.
  - For *crash occurrence*, the risk factors include excessive speed, drinking and driving, unsafe vehicles, unsafe road design, and the related lack of effective law enforcement and safety regulations.
  - For *injury severity*, the risk factors include the non-use of seat-belts, child restraints and crash helmets; lack of "forgiving" vehicle fronts to protect pedestrians in a collision; roadside infrastructure that is unprotective in a crash; and human tolerance factors.
  - For *post-crash injury outcomes*, the risk factors include delays in detecting a crash and providing life-saving measures and psychological assistance; lack of or delayed emergency care on the spot and transport to a health facility; and the availability and quality of trauma care and rehabilitation.
- Road safety is a shared responsibility. Reducing the risk in the world's road traffic systems requires commitment and informed decision-making by government, industry, nongovernmental organizations and international agencies and participation by people from many different disciplines, such as road engineers, motor vehicle designers, law enforcement officers and health professionals and community groups.
- Vision Zero in Sweden and the sustainable safety programme in the Netherlands are examples of good practice in road safety. Such good practice can also have other benefits. It can encourage healthier lifestyles involving more walking and cycling and can reduce the noise and air pollution that result from motor vehicle traffic. Colombia is an example of a developing country that is beginning to implement a similar strategy.
- The important role that public health can play in the prevention of road traffic injuries includes: the collection and analysis of data in order to demonstrate the health and economic impact of road traffic crashes; research on risk factors; the implementation, monitoring and evaluation of interventions; the delivery of appropriate primary prevention, care and rehabilitation for injured people; and advocacy for greater attention to the problem.

Road traffic crashes are predictable and can be prevented. Many high-income countries have shown sharp reductions in crashes and casualty numbers over the past couple of decades by adopting a systems approach to road safety that emphasizes environment, vehicle and road user interventions, rather than solely focusing on direct approaches aimed at changing the behaviour of road users. Although solutions for low-income and middle-income countries may differ from those countries that have a longer

history of motorization, some basic principles are the same. These include, for example, good road design and traffic management, improved vehicle standards, speed control, the use of seat-belts and the enforcement of alcohol limits. The challenge is to adapt and evaluate existing solutions, or else create new solutions in low-income and middle-income countries.

Transferring and adapting some of the more complex measures are more long term and require country-specific research and development. In addition, more work is called for in all countries to find new and better road safety measures. For example, provision of safer fronts on new designs of motor vehicles is urgently needed to reduce the harm caused in vehicle collisions with pedestrians and cyclists.

There are many proven science-based interventions, as well as promising strategies still under study. Governments can make use of these to develop effective and cost-effective road safety programmes. With properly targeted investment, countries should derive considerable social and economic benefits from reduced road traffic deaths, injuries and disabilities.

Recommended actions

This report offers governments the opportunity to assess the current status of road safety in their country, review policies and institutional arrangements and capacity, and take appropriate actions. All the following recommendations should be addressed across a wide range of sectors and disciplines if they are to achieve success. However, the recommendations should be treated as flexible guidelines. They leave much room for adaptation to local conditions and capacities.

In certain low-income and middle-income countries with limited human and financial resources, it may be difficult for governments to apply some of these recommendations on their own. In these circumstances, it is suggested that countries work with international or nongovernmental organizations or other partners to implement the recommendations.

Recommendation 1: Identify a lead agency in government to guide the national road traffic safety effort

Each country needs a lead agency on road safety, with the authority and responsibility to make decisions, control resources and coordinate efforts by all sectors of government – including those of health, transport, education and the police. This agency should have adequate finances to use for road safety, and should be publicly accountable for its actions.

Experience across the world has shown that different models can be effective in road safety and that each country needs to create a lead agency appropriate to its own circumstances. The agency might take the form, for example, of a designated, standalone bureau, or a committee or cabinet representing several different government agencies. It might also be part of a larger transport organization. The agency might undertake much of the work itself or else it might delegate work to other organizations, including provincial and local governments, research institutes or professional associations.

Specific efforts should be taken by the agency to engage all significant groups concerned in road safety, including the wider community. Awareness, communication and collaboration are key to establishing and sustaining national road safety efforts.

National efforts will be boosted if one or more well-known political leaders can actively champion the cause of road safety.

Recommendation 2: Assess the problem, policies and institutional settings relating to road traffic injury and the capacity for road traffic injury prevention in each country

An important element in dealing with road safety is ascertaining the magnitude and characteristics of the problem, as well as the policies, institutional arrangements and capacity within the country to deal with road traffic injuries. This includes an understanding not only of the volume of traffic deaths, injuries and crashes, but also of which road users are most affected; in which geographic areas the greatest problems are found; what risk factors are contributing; what road safety policies, programmes and specific interventions are in place; what institutional structures are addressing the road traffic injury problem; and what their capacity is. Intermediate outcome measures – such as mean speeds, rates of seat-belt wearing, and rates of helmet wearing – can also be useful and can be obtained through simple surveys.

Possible sources of data include: police; health ministry and health care settings; transport ministries; insurance firms; motor vehicle manufacturing companies; and government agencies collecting data for national planning and development. However, the accuracy, consistency and thoroughness of these data should be assessed before making use of them.

Information systems on road traffic deaths and injuries should be simple and cost-effective to implement, appropriate to the skill levels of the staff using them, and consistent with national and international standards.

Standards that could be easily and profitably adopted include: the use of the 30 day traffic fatality definition; the International Statistical Classification of Diseases and Related Health Problems; the International Classification of External Causes of Injury (ICECI); and the Injury Surveillance and Survey guidelines developed by WHO and its collaborating centres.

Data should be widely shared among the relevant authorities and concerned groups, particularly those responsible for traffic, law enforcement, health and education.

The economic impact of road traffic injuries in most countries is substantial. Where this is possible, assessing the direct and indirect economic costs, in particular relative to gross national product, can help increase awareness of the scale of the problem.

A lack of data, though, should not dissuade governments from beginning to implement many of the other recommendations in this report.

Recommendation 3: Prepare a national road safety strategy and plan of action

Each country should prepare a road safety strategy that is multisectoral – involving agencies concerned with transport, health, education, law enforcement and other relevant sectors – and multidisciplinary – involving road safety scientists, engineers, urban and regional planners, health professionals and others. The strategy should take the needs of all road users into account, particularly vulnerable road users, and should be linked to strategies in other sectors. It should involve groups from government, the private sector, nongovernmental organizations, the mass media and the general public.

A national road safety strategy needs to set ambitious but realistic targets for at least five or ten years. It should have measurable outcomes and sufficient funding to develop, implement, manage, monitor and evaluate actions. Once the road safety strategy is prepared, a national action plan, scheduling specific actions and allocating specific resources, should be developed.

Recommendation 4: Allocate financial and human resources to address the problem

Well-targeted investment of financial and human resources can reduce road traffic injuries and deaths considerably. Information from other countries on their experience with various interventions can help a government in assessing the costs against the benefits of specific interventions and set priorities based on which interventions are likely to be the best investment of scarce financial and human resources. Similar cost–benefit analyses of possible interventions in other areas of public health can help set overall government priorities for expenditure on public health.

Countries may have to identify potential new income sources to afford the investment needed to achieve road safety targets. Examples include fuel taxation, road and parking charges, vehicle registration fees and fines for traffic violations. Area-wide safety assessments, at the proposal stage of projects that may influence road safety, and safety audits, as projects are carried through to completion, can help make optimal use of limited resources.

Many countries do not have the human resources with the training and experience required to develop and implement an effective road safety programme and therefore need to develop these resources. Appropriate training programmes should be a priority. Such training should cover specialist fields – such as statistical analysis, road design and trauma care – as well as fields cutting across disciplines – such as urban and regional planning, policy analysis and development, road traffic planning and health planning.

WHO is currently developing a curriculum for teaching the prevention of road traffic injury in schools of public health and other settings. Several international networks, including the Injury Prevention Initiative for Africa and the Road Traffic Injury

Network, currently provide training, as do many schools of public health and engineering.

International conferences – such as the World Conferences on Injury Prevention and Safety Promotion, the International Conferences on Alcohol, Drugs and Traffic Safety (ICADTS), the conferences of the International Traffic Medicine Association (ITMA) and the congresses of the World Road Association (PIARC) – provide opportunities to exchange knowledge, establish networks and potential partnerships, and strengthen country capacity.

Efforts should be made to increase attendance by representatives from low-income and middle-income countries at these conferences and to involve them in setting global and regional agendas for road safety.

Recommendation 5: Implement specific actions to prevent road traffic crashes, minimize injuries and their consequences and evaluate the impact of these actions

Specific actions are needed to prevent road traffic crashes and to minimize their consequences. These actions should be based on sound evidence and analysis of road traffic injuries, be culturally appropriate and tested locally, and form part of the national strategy to address the problem of road crashes.

Chapter 4 of the main report discussed road safety interventions in detail, with their effects on reducing the frequency and severity of crashes, as well as their cost-effectiveness, where available. No standard package of interventions is suitable for all countries. However, all countries can follow several good practices, including:

- incorporating as a long-term goal, safety features into **land-use and transport planning** – such as the provision of shorter and safer pedestrian and bicycle routes and convenient, safe and affordable public transport – and **road design**, including controlled crossings for pedestrians, rumble strips and street lighting;
- setting and enforcing **speed limits** appropriate to the function of specific roads;
- setting and enforcing laws requiring **seat-belts** and **child restraints** for all motor vehicle occupants;
- setting and enforcing laws requiring riders of bicycles and motorized two-wheelers to wear **helmets**;
- setting and enforcing **blood alcohol concentration limits** for drivers, with random breath testing at sobriety checkpoints;
- requiring **daytime running lights** for two-wheeled vehicles (the use of daytime running lights on four-wheeled vehicles should also be considered);
- requiring that motor vehicles be **designed for crashworthiness** to protect the occupants, with efforts to expand this concept to the design of the fronts of motor vehicles, so as to protect pedestrians and cyclists;
- requiring new road projects to be subject to a **road safety** audit, by a road safety specialist independent of the road designer;
- managing existing **road infrastructure** to promote safety, through the provision of safer routes for pedestrians and cyclists, traffic calming measures, low-cost remedial measures and crash-protective roadsides;
- strengthening all links in the **chain of help for road crash victims**, from the crash scene to the health facility; for example, specific groups, such as commercial vehicle drivers, most likely to be first on the scene of crashes, might be provided with basic training in first aid, and health professionals might be provided with specialized training in trauma care;
- enhancing programmes of law enforcement with **public information and education** campaigns – for example, on the dangers of speeding or driving while under the influence of alcohol, and the social and legal consequences of doing so.

Recommendation 6: Support the development of national capacity and international cooperation

The world faces a global road safety crisis that has not yet been fully recognized and that will continue to grow unless appropriate action is taken. International organizations – including United Nations agencies, nongovernmental organizations

and multinational corporations – and donor countries and agencies have important roles to play in addressing this crisis and strengthening road safety around the world.

Dedicating World Health Day 2004 to road safety is one step WHO is taking in this direction. Beyond this, the donor community urgently needs to dedicate more of its resources to helping low-income and middle-income countries improve road safety. Currently, the level of support given to road safety is far below that for other health problems of comparable magnitude. Few multilateral donors have included road safety among their priority areas for funding. With some exceptions, such as the FIA, Volvo and Rockefeller Foundations, few foundations to date have provided significant funding for international road safety programmes.

Several global and regional United Nations or intergovernmental agencies are active in road safety. Although there have been joint efforts, little coordinated planning between these agencies takes place on any large scale. In addition, no lead agency takes responsibility for ensuring that such coordinated planning takes place. This situation must change so that responsibility is clearly assigned, specific roles are allocated to specific agencies, duplication is avoided and a firm commitment is forthcoming to produce and implement a global plan for road safety.

There first needs to be a forum where those involved can meet and discuss the development of such a global plan. The plenary meeting of the United Nations General Assembly taking place on 14 April 2004 is a milestone in this direction. A follow-up process, though, is needed. This process should include regular meetings of relevant government ministers so as to develop and endorse a global plan of action or charter for road safety, consistent with other global initiatives such as the Millennium Development Goals.

Finally, international nongovernmental organizations and the private sector can help raise awareness locally and globally, as committed citizens, employers and socially responsible corporate entities.

Conclusion

This report attempts to contribute to the body of knowledge on road safety. It is hoped that it will inspire and facilitate increased cooperation, innovation and commitment to preventing road traffic crashes around the world.

Road traffic crashes are predictable and therefore preventable. In order to combat the problem, though, there needs to be close coordination and collaboration, using a holistic and integrated approach, across many sectors and many disciplines.

While there are many interventions that can save lives and limbs, political will and commitment are essential and without them little can be achieved. The time to act is now. Road users everywhere deserve better and safer road travel.

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