TRANSPORT FOR HEALTH

THE GLOBAL BURDEN OF DISEASE FROM MOTORIZED ROAD TRANSPORT

FOREWORD BY
WORLD BANK GROUP PRESIDENT JIM YONG KIM

GLOBAL ROAD SAFETY FACILITY
THE WORLD BANK GROUP

INSTITUTE FOR HEALTH METRICS AND EVALUATION
UNIVERSITY OF WASHINGTON

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This report was prepared by the Global Road Safety Facility at the World Bank and the Institute for Health Metrics and Evaluation (IHME) at the University of Washington and was based on seven papers for the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010) published in *The Lancet* (2012 Dec 13; 380). GBD 2010 had 488 co-authors from 303 institutions in 50 countries. The work was made possible through core funding from the Bill & Melinda Gates Foundation. The views expressed are those of the authors. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of the World Bank, its Board of Executive Directors, or the governments they represent.

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ABOUT THE GLOBAL ROAD SAFETY FACILITY AT THE WORLD BANK GROUP

The Global Road Safety Facility (GRSF), a global partnership program administered by the World Bank, was established to help address the growing crisis of road traffic deaths and injuries in low- and middle-income countries. GRSF provides funding, knowledge, and technical assistance that catalyze further investments through World Bank projects addressing road safety. GRSF also partners and collaborates with other multilateral organizations, the private sector and NGOs, and country-based agencies. To express interest in collaborating with the GRSF, or to receive copies of this publication, please contact the GRSF at www.worldbank.org/grsf.

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The Institute for Health Metrics and Evaluation (IHME) is an independent global health research center at the University of Washington that provides rigorous and comparable measurement of the world's most important health problems and evaluates the strategies used to address them. IHME makes this information freely available so that policymakers have the evidence they need to make informed decisions about how to allocate resources to best improve population health.

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FOREWORD

Transport for Health focuses timely attention on the growing burden that motorized road transport imposes on global health development. By quantifying the burden of disease attributable to both road injury and air pollution from vehicles, the authors have found that motorized road transport deaths exceed those from diseases such as HIV, tuberculosis, or malaria. That is a powerful wake-up call.

Mobility solutions need to address the whole gamut of human needs: transport that is clean and affordable must also be safe for people who want access to jobs, health, and education. Road injuries now rank as the world's eighth-leading cause of death and the number-one killer of young people ages 15 to 24. While the disease burden attributed to ambient air pollution has declined among richer regions such as Western Europe and North America, over the last 20 years we have seen a sharp rise in South Asia and East Asia.

These alarming findings underscore the urgent need to spread improvements in transport pollution and safety across world regions. Building the institutional capacity to address this challenge, by mobilizing expertise across health and transport sectors, is also crucial. It is a matter of life, death, and equity: approximately 90% of all road crashes now happen in low- and middle-income countries; yet they own only half of the world's motor vehicles. More than half of global deaths are among pedestrians and operators of motorized two-wheeled vehicles. Rates are higher in the world's poorest regions. These losses are tragic and needless. Families often lose their breadwinners or have to pay for expensive medical treatment. Many are plunged into poverty as a result.

Road crashes cost an estimated 1% to 5% of GDP in developing countries, undermining efforts to reduce poverty and boost shared prosperity. In the coming years, the World Bank Group, our partners through the Global Road Safety Facility, the international donor community, and governments worldwide need to scale up efforts to save millions of lives and avoid serious injuries, as mandated by the United Nations Decade of Action for Road Safety 2011-2020.

The work conducted by the Institute for Health Metrics and Evaluation to update the Global Burden of Disease (GBD) dataset is particularly valuable. These findings will help us sensitize policymakers to the staggering cost of current and future health trends, and to mobilize appropriate responses to transport and health challenges in an increasingly urbanized and motorized world.

Facts in hand, I am convinced we can achieve safer, cleaner, and more affordable transport solutions that benefit the poor, create resilient economies, and save millions of lives.

Jim Yong Kim

President
The World Bank Group

FOREWORD

This report summarizes the findings of a long and meticulous journey of data gathering and analysis to quantify the health losses from road deaths and injuries worldwide, as part of the path-finding Global Burden of Disease (GBD) study. It is important, first, to acknowledge the profound contribution made by the lead authors and global team of injury prevention professionals to estimate the disease burden of road trauma, before absorbing their findings and recommendations. Without their dedication and tenacity, the way forward would be less certain. The first GBD study, published nearly two decades ago, signaled an emerging road safety crisis in developing regions of the world. It triggered a remarkable program of global advocacy that culminated in the United Nations Decade of Action for Road Safety and Global Plan to bring road safety outcomes under control in these regions by 2020. However, limited investment has been mobilized so far to implement the UN initiative. The second GBD study, and related analyses presented in this report, confirm the importance of road safety as a global development priority and the urgency with which it must be addressed.

The report's findings highlight the growth in road deaths and injuries globally, and their substantial impacts on maternal and child health, despite sustained reductions over the last three to four decades in high-income countries. Combined with the deaths arising from vehicle pollution, the road transport death toll exceeds that of, for example, HIV/AIDS, tuberculosis, malaria, or diabetes. This statistic further reinforces the call for global action. Without these GBD estimates we would not have a clear picture of the true situation because official country data in the developing world vastly understate the scale of road transport health losses.

The report's findings also underscore the policy complexities of managing the adverse health impacts of increasing road vehicle travel. These include premature death and disability arising from road crashes, air pollution, diminished physical activity, and greenhouse gas emissions. While estimates of road crash injuries have been improved, and conservative estimates of the disease burden attributable to road vehicle pollution have been made, the adverse health impacts of reduced physical activity and greenhouse gas emissions resulting from increased road vehicle use are yet to be reliably estimated. Nevertheless, it is clear from the evidence presented that the potential is substantial for safer active transport facilities to reduce the growing burden of non-communicable diseases and climate change impacts.

The issue remains of how to best use the report's findings. A strong case is made for improved data collection and more robust accounting of adverse health impacts within a sustainable development framework. Multisectoral collaboration, strengthened institutional management capacity, and the development of more comprehensive transport evaluation tools will be integral to this desired shift in

practice. Above all, the report's findings make it clear that the economic benefits of reducing the health losses accruing to road transport are too huge to ignore. In the case of road safety and air quality improvements, they have proved to outweigh their costs – as demonstrated by the experience of high-income countries over the last four decades – and the business case for integrated action is compelling.

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PREFACE

Two decades ago, the first iteration of the Global Burden of Disease study brought attention to the growing toll of premature death and disability from road injury. Since that time, deaths from road injuries increased to become the eighth-leading cause of death worldwide in 2010. Road injuries are a universal threat to population health across rich and poor countries alike and disproportionately impact the most economically productive age groups in society.

The increasing use of vehicles over time has led to more air pollution, which also negatively impacts health. This report marks the first effort to quantify both the burden of disease attributable to road injury and the burden linked to air pollution from vehicles. While the consequences of road injury tend to be immediate and severe, air pollution from vehicles is more insidious and can lead to ischemic heart disease, stroke, chronic lung diseases, and lower respiratory infections. To strengthen our understanding of this health risk, we need to improve the data available on vehicle pollution and the methods for estimating its contribution to disease burden. If this challenge can be met, it will allow researchers and policymakers to monitor progress in reducing the burden from vehicle emissions.

Ministry of health officials are typically viewed as the chief stewards of countries' population health, but reducing the disease burden from motor vehicles requires action from multiple sectors. As economies grow and demand for cars and roads increases, the transport sector plays a vital role in designing, building, and maintaining an infrastructure and regulatory system that will encourage economic growth while minimizing health loss. Policymakers can improve health by implementing measures shown to effectively reduce disease burden from transport, such as vehicle safety and emissions regulations, seatbelt and helmet requirements, and speeding and drunk-driving laws. These regulations are only as effective as they are enforced legally, requiring investment to ensure compliance with these laws.

The success we see in high-income countries, where premature death and disability from road injuries have dropped, shows us it is possible to reverse this growing problem. The United States reduced its burden of road injuries by 16% between 1990 and 2010, despite a significant increase in population and vehicles on the road. Many Western European and high-income countries in the Asia Pacific region reduced their burdens even more dramatically. Japan reduced its disease burden from road injuries by 42% between 1990 and 2010, and Sweden lowered its burden by 30%. Case studies of interventions, policies, regulations, and institutional capacity to deliver them in these high-achieving countries could help elucidate key lessons that other nations can follow to reduce the burden of road injuries.

Annual updates of the Global Burden of Disease will allow decision-makers to continually monitor the impact of road injuries in their countries as they implement

new policies and design programs to address this important health problem. By collaborating across sectors, replicating effective policies carried out in other countries, and making an ongoing commitment to improve data and research, we can get closer to realizing a world where everyone enjoys the benefits of safe transport and lives a long and healthy life.

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EXECUTIVE SUMMARY

Rapid improvements in road transport have helped many nations make progress toward their development goals. Transport is often one of the most highly funded sectors in development bank lending portfolios due to ongoing demand from borrowers as well as its role in stimulating economic growth and competitiveness. At the same time, the global development community is increasingly concerned about the social costs of growth in road transport, particularly the impacts on human health due to the rise in road traffic injuries and impacts on non-communicable diseases via emissions and decreased physical activity.

This report quantifies, for the first time, the global health loss from injuries and air pollution that can be attributed to motorized road transport. It combines estimates of the global burden of road injuries based on a large pool of new data from the most information-poor regions with estimates of the health effects of pollution from vehicles. The results of this analysis show the following:

- Motorized road transport imposes a large burden on population health, resulting in more than 1.5 million deaths and 79.6 million healthy years of life lost annually. Deaths from road transport exceed those from HIV, tuberculosis, or malaria. Injuries and pollution from vehicles contribute to six of the top 10 causes of death globally.
- Road injuries have a substantial impact on maternal and child health. Health loss attributable to motorized road transport exceeds that from key risk factors affecting children, including childhood underweight and suboptimal breastfeeding. Road injuries rank among the top 10 causes of death after the first year of life through age 59. In addition, road injuries are a top-10 cause of death among women of childbearing age and are the fourth-leading cause among women aged 15 to 29 years.
- The burden due to motorized road transport is growing. Over the last two decades, deaths due to road crashes grew by 46%. Deaths attributable to air pollution, to which motor vehicles are an important contributor, grew by 11%.
- Health loss resulting from the combined effects of road injuries and pollution from transport is substantial in all regions. While the deaths from road transport are dominated by road injuries in poorer regions, such as sub-Saharan Africa, health loss due to pollution from vehicles tends to be highest among richer regions, such as Western Europe.
- Injuries are responsible for most of the burden of motorized road transport, accounting for 95% of the healthy life years lost. Road crashes result in 1.3 million deaths annually and 78.2 million nonfatal injuries warranting medical care.
- Pedestrians alone account for 35% of road injury deaths globally and over 50% in East and Central sub-Saharan Africa.

- Pollution from vehicles is the cause of 184,000 deaths globally, including 91,000 deaths from ischemic heart disease, 59,000 deaths from stroke, and 34,000 deaths from lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer.
- Official government statistics substantially underreport road injuries. Estimates based on Global Burden of Disease 2010 data suggest, for example, that road injury deaths are more than twice the official statistics in India, four times those in China, and more than six times the official numbers in parts of Africa.

KEY CONCLUSIONS AND RECOMMENDATIONS

This report reaffirms the need for safe and clean transport for achieving global health and development goals. It calls for a multisectoral collaboration that includes the transport, health, and urban sectors, among others, to help achieve beneficial and sustainable development. In particular:

- Road injuries are a major contributor to the Global Burden of Disease. Thus, rapidly scaling up road safety programs alongside the expansion of transport is vital for saving lives while promoting development. Mitigating the health risks requires a long-term investment strategy to build the capacity of national institutions so they can actively manage safety and mobility performance through targeted interventions. This is necessary given the multisectoral complexity of road safety and demands a systematic approach rather than isolated efforts with specific interventions.
- While malnutrition, diarrhea, and many infectious diseases occur in settings of extreme poverty, the health burden associated with road transport spreads with economic growth and rapid motorization. This need not be the case, provided countries, aid agencies, and donors develop comprehensive and country-specific policy frameworks for investing in the health and well-being of populations. It took developed countries 70 years to reverse negative health trends from road transport, but developing countries can accelerate this process through strategic investments and collaboration across sectors.
- Due to limitations of available data and methods, we have likely underestimated the effects of pollution from vehicles. Additional research is needed to obtain more detailed geographic information on human exposure to air pollution in rapidly motorizing regions and to better understand the health effects of exposure to traffic-related pollutants. In addition, a comprehensive accounting of the burden of road transport requires research to quantify the loss of physical activity due to motorization, which is not possible with currently available data and methods.
- There is an urgent need for better tracking of the health impacts of road transport. Statistical systems need to be expanded and improved to collect key indicators to monitor and evaluate these effects. The absence of reliable accounting of health impacts not only endangers effective multisectoral action, it can waste government resources or lead to development aid funding being targeted at ineffective solutions.

INTRODUCTION

MOTORIZED ROAD TRANSPORT POSES A GROWING THREAT TO POPULATION HEALTH

International and national development agencies have long viewed building roads as a key strategy for driving economic growth and improving the health and well-being of people. Providing reliable transport infrastructure can stimulate economic development in several ways. For instance, foreign direct investment is attracted to regions that provide high-quality road infrastructure to facilitate efficient logistics.[1] Within a country, road infrastructure connects remote areas with centers of trade and connects centers of industry to global markets, spurring the growth of trade and reducing costs by improving access to goods and services.[1]

Since 2000, the Millennium Development Goals (MDGs) have been the central focus of global development. While the MDGs did not explicitly address the transport sector, roads have been viewed as crucial for successfully achieving several of the MDGs. In 2005, the African Union and the United Nations (UN) Economic Commission for Africa wrote a report[2] calling for widespread infrastructure improvements, stating, "The significance of transport services to each of the MDGs means that effective pursuit of the latter requires priority attention to those transport services, which are relevant to each." Roads bring people closer to health care facilities and educational opportunities. In particular, rural connectivity helps reduce maternal mortality through better access to maternal care.[3] Rural roads have impact on increasing the enrollment of girls in school.[3] In addition to being an end in itself, education of girls is important to population health as it helps reduce fertility rates and improve maternal and child health, among other mechanisms.[4] Similarly, roads facilitate access to food markets and can promote better nutrition.[3]

Motorized road transport has grown briskly in recent decades, especially in regions with the most rapidly growing economies. In the last two decades, China has built a highway system that, by Chinese government estimates, rivals that of the United States, and it plans to further develop the network substantially over the next decade.[5] In India, rapid expansion of the highway infrastructure is currently underway because insufficient road transport is viewed as a key impediment to industrial growth and has been viewed as a reason for the country's failure to achieve the full benefits of economic reforms.[6] In sub-Saharan Africa, where most people do not have access to all-weather roads, road transport is seen as a key solution to providing basic services, reducing poverty, and driving economic growth.[3]

However, motorized road transport is also closely linked to several threats to human health and well-being that have not been previously assessed in a comprehensive manner. These harms include the direct health effects of road injuries and vehicular emissions, the indirect health effects of sedentary lifestyles resulting from frequent use of motorized transport, and the threat of catastrophic environmental damage

through climate change, to which vehicular emissions are a key contributor. Each of these issues is increasingly receiving attention. Our knowledge of global road safety has substantially improved in recent years due to several epidemiological studies such as the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010), which is the basis of this publication. While the Global Burden of Disease due to ambient air pollution has also been characterized, the contribution of emissions from vehicles has never been estimated. In this report, we estimate these for the first time. Although studies to estimate the global burden of physical inactivity have become increasingly sophisticated, the contribution of motorization to physical inactivity has not been measured and represents an important gap in our assessment of the health impacts of motorized road transport. Finally, although action to address climate change is urgently needed, the connections between transport, climate, and health have been extremely difficult to quantify.[7]

Despite these numerous limitations, the systematic and comprehensive assessment of the health effects of motorized road transport presented in this publication can help guide decision-making in the transport sector for a safer and more prosperous future.

NEED FOR A MULTISECTORAL APPROACH

Since the identification of road injuries as one of the top 10 causes of death and disability by the original GBD study in 1993, substantive global efforts have been undertaken to establish road safety as a development priority. In May 2011, the UN Decade of Action for Road Safety 2011-2020 was launched in more than 100 countries with the goal of preventing 5 million road traffic deaths and 50 million serious injuries. The launch was a culmination of substantial efforts by international and national agencies. These included the release of the 2004 *World Report on Road Traffic Injury Prevention* by the World Health Organization (WHO) and the World Bank, multiple UN and World Health Assembly resolutions calling on governments to improve road safety, and the first Global Ministerial Conference on Road Safety in 2009.[8] Numerous co-sponsoring country governments, key UN regional agencies, and multilateral development banks have endorsed the call for the Decade of Action and its goals.

At the same time, non-communicable diseases, which are linked closely to motorized transport through the health effects of air pollution and physical inactivity, have emerged as a major health problem. In September 2011, the High-level Meeting of the UN General Assembly adopted the Political Declaration on the Prevention and Control of Non-communicable Diseases.[9] It is now considered likely that non-communicable diseases will figure prominently in the post-MDG era beginning in 2015.

A multisectoral approach for addressing the health impacts of transport is key for maximizing public health improvements. For example, promoting active transport, such as walking and biking, has emerged as a guiding vision among public health professionals. However, people tend not to walk, bike, or take public transport

unless these activities are safe.[10] In fact, a growing body of literature shows that such programs are most successful when they employ an integrated approach that includes providing safe infrastructure such as sidewalks and bike lanes, supportive land use planning, and advocacy and education.[11]

Providing infrastructure that makes active modes of travel safe, secure, and convenient is particularly important, making the transport sector the key enabler for the multisectoral goal of healthy development. Major international institutions, such as development banks, are attempting to reframe their development agenda to be consistent with these principles of sustainable transport and development.[12] Commitments for sustainable transport growth, as seen at the 2012 Rio+20 Summit,[12] although small, are important steps toward this broader vision.

PURPOSE OF THIS REPORT

This report is the first attempt to assess the combined direct global health loss that can be attributed to motorized road transport. Specifically, we quantify the health impacts of motorized road transport from 1) injuries due to road traffic crashes over the last two decades, and 2) air pollution generated by motorized road transport ("pollution from vehicles").

We did not estimate indirect health impacts, such as physical inactivity, and distal impacts, such as climate change, because we lacked sufficient epidemiological data to construct estimates of these effects at a global scale. Finally, we discuss the implications of our findings for transport and health policy.

METHODS

Our estimates of the health losses due to motorized road transport are based on GBD 2010, which is a systematic, scientific effort to quantify the comparative magnitude of health loss due to 291 diseases and injuries, 1,160 sequelae (direct consequences of disease and injury, also known as complications), and 67 risk factors for 20 age groups and both sexes in 1990, 2005, and 2010. GBD 2010 produced estimates for 187 countries and 21 regions. GBD 2010 generated estimates of the burden of road injuries as well as the burden that can be attributed to outdoor air pollution from all sources. For the first time, we estimated for this report the amount of premature death and disability that is attributable to air pollution from motor vehicles ("pollution from vehicles") and combined that with the burden of road injuries to construct estimates of the total health loss due to motorized road transport. This chapter provides a synopsis of methods. For more details, see Annex 1 and associated GBD 2010 publications.[13]

ESTIMATING THE BURDEN OF ROAD INJURIES

As part of GBD 2010, we accessed and assessed all empirical measurements of population health that could inform estimates of the incidence of fatal and nonfatal road injuries. These included data from vital registration systems, verbal autopsy studies, mortuary/burial registers, household surveys, hospital databases, and prospective studies of disability outcomes following injuries. Prior to analysis, these data sources were systematically cleaned and standardized. Next, we estimated road injury mortality in all countries using Cause of Death Ensemble Modeling (CODEm), which is an analytical tool used in GBD 2010 that tests a wide variety of possible statistical models of causes of death and creates a combined "ensemble" model that provides the best predictive performance. We assessed the burden of nonfatal road injuries by first calculating the incidence of nonfatal crashes using population-based data (e.g., household surveys), then estimating the complications from crashes using hospital data. Next, we estimated the duration of disability based on prospective follow-up studies, and finally, estimated health loss by applying disability weights (a number on a scale from 0 to 1 that represents the severity of health loss associated with a health state).

ESTIMATING THE BURDEN OF VEHICULAR EMISSIONS

We estimated human exposure to annual average levels of fine particulate air pollution ($PM_{2.5}$) from road transport in two steps. First, we developed a database of geo-referenced, annual average $PM_{2.5}$ measurements from surface monitors in 2005, combined with estimates of $PM_{2.5}$ derived from satellite-based observations and estimates of $PM_{2.5}$ from a global atmospheric chemical transport model (TM5). Thus, we estimated $PM_{2.5}$ levels at a grid resolution of 10 x 10 square kilometers

across the globe for the year 2005 and extrapolated it to 1990 and 2010 based on observed trends. Second, we estimated the contribution of road transport to overall $PM_{2.5}$ for 2010 in all countries using a global air quality source-receptor model that links emissions of pollutants within a given source region with downwind impacts. We estimated the country-specific burden of disease attributable to total $PM_{2.5}$ exposure using nonlinear functions for the leading global causes of death and disability associated with outdoor air pollution: ischemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease, and acute lower respiratory tract infections in children. These risk functions were used in GBD 2010 to generate country-level estimates of the burden of disease attributable to exposure to ambient $PM_{2.5}$. We then estimated the country-specific burden of disease attributable to $PM_{2.5}$ from road transport by multiplying the country-specific total $PM_{2.5}$-attributable burden by the region-specific (country-specific for some large countries) proportion of ambient $PM_{2.5}$ from road transport.

We report burden of disease using the following standard metrics of population health loss:

- **Years of life lost (YLLs):** This is the number of years of life lost due to premature death. It is calculated by multiplying the number of deaths at each age by a standard life expectancy at that age.
- **Years lived with disability (YLDs):** Years of life lived with any short-term or long-term health loss, adjusted for severity.
- **Disability-adjusted life years (DALYs):** This is the sum of YLLs and YLDs. DALYs are also defined as years of healthy life lost.