Burden of Road Injuries in Sub-Saharan Africa

GRSF
Global Road Safety Facility

HARVARD | SCHOOL OF PUBLIC HEALTH
Department of Global Health
and Population

Kavi Bhalla, PhD
International Injury Research Unit
Department of International Health
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD, 21215, USA

www.globalburdenofinjuries.org, kbhalla@jhsph.edu

BURDEN OF ROAD INJURIES IN SUB-SAHARAN AFRICA

Data Sources, Methods, and Estimates of the National Incidence of Road Injuries

January 2014

Kavi Bhalla*, James Harrison, Saeid Shahraz, Jerry Abraham, David Bartels, Pon-Hsiu Yeh, Mohsen Naghavi, Rafael Lozano, Theo Vos, David Phillips, David Chou, Ian Bollinger, Diego Gonzalez-Medina, Brittany Wurtz, and Christopher JL Murray

**Assistant Professor, International Injury Research Unit, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, 21217, Email: kbhalla@jhsph.edu.*

About this project

The 2010 Global Burden of Disease (GBD-2010) was a systematic effort to quantify the comparative magnitude of global health loss due to 291 diseases and injuries, 67 risk factors, and 1,160 sequelae by age, sex, and country from 1990 to 2010. The project was led by the Institute for Health Metrics and Evaluation (IHME) and included a consortium of academic institutions. The World Bank Global Road Safety Facility commissioned a special effort at Harvard University to improve the estimates of road injuries in sub-Saharan Africa generated as part of GBD-2010 by incorporating more data and better methods for the region.

For information about GBD-2010 visit www.healthmetricsandevaluation.org/gbd

For more information related with this report visit africa.globalburdenofinjuries.org

Suggested citation

Bhalla, K, Harrison, J, Shahraz, S, Abraham, JP, Bartels, D, Yeh, PH, Naghavi, M, Lozano, R, Vos, T, Phillips, D, Chou, D, Bollinger, I, Gonzalez-Medina, D, Wurtz, B, and Murray, CJL, 2013, Burden of Road Injuries in Sub-Saharan Africa, Department of Global Health and Population, Harvard School of Public Health, Boston, MA, africa.globalburdenofinjuries.org.

Acknowledgements

We extend our deepest appreciation to the members of the GBD-Injury Expert Group, many of whom have provided extensive feedback and advice during the development of this research effort. In particular, the following individuals helped access and analyze relevant data from Africa: Safa Abdalla, Kunuz Abdella, William Ackaah, Olumuyiwa Adebona, Frank Atuguba, Kidist Bartolomeos, Ayaga Bawah, James Damsere-Derry, Daniel Darko, Nicole DeSantis, Beth Ebel, Suad Eltahir, Stalin Ewoigbokhan, Uwom Eze, Alan Hill, Kenneth Hill, Michael Levin, Sydney Ibeanusi, Syed Jaffar Hussain, Lisa Knowlton, Olive Kobusingye, Adofo Koranteng, Steven Lwendo, Michael Lipnick, Fred Wabwire Mangen, Richard Matzopoulous, Charlie Mock, Robert Mtonga, Mable Nakitto, George Pariyo, Joan Ozanne-Smith, Margaret Peden, Megan Prinsloo, Georges Reniers, Frederick Rivara, Rania Saad, Osman Sankoh, Zeinab Swaraddahab, Maria Valenti, Bonnie Wandera, Ruru Wang, Jeffrey Witte, and Diego Zavala. This project relied primarily on secondary analysis of existing data sources. Many of these data exist because of years of hard work on the part of numerous researchers, professionals, medical institutions, and national and international health and transport agencies. Notably, these agencies include the World Health Organization, the INDEPTH network, AMEND, MEASURE DHS, and the International Physicians for the Prevention of Nuclear War. Without the primary data collection undertaken by these national and international agencies, our work would not be possible.

We are grateful to Professor Christopher Murray's team of researchers at IHME, who led the core GBD-2010 project.

Finally, we extend our gratitude to the World Bank Global Road Safety Facility (GRSF) for providing the core grant funding to support improving the estimates of the burden of road injuries in sub-Saharan Africa as part of GBD-2010 study.

Contents

Tables

Figures

Executive Summary

The UN Decade of Action for Road Safety 2011-2020 calls on national governments in sub-Saharan Africa and worldwide to direct substantial resources to stem the increasing burden of road traffic injuries. Bringing such attention to road safety requires demonstrating the importance of the problem relative to other major threats that currently confront sub-Saharan Africa. Therefore, in this study, we estimate the burden of road injuries relative to other health issues in the region through a systematic and scientific effort to quantify the comparative magnitude of health loss due to all diseases and injuries. We track the relative evolution of diseases and injuries since 1990 to show the increasing importance of road injuries to the health and development agenda in sub-Saharan Africa. We find that:

- Road injury deaths are severely underreported in most sub-Saharan countries. Our estimates are often six times those of official government statistics. In Nigeria, they are 14 times the official statistics of the national road death toll.
- Road injuries killed 231,000 people in sub-Saharan Africa in 2010, accounting for almost one-fifth of the global road injury death toll. In addition, there were over 8 million non-fatal injuries, of which 885,000 were severe enough to warrant hospital admission if adequate access to medical care were available. The combined burden of non-fatal road injuries in sub-Saharan Africa exceeded 14 million healthy life years lost.
- Western, Central and Eastern sub-Saharan Africa have the highest road injury death rates of any global region. The death rate in Western sub-Saharan Africa is more than four times the rate in Western Europe.
- Road injuries are the 8th leading cause of death in sub-Saharan Africa and the 10th leading cause of healthy life years lost. The public health burden of road injuries exceeds that from tuberculosis and maternal disorders.
- Deaths due to road injuries have grown by 84% in sub-Saharan Africa since 1990, almost twice the global increase. The Western and Southern regions of sub-Saharan Africa had the highest growth in road deaths of any region in the world, more than doubling over this period.
- Road injuries are the 7th leading cause of death in males in sub-Saharan Africa. They are the 13th leading cause of death in females, compared with 18th globally. The road injury death rate for females in Western sub-Saharan Africa is more than twice the global average and almost five times the rate in Western Europe.
- Road injuries pose a high burden over the entire life course in sub-Saharan Africa, impacting not just young adults but also children and the elderly. Among children aged 1-4 years, road injuries are the 8th leading cause of death in the region. Among adults aged 70+ years, road injuries are the 12th leading cause of death and 14th leading cause of healthy life years lost, compared with 26th and 23rd globally.
- Pedestrians comprise 44% of road deaths in sub-Saharan Africa, substantially more than the global average of 35%. The rate of pedestrian deaths in Western sub-Saharan Africa is 8 times the rate in Western Europe.
- Nigeria has the highest road injury death rate (52.4 per 100,000 people) of any country globally. Mozambique has the third highest death rate (46.7 per 100,000). These rates are more than 15 times the death rates in Sweden, UK, and the Netherlands, which have among the lowest death rates globally.
- Four countries (Nigeria, Ethiopia, South Africa, and Sudan) together account for half the road injury death toll of sub-Saharan Africa.

Road safety has emerged as an important health priority in sub-Saharan Africa. Trends over the last two decades show that road injury rates in the region have remained at among the highest in the world even though substantial improvements are being made in controlling other diseases, such as tuberculosis, malaria, and diarrheal disease. Unless significant preventive efforts are undertaken, road safety will continue to climb in regional health rankings during the UN Decade of Action for Road Safety. National governments and the international development community need to prioritize road safety in the region and implement the recommendations of the 2004 World Report on Road Traffic Injury Prevention.

Chapter 1: Introduction

The need for reliable statistics in the UN Decade of Action

The United Nations (UN) Decade of Action for Road Safety 2011-2020 was launched in May 2011 with the goal of preventing five million road traffic deaths over 10 years. The launch of the Decade of Action was a culmination of substantial efforts by governmental, non-governmental, and international agencies across the world including in sub-Saharan Africa. These included the release of the 2004 World Report on Road Traffic Injury Prevention by the World Health Organization (WHO) and the World Bank, regional conferences such as the 2009 pan-African conference and several UN resolutions calling on governments to improve road safety. Numerous co-sponsoring country governments from Africa and worldwide, key UN agencies, and multilateral development banks have endorsed the call for the Decade.

If the Decade of Action is to deliver on its promise to halt the rise in road traffic injuries, it will need to create an important change in how development professionals view roads and highways. Transport infrastructure is a key contributor to economic growth and human development because it helps connect markets and provide access to health care services and education (World Bank, 2008). More particularly, Africa's deficit in the availability of paved roads has been shown to be a key barrier to development (Foster & Briceno-Garmenida, 2009). Therefore, improving access to all-season roads through low-cost designs is likely to be a key goal of the transport sector in Africa for the coming decades. However, simply increasing the stock of paved roads will inevitably lead to a concomitant increase in road traffic injury rates. Instead, the Decade of Action proposes a vision where highways incorporate safety infrastructure (e.g. median barriers, rumble strips, guardrails), motor vehicles include safety features (e.g. crashworthiness design, crash avoidance technology), people are encouraged to travel safely via enforcement and large-scale behavior change interventions, and all aspects of road safety, including post-crash response, are carefully managed by a suitably empowered road safety agency. This vision seeks to transform human transportation from an unmanaged environment of high-risk and high-energy interactions between people and vehicles, to a coordinated system in which risks are carefully managed, through measures such as segregation of transport modes and engineering of vehicles and infrastructure to make crashes more forgiving when they occur.

In order to justify the investments needed in safe transport systems, we need to estimate the social costs imposed by road traffic crashes and compare them with the range of other problems that threaten human health and wellbeing. The poorest regions of Africa have high rates of deaths from communicable, maternal, neonatal and nutritional causes. In regions that are undergoing rapid economic development there are rising rates of non-communicable diseases as well. In such a context, the Decade of Action will get the political and financial attention it needs only if we can show the relative importance of road safety to health and development in the region.

Therefore, the question before us at the beginning of the Decade is not whether road injuries pose a big problem in sub-Saharan Africa but how do they compare with other threats faced by the region. The Global Burden of Disease 2010 (GBD-2010) project provides one answer to this question through a systematic and scientific effort to quantify the comparative magnitude of health loss due to diseases and injuries, including road injuries by age, sex, and country. We present results from 1990 to 2010 allowing us to see not only how road injuries rank relative to other health issues in countries across sub-Saharan Africa, but also their relative evolution. The outputs – leading causes of death and ill health – can provide countries, regions, and the global development community guidance on how to prioritize road safety in their health and development agendas.

In addition to making the case for road safety in the national agenda, countries in sub-Saharan Africa that make the commitment to address the problem need reliable statistics for managing their progress towards safety. They need dependable information to develop road safety strategies, identify suitable interventions, set achievable safety targets and monitor progress towards achieving them. Although the primary focus of GBD-2010 is to construct reliable estimates of national health metrics for all diseases, the results of this analysis allow explicit comparisons with other data systems, such as traffic police, that are commonly used as a source of official national road injury statistics.

The poor state of knowledge about road injury metrics in sub-Saharan Africa

Unfortunately, the state of knowledge about the incidence and burden of road injuries in sub-Saharan Africa has remained dismal. In our 2011 report, Road Injuries in 18 Countries, we showed that official government statistics of road injuries in most low- and middle- income countries globally, and especially in sub-Saharan Africa, are substantially lower than statistically modeled national estimates (Bhalla et al. 2011). Most researchers and agencies were already aware that non-fatal crashes are severely underreported in official statistics. However, the 18 Countries Report highlighted that even death counts in official statistics are likely much lower than reality in many countries. The 18 Countries Report compared official government statistics compiled by the 2009 Global Status Report on Road Safety (WHO, 2009) with modeled estimates and found that in many developing countries estimates of road deaths were more than twice, and in many sub-Saharan African countries more than six times, the deaths reported in official government statistics.

Constructing national estimates of road injuries to validate official statistics is analytically challenging in sub-Saharan Africa. Most countries in the region have little infrastructure for large-population health surveillance. Therefore, most previous work in estimating the regional incidence of road injuries in sub-Saharan Africa has not used local measurements. Instead such estimates have relied on statistical models that predict road injuries based on national income or vehicle stocks. For instance, the recently released 2013 Global Status Report on Road Safety (WHO, 2013), only used health statistics from three sub-Saharan African countries – South Africa, Mauritius, and Zimbabwe – that together only account for 7% of the regional population.

However, although national health surveillance systems are rare in Africa, our report demonstrates that there are many sub-national sources of information that can be used to triangulate to estimates of the burden of road injuries. Typically, most countries in sub-Saharan Africa have a patchwork of data sources that include incomplete vital registration systems, small population demographic surveillance systems, urban mortuary and burial registers, hospital registries, among other sources. Most of these sources have never been used to construct estimates of national and regional road traffic mortality because this requires substantial analytical work and the results have substantial uncertainty.

It is, of course, important and urgent to invest in health surveillance infrastructure in the most information-poor settings. However, we must also recognize that it is unlikely that in many countries such infrastructure will not be available in the near future. In fact, despite repeated calls for investing in improving infrastructure for vital registration systems in Africa, there has been little improvement in such systems in several decades (Mahapatra et al., 2007). The call for the UN Decade of Action for Road Safety makes it clear that we cannot wait for data systems to improve in the poorest regions of the world before investing in road safety. If the Decade is to succeed, it needs large financial and political commitments and that requires a clear assessment now of the burden of road injuries compared with other threats that confront society.

The Global Burden of Disease and Injury Study

In this report we address the challenge of producing comparable estimates of the burden of road injuries in sub-Saharan Africa relative to other health threats that confront the region. Our analysis was done as a part of GBD-2010, which is the only comprehensive effort to estimate deaths and non-fatal health outcomes for the world. The results from the first revision of the study, GBD-1990 have proven immensely influential in shaping global health priorities and on shining the light on neglected diseases. For instance, GBD-1990 brought malaria and depression to the world health agenda (Murray & Lopez, 1997). Importantly, these results also showed for the first time that road safety was a leading and growing health concern not just in the highly motorized parts of the world but also in low- and middle-income countries. Estimates from the GBD study were the source of much of the statistical information provided in the 2004 World Report on Road Traffic Injury Prevention (WHO, 2004) that helped initiate the political processes that culminated in the declaration of the UN Decade of Action.

The broader GBD-2010 study and our specific work on road injuries involve several innovations that have important implications on the study findings. A key advancement is the large amount of local epidemiological data from sub-Saharan Africa that have been incorporated in this assessment of global disease and injury patterns. We worked within an overarching GBD vision of incorporating all possible sources of information in a region after careful correction of biases. A substantial project-wide effort was made to incorporate data from vital registers, sample registration systems, and demographic surveillance systems, among many others, in all global regions. We coupled this broad search with a targeted effort to improve data from the sub-Saharan Africa regions. Chapter 2 (Data Sources) describes the specific data sources and their regional availability and paints a picture of a world that is much richer in epidemiological data than previously believed.

Handling the large amounts of data, and the non-traditional nature of most of the data sources from sub-Saharan Africa, required the development of new analytical approaches and tools. These methodological innovations ranged from improved methods for identification and reattribution of cases coded to poorly defined causes, to the development of ensemble modeling for estimating causes of death from a wide range of statistical models. Another important analytical innovation was in weaving together vastly different types of data into a coherent set of estimates of non-fatal injuries. We developed a model to link incidence of road injury estimates derived from a large collection of national and sub-national household surveys, mappings from external cause to health outcomes developed from hospital data, and estimates of long term disability based on a set of recent follow-up studies. These methods rely on many assumptions and will likely undergo substantial refinements in the years to come. However, this is the only known attempt at large-scale coupling of empirical data to construct global estimates of the burden of non-fatal road injuries. Chapter 3 (Methods) describes these methodological innovations in more detail.

These analyses allow us to generate explicit comparisons of the problem of road safety with other health problems at the national and regional levels in sub-Saharan Africa, which we describe in Chapter 4 (Results). In addition to relative comparisons with other diseases, we provide estimates of the absolute magnitude of road injury rates. Further, we compare our national road injury mortality estimates with official government statistics to illustrate the extent of national underreporting. In addition to deaths, we provide national estimates of the incidence of non-fatal road injuries. These are the first comparable statistics of non-fatal road injury incidence ever estimated for the region.

Finally, in Chapter 5, we discuss the implications of this report focusing on road safety policy and future directions for research in road safety metrics.

References

- Bhalla, K, Shahraz, S, Abraham, J, Bartels, D, and Yeh, PH, 2011, Road injuries in 18 countries, Department of Global Heath and Population, Harvard School of Public Health, Boston, MA, USA. Available from: roadinjuries.globalburdenofinjuries.org
- Calderón, C, 2009, Infrastructure and growth in Africa. World Bank Policy Research Working Paper, World Bank, Washington, DC.
- Foster, V, & Briceno-Garmendia, C, 2010, Africa's infrastructure: a time for transformation. Washington, DC: Agence Française de Développement and the World Bank.
- Mahapatra, P, Shibuya, K, Lopez, AD, Coullare, F, Notzon, FC, Rao, C, and Szreter, S, 2007, Who Counts? Civil registration systems and vital statistics: successes and missed opportunities. Lancet, 370, 1653-63.
- Murray, CJ, and Lopez, AD, 1997, Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. Lancet, 349(9063), 1436-1442.
- World Bank, 2008, Safe, Clean, and Affordable - Transport for Development. The World Bank Group's Transport Business Strategy for 2008-2012. World Bank Group: Washington, DC.
- World Health Organization, 2004, World report on road traffic injury prevention. World Health Organization: Geneva.
- World Health Organization, 2009, Global status report on road safety: time for action. World Health Organization: Geneva.
- World Health Organization, 2013, Global status report on road safety - supporting a decade of action, World Health Organization: Geneva.

Chapter 2: Data Sources

Overview of data collection

Our basic guiding principle is that estimates of the burden of disease and injury should be generated through the careful analysis and correction for bias in all sources of information available in a region. Thus, we attempted to get access to all empirical measurements that could help inform estimates of the incidence of fatal and non-fatal injuries in sub-Saharan Africa. The broader GBD-2010 study undertook a project-wide effort to identify and acquire all relevant data sources for all diseases in all global regions. The Injury Expert Group of GBD-2010 aided these efforts via focused attention to improve access to global injury data (Bhalla et al. 2009). This hunt for data sources was conducted with a strategic focus on tracking the regional availability of data sources for mortality and morbidity and working to fill the information gaps. As we illustrate in this chapter, the quality of information available to estimate the burden of injuries varies substantially across the world -- dividing the world into information-rich and information-poor regions. In some countries there are many sources of data for estimating both the incidence of deaths and non-fatal injuries from road crashes. In many others, the data sources for estimating deaths are fairly reliable but sources for estimating the incidence and burden of non-fatal injuries are not. And, in several others, there are comparatively few data sources available that allow population-based estimates of the incidence and public health burden of injuries. In these countries and regions, available data may not represent the entire national population, may have biases towards certain causes of diseases and injury, and may be poorly coded.

Our preliminary assessment of data availability for estimating the global burden of injuries identified the sub-Saharan Africa regions as the most information-poor regions of the world. Therefore, in this project we undertook a special effort to identify and acquire data sources in these regions that have not been traditionally used for estimating the burden of injuries. We conducted snowball searches of the published and gray literature from Africa, discussed data sources with regional experts, and worked closely with collaborators in seven countries to understand the architecture of local data sources and develop strategies for incorporating key data sources in the GBD analysis. We developed national and regional data source inventories and reviewed these with international and regional experts at two meetings (Boston, USA, 2009, and Swansea, UK, 2010) of the GBD Injury Expert Group.

When data sources were identified, we requested access to information as follows. We invited local collaborators to provide us with individual-record data, which would allow us to extract point estimates of various parameters classified to our definitions. When such data access was not feasible, we requested collaborators to provide tabulations extracted to our specifications (e.g. coded to GBD-2010 cause, age-, and sex- categories). Finally, when such analysis of data by our collaborators was not possible, we requested access to reports and publications that presented the most detailed results from the datasets.

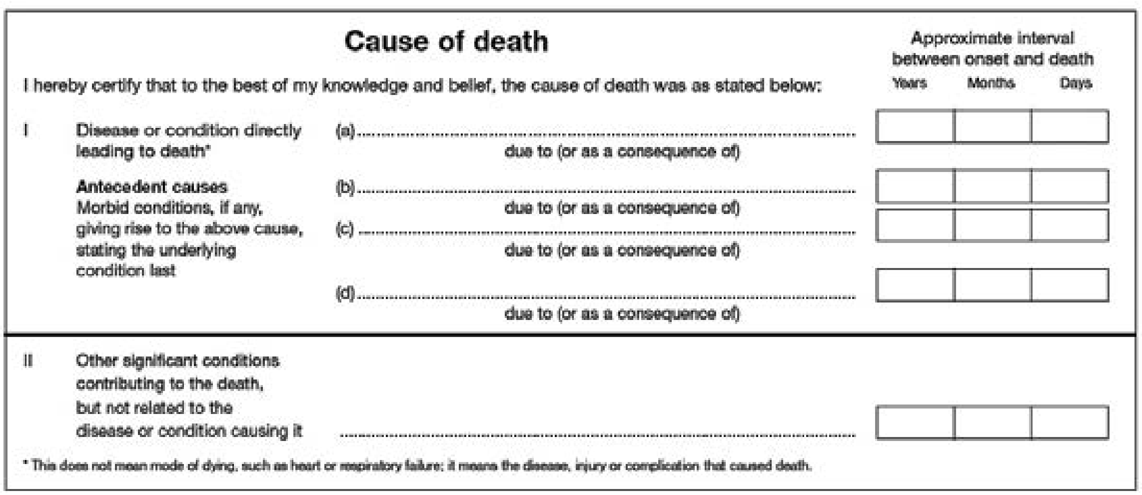
In the following sections, we highlight the various forms of data sources that we used to estimate the mortality and morbidity burden of injuries in sub-Saharan Africa. Wherever possible, we compare regional data availability with global data availability to highlight data weaknesses in the region. Our focus here is only on the data sources directly relevant to estimating road injuries. However, it should be noted that the estimates of the regional burden of disease involved many other data sources collected by the broader GBD-2010. These data are indirectly relevant to road injury estimates because the analytical structure of the project cross-links estimates of different diseases.

Data sources for estimating road injury mortality

Vital registration

Traditionally, public health researchers estimate national cause-specific mortality through analysis of data reported in national vital registration systems. Most countries around the world have civil registration systems that aim to provide individuals with an official government record of births and deaths that can be used for establishing legal status, nationality, and inheritance. In many countries, civil registers also include information about causes of death certified by a medical professional (Figure 2.1), giving civil registration the potential to be one of the most comprehensive sources for tracking national cause-specific mortality patterns. As a result, the availability and quality of vital registration statistics has received substantial attention in the global health literature (Hill et al., 2007, Mahapatra et al., 2007).

Figure 2.2 compares the availability of death registration data from countries in sub-Saharan Africa with countries in other regions. The figure illustrates that relatively few country-years of vital registration data were available from countries in the sub-Saharan Africa regions to GBD-2010. Even when available, much of the vital registration data from these countries has low completeness, often only covering selected urban centres, and uncertain quality of coding of causes of death (Mahapatra et al., 2007). Therefore, with a few exceptions such as South Africa, data from vital registers in sub-Saharan Africa are a relatively poor source for estimating the national incidence of injuries. However, they provide valuable information for the national sub-populations that they cover. In contrast, long time-histories of data are available from many regions of the world, including many low and middle-income regions. These include most countries in the Latin American regions, and Central and Eastern Europe, where national death registers are relatively complete, have high coverage, and relatively good quality of coding for estimating the national burden of injuries (Bhalla et al., 2010).



Cause of death

Approximate interval between onset and death — Years, Months, Days

I hereby certify that to the best of my knowledge and belief, the cause of death was as stated below:

I Disease or condition directly leading to death* (a) .... due to (or as a consequence of)

Antecedent causes
Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last
(b) .... due to (or as a consequence of)
(c) .... due to (or as a consequence of)
(d) .... due to (or as a consequence of)

II Other significant conditions contributing to the death, but not related to the disease or condition causing it ....

* This does not mean mode of dying, such as heart or respiratory failure; it means the disease, injury or complication that caused death.

Figure 2.1 Cause of death section of a sample medical certificate of death

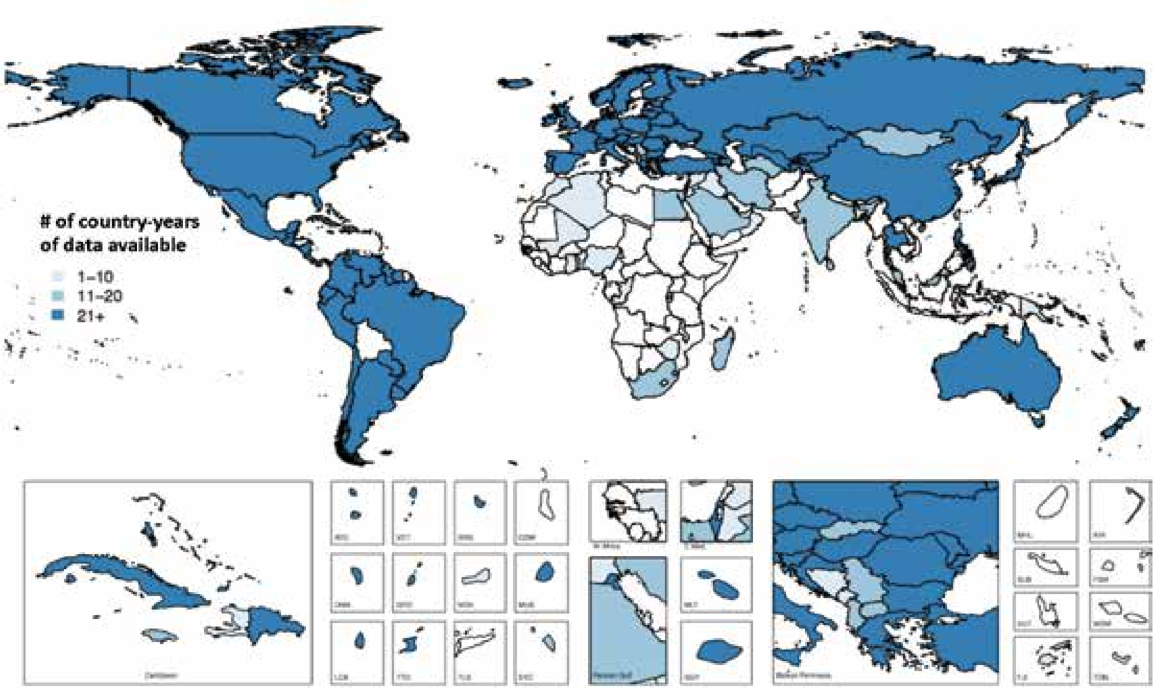
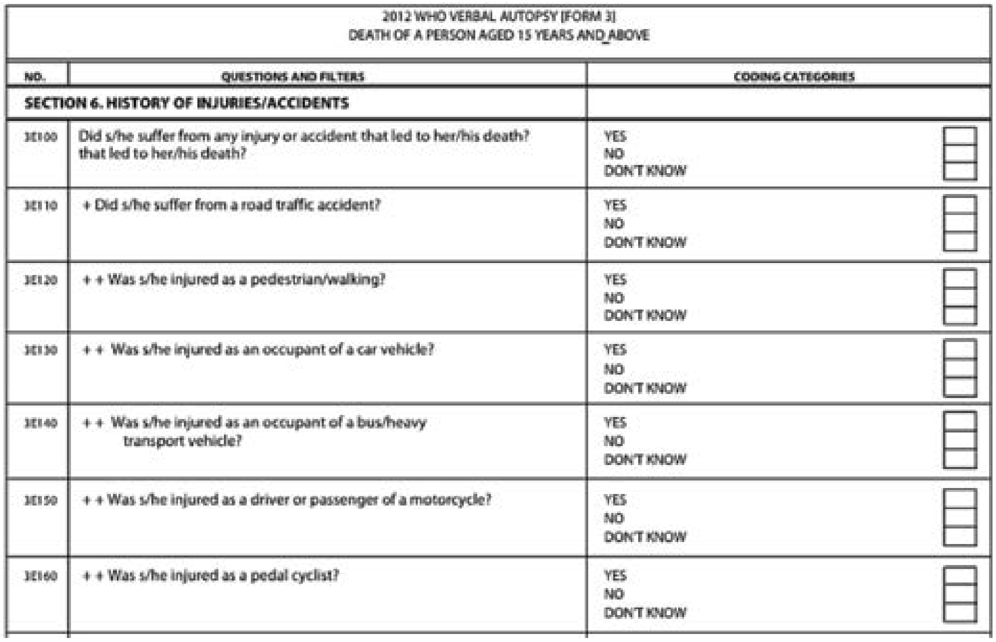


Figure 2.2 Global distribution of national vital registration datasets used for estimating injury mortality in GBD-2010

Verbal autopsy

In the absence of high quality vital registration systems in sub-Saharan Africa, alternate sources for estimating cause-specific mortality are particularly important. One approach for this involves assessing causes of death via a verbal autopsy, where family members of the deceased are asked about the circumstances and symptoms prior to death. Verbal autopsies may be conducted as large sample surveys or as part of surveillance in smaller communities. The process typically involves a team of trained researchers who use a structured list of questions (Figure 2.3). The validity of the causes of death identified by verbal autopsy methods has received substantial attention in recent years. In comparison with other causes of death, road injuries are usually identified accurately using verbal autopsies (Murray et al., 2007).

Figure 2.4 shows the global distribution of countries for which we used verbal autopsy data as an input for estimating road injury mortality. The figure shows that verbal autopsy data were available from many countries in regions that are poorly covered by vital registration systems. Notably, data were available from many countries in the sub-Saharan Africa regions, typically from Health and Demographic Surveillance Sites (HDSS) that monitor health of populations in rural communities. Many of these HDSS sites belong to the INDEPTH network and are among the only data sources available for estimating rural mortality patterns in sub-Saharan Africa. Figure 2.5 illustrates the injury death fraction (i.e. the fraction of all deaths that are due do injuries) at nine HDSS sites.



2012 WHO VERBAL AUTOPSY [FORM 3] DEATH OF A PERSON AGED 15 YEARS AND ABOVE		
NO.	QUESTIONS AND FILTERS	CODING CATEGORIES
SECTION 6. HISTORY OF INJURIES/ACCIDENTS		
3E100	Did s/he suffer from any injury or accident that led to her/his death? that led to her/his death?	YES NO DON'T KNOW
3E110	+ Did s/he suffer from a road traffic accident?	YES NO DON'T KNOW
3E120	+ + Was s/he injured as a pedestrian/walking?	YES NO DON'T KNOW
3E130	+ + Was s/he injured as an occupant of a car vehicle?	YES NO DON'T KNOW
3E140	+ + Was s/he injured as an occupant of a bus/heavy transport vehicle?	YES NO DON'T KNOW
3E150	+ + Was s/he injured as a driver or passenger of a motorcycle?	YES NO DON'T KNOW
3E160	+ + Was s/he injured as a pedal cyclist?	YES NO DON'T KNOW

Figure 2.3 Questions related with road injuries in a typical verbal autopsy questionnaire
Source: World Health Organization, 2012, Verbal Autopsy Standards: The 2012 WHO verbal autopsy instrument Release Candidate 1, Geneva: World Health Organization.

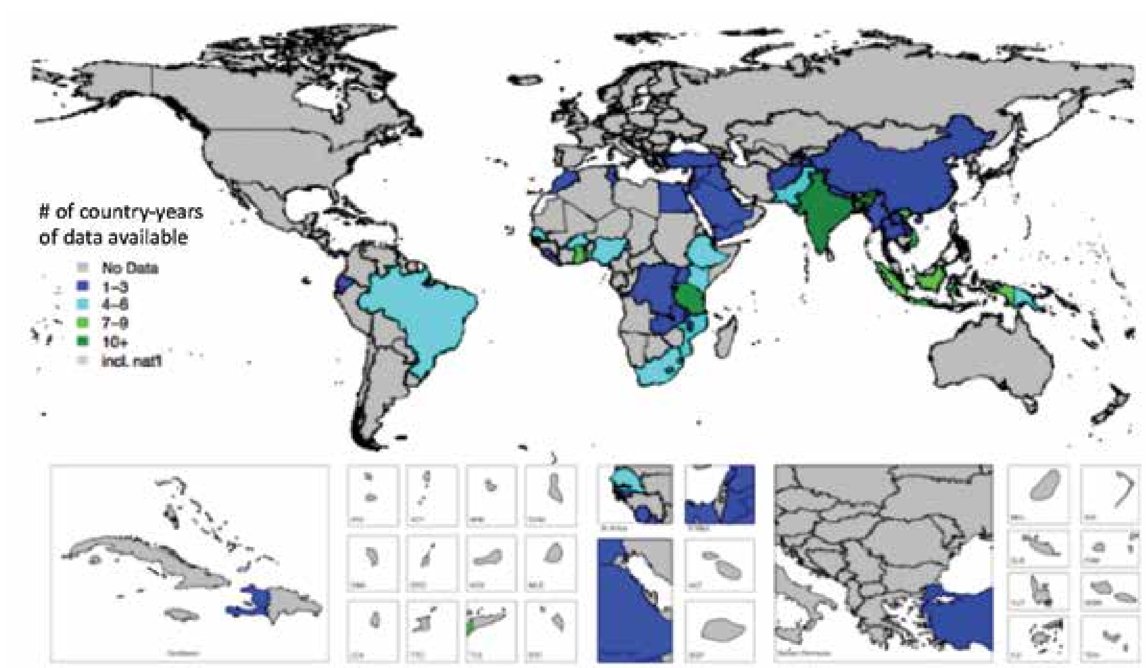


Figure 2.4 Global distribution of verbal autopsy datasets used for estimating injury mortality in GBD-2010

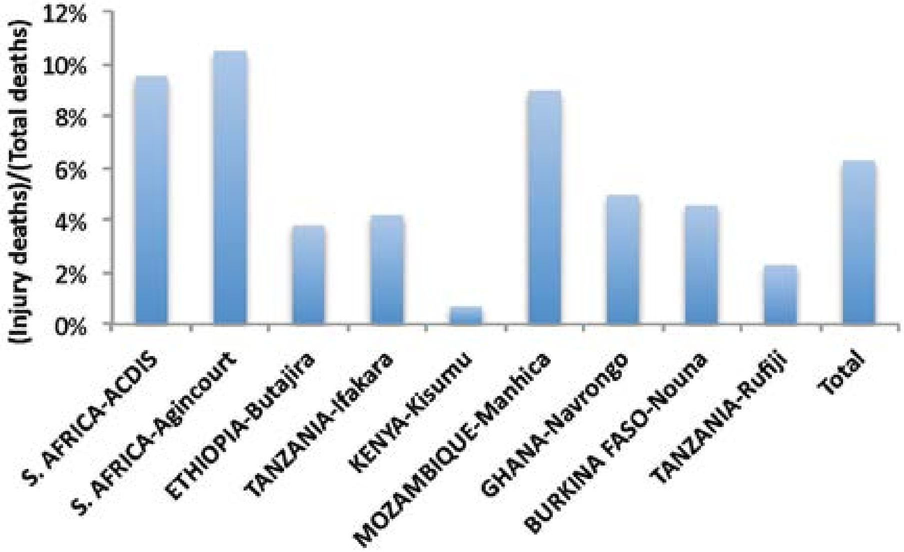


Figure 2.5 Injury death fractions reported at nine HDSS sites in sub-Saharan Africa
Source: Estimated from data for the period 1999-2002 provided by the INDEPTH Network to GBD-2010

Mortuary and burial registers

Even in countries that do not have a properly functioning vital registration system, local law can require a range of medico-legal practices that can create opportunities for obtaining statistics related with causes of injury deaths. Our investigations in sub-Saharan Africa revealed that the mortuaries attached to hospitals in the main urban centers of many countries routinely conduct investigation into the causes of deaths that do not have a history of disease. The findings from these investigations are usually recorded either digitally or in paper registers. Similarly, in many countries in the region, laws require relatives to obtain a permit before a dead body can be buried or cremated. The government offices issuing these certificates often keep records that identify causes of death as reported on the medical death certificate, if available, or as reported by the individual requesting the permit.

We expect relatively high quality of coding of road injury deaths in such data. Mortuaries typically employ trained professionals, who are often trained as forensic pathologists, and accurately identifying the causes of death is a primary focus of these investigations. Although causes listed in burial registers do not involve similar investigative efforts, our investigations comparing burial data with verbal autopsies in Ethiopia suggest that road injury deaths are accurately coded. This is likely because unlike most other causes of death, external causes of injury deaths are relatively easy to identify by lay reporters.

Therefore, we conducted a substantial effort aimed at identifying mortuaries and burial permit offices in sub-Saharan Africa. Whenever possible, we digitized existing data on causes of death available from mortuary and burial registers. In addition, we searched the published and gray literature for studies conducted at such sites and extracted information on causes of death.

Figure 2.6 shows the distribution of countries from sub-Saharan Africa for which we used mortuary and burial permits for estimating road injury mortality. Tables 2.1 and 2.2 provide locations, time period and case counts for the eight mortuary datasets from sub-Saharan Africa.

Our analysis of mortuary data revealed that the cause-of-death patterns were substantially biased towards injury deaths as expected from the medico-legal framework in which the mortuaries function. This bias implies that mortuary data cannot be used to estimate patterns for all causes of death. Thus, in our analysis, the use of mortuary data is restricted to identifying causes of injury deaths. Figure 2.7 illustrates the external causes of injury deaths that were recorded at these mortuaries.

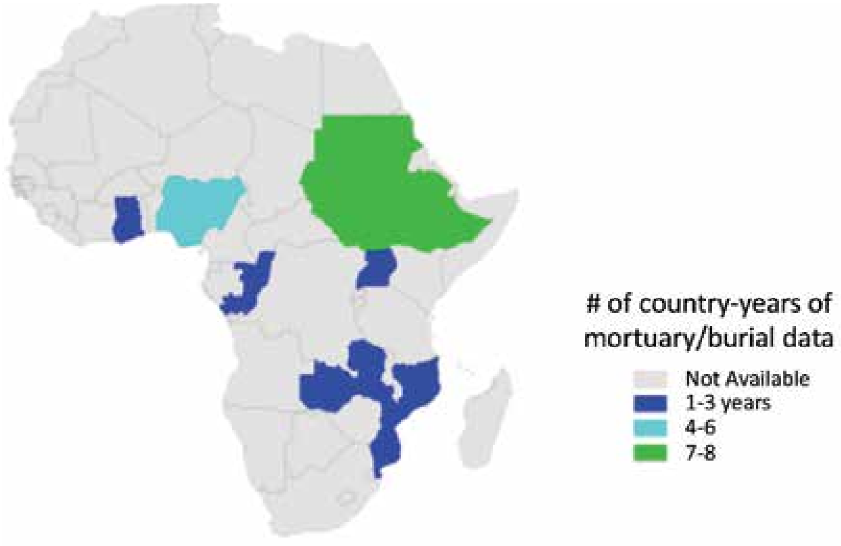


Figure 2.6 Distribution of verbal autopsy datasets from sub-Saharan Africa used in GBD-2010

REGION	COUNTRY	CITY	MORTUARY/BURIAL OFFICE
Sub-Saharan Africa, East	Ethiopia	Addis Ababa	King Menelik II Hospital Mortuary
Sub-Saharan Africa, West	Ghana	Kumasi	Komfo Anokye Teaching Hospital
Sub-Saharan Africa, South	Mozambique	Maputo	Maputo Central Hospital Mortuary
Sub-Saharan Africa, West	Nigeria	Ibadan	Ibadan University College Hospital Mortuary
Sub-Saharan Africa, East	Sudan	Omdurman Khartoum	Omdurman Hospital Mortuary Khartoum Teaching Hospital Mortuary
Sub-Saharan Africa, East	Uganda	Kampala	Mulago Teaching Hospital and Kampala City Mortuary
Sub-Saharan Africa, South	Zambia	Lusaka	Lusaka Burial Permit Registry at University Teaching Hospital

Table 2.1 Location of the mortuaries in seven countries in sub-Saharan Africa that contributed data to GBD-2010

Country	Period	Dates	Cases
Ethiopia	1 year	Jul 2006 - Jun 2007	1,114
Ghana	2 years	2005 – 2006	1,545
Mozambique	10 years	1994 – 2003	12,354
Nigeria	3 years	2007- 2009	1,045
Sudan	4 months	2010	255
Uganda	6 months	Jul - Dec 2007	757
Zambia	13 months	Nov 2007 - Dec 2008	594

Table 2.2 Duration and case counts for mortuary data from sub-Saharan Africa

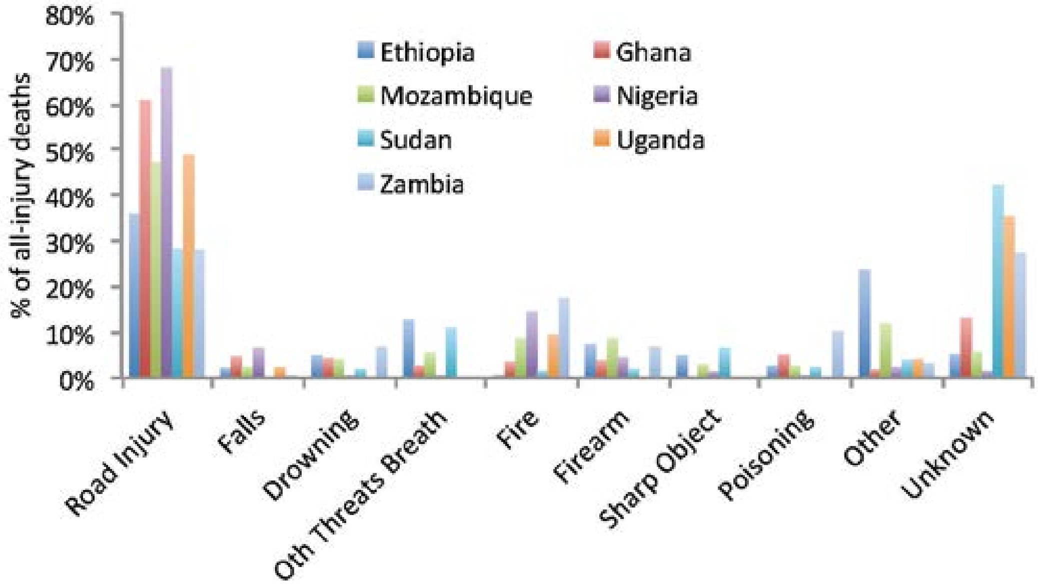


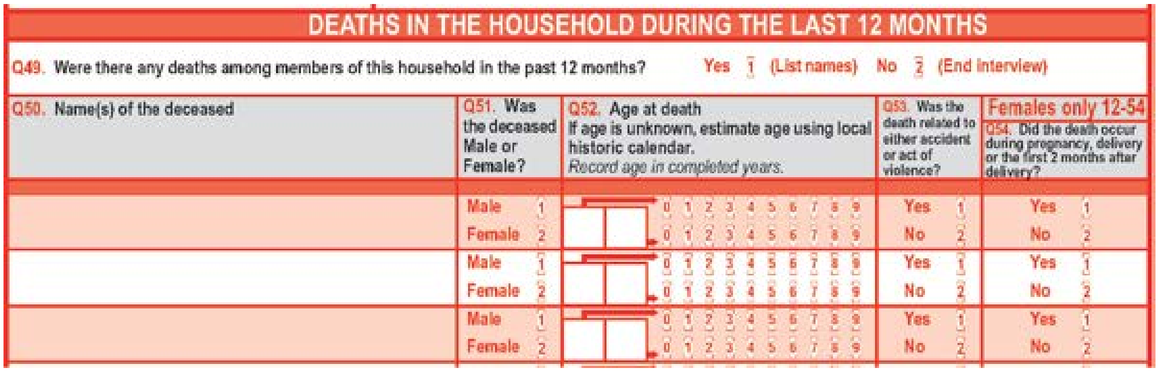
Figure 2.7 External causes of injury deaths recorded in mortuaries in sub-Saharan Africa

National population censuses and large sample surveys

Censuses are conducted decennially in most countries to generate information on the size and distribution of national population for planning and administration. A census, which in principle involves canvassing all households, may be followed by a large post-census nationally representative sample survey. In recent years, such surveys in many countries have included questions about household deaths in the previous year with the aim of estimating adult mortality and maternal mortality. Further, in order to improve estimates of maternal mortality, these surveys often include a "weed-out" question asking if the death was due to injury or violence. Figure 2.8 illustrates the mortality module from a typical questionnaire that was used in the 2008 census in Sudan. In such cases, the census data are a useful source of information for constructing national estimates of deaths that occur from external causes. Although road injuries are not specifically identified in most censuses, the accurate estimates of injury totals derived from census data, substantially reduces uncertainty in estimates of all sub-categories of injuries, including road injuries.

We checked the questionnaires for all household censuses conducted in sub-Saharan Africa in the last three decades and identified those that include questions that could be used to estimate injury mortality rates. Table 2.3 lists the country-year for which census data was available to GBD-2010. Next, we identified organizations that held the data for these censuses and worked with them to acquire tabulations of injury mortality disaggregated by age-, sex- and urban-rural.

Since census data has never before been used to estimate injury mortality pattern, we tested the face validity of the results in one country. South Africa is the only country in sub-Saharan Africa with a relatively complete death registration system. The 2001 census in South Africa included questions on injury mortality. Similarly, a large nationally representative community survey in South Africa in 2007 also included questions that allowed measurement of injury mortality. Thus, we compared the age-sex- specific injury death fractions (i.e. the fraction of all-cause deaths that are due to injuries) from the census and the death registration system for these two years (Figure 2.9). We found that in both cases the estimates based on census data closely tracked those based on vital registration providing important face-validity to censuses as a data source for estimating injury mortality rates in sub-Saharan Africa.


DEATHS IN THE HOUSEHOLD DURING THE LAST 12 MONTHS

Q49. Were there any deaths among members of this household in the past 12 months? Yes 1 (List names) No 2 (End interview)

Q50. Name(s) of the deceased	Q51. Was the deceased Male or Female?	Q52. Age at death If age is unknown, estimate age using local historic calendar. *Record age in completed years.*	Q53. Was the death related to either accident or act of violence?	Females only 12-54 Q54. Did the death occur during pregnancy, delivery or the first 2 months after delivery?
	Male 1 Female 2	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9	Yes 1 No 2	Yes 1 No 2
	Male 1 Female 2	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9	Yes 1 No 2	Yes 1 No 2
	Male 1 Female 2	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9	Yes 1 No 2	Yes 1 No 2

Figure 2.8 Questions related with injuries in the mortality module of a typical census
Source: 2008 Census Questionnaire, Sudan Central Bureau of Statistics

Census/Survey Country-year	Type of Information Available
South Africa – 2001	Deaths due to accident or violence
South Africa–2007*	Natural and un-natural deaths by age, sex
South Sudan – 2008	Deaths due to accident or violence
North Sudan – 2008	Deaths due to accident or violence
Sierra Leone – 2004	Cause-specific deaths by age, sex. However, injuries are included in "Other causes"
Lesotho-2006	Cause-specific deaths by age, sex
Malawi-2008	Deaths due to accident/injury question for women 15-49 years old
Mozambique – 2007*	Deaths due to accident or violence

Table 2.3 Census datasets from sub-Saharan Africa that were used to estimate injury mortality in GBD-2010
** Large nationally representative household surveys*

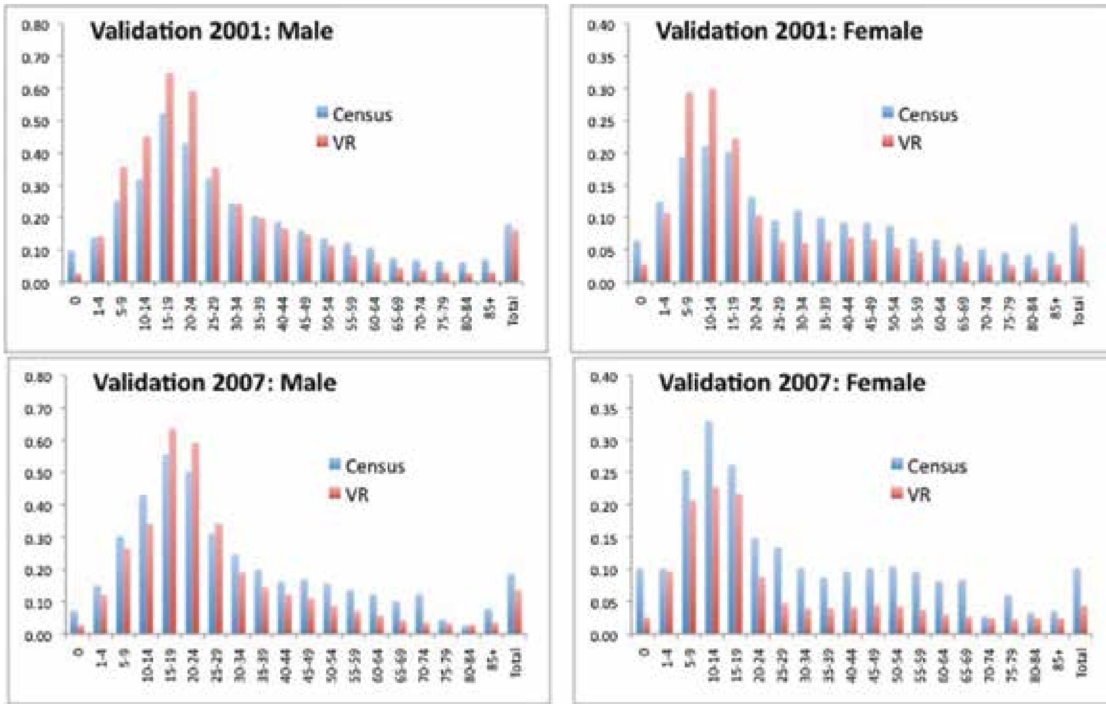


Figure 2.9 Injury death fractions measured in the 2001 South African Census and the 2007 South African Community Survey compared with estimates from national death registration data from the same years.

Sibling mortality surveys

Several health survey programs, notably including the World Health Surveys and Demographic and Health Surveys, include sibling mortality modules that aim to estimate adult mortality by asking respondents about sibling survival. As with the post-census surveys discussed above, these surveys occasionally include weed-out questions aimed at improving estimates of maternal mortality. In addition, some surveys, such as the WHS, include a verbal autopsy module asking about causes-of-death (Figure 2.10). Thus, we undertook a systematic search for surveys that included sibling mortality questions in sub-Saharan Africa and extracted estimates of injury and road injury mortality, wherever possible. Figure 2.11 shows the global distribution of these surveys and highlights the availability of such information from countries in sub-Saharan Africa.

For each sibling death recorded in Section B-1, answer the following questions.

		a. Sibling 1		b. Sibling 2		c. Sibling 3		d. Sibling 4		e. Sibling 5		f. Sibling 6		g. Sibling 7	
Q5200	If deceased, a woman aged 15-49, was she pregnant when she died?	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5
Q5201	If deceased, a woman aged 15-49 did she die during childbirth?	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5
Q5202	If deceased, a woman aged 15-49 did she die within 2 months after the end of pregnancy or childbirth?	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5
Q5203	Was the death associated with injury?	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5	Yes 1	No 5
Q5204	Was it due to 1. Accident 2. Suicide 3. Murder 4. War 5. Natural disaster														

Figure 2.10 Example of questions related with injuries in the sibling mortality section of a health survey
Source: 2003 World Health Surveys Questionnaire

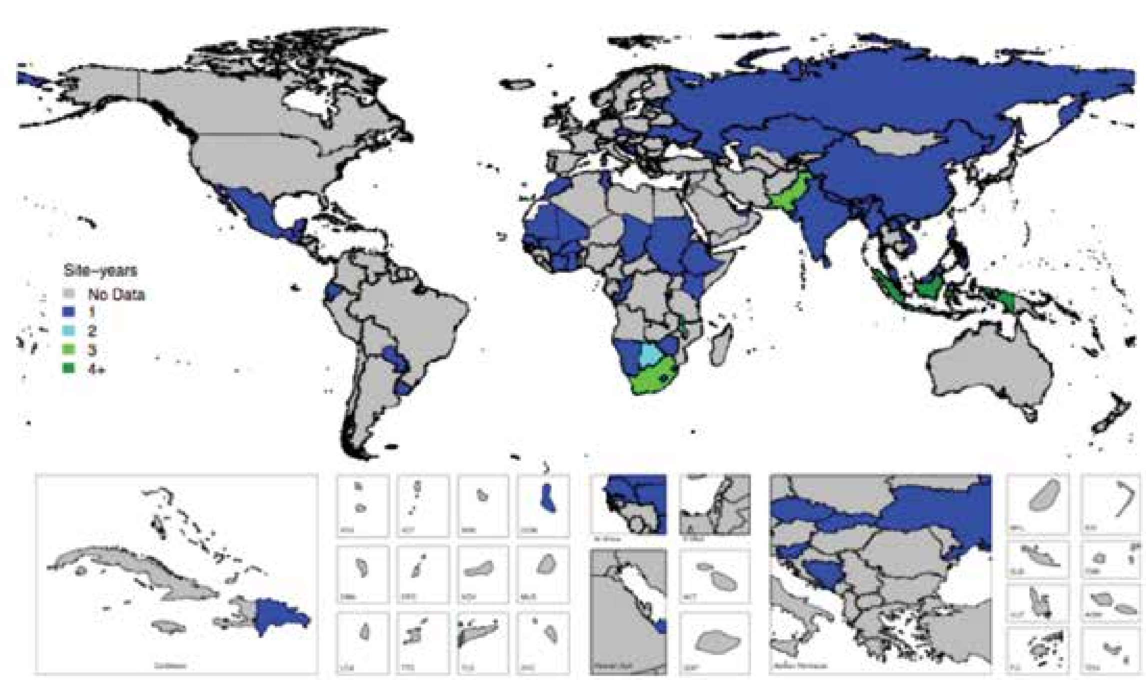


Figure 2.11 Sibling mortality surveys that were used in our analysis of global road injury mortality

Traffic police reports

In most countries, statistics of deaths from road injuries are available from national traffic police. These statistics are usually the basis of official government statistics of national road injury deaths. We obtained traffic police data from the 2009 WHO Global Status Report on Road Safety, which provides a systematic compilation of official statistics from almost all countries in sub-Saharan Africa. Our initial assessment of these official statistics suggested dramatic underreporting of road deaths especially in the most information-poor regions. Thus, the primary use of the police reports in our analysis was to estimate the proportions of total road injury deaths that correspond to the various sub-categories of road users.

Data sources for estimating road injury morbidity

While road crashes are the external cause of health loss, the morbidity itself is due to the resulting sequelae, i.e. the nature of injuries (e.g. spinal cord injury, traumatic brain injury) resulting from the crash. Thus, measuring the burden of non-fatal road injuries has three key aspects. First, we need to estimate the incidence of non-fatal road crashes. Since the incidence of crashes depends on local transport characteristics, it can vary substantially across countries and regions. Thus, it was important for this project to acquire population-based estimates of the incidence of road crashes from household surveys from as many countries in sub-Saharan Africa as possible. Second, we need to convert incidence of road crashes into estimates of the incidence of the various sequelae of road crashes. Characterizing this relationship of external causes to sequelae requires high-quality hospital databases. To a large extent, the distribution of the nature of injuries resulting from a road crash is independent of country and region. Thus, regional diversity in data sources was considered less important for hospital databases used in this aspect of the project than geographic diversity in data sources for estimating incidence of road crashes. Finally, we need to estimate the short-term and long-term disability due to these sequelae. This information is available from studies that track the health of patients over the months and years following an injury. In the following sections, we describe the key data sources that we used for each of these aspects of estimating the burden of non-fatal road injuries.

National and community household surveys

The primary use of survey data in our models is to construct estimates of the incidence of non-fatal road injuries in the four sub-Saharan African regions (East, West, South, and Central). As with other data sources, we conducted an extensive search for survey data via snowball literature searches and direct communications with injury researchers. Once a household survey was identified, the owner of the data was contacted and access to raw data was requested. If they could not provide raw data, we requested access to specific tabulations of measurements to GBD definitions. When no data was available from the researcher or agency that conducted the survey, we extracted data from any publications (journal articles, reports, web-tables) that reported results from the survey.

While all of these household surveys included the measurement of road injury incidence as one of their aims, they nevertheless used widely varying instruments (questionnaires) to conduct such measurements. This variation in survey instruments reflects the lack of consensus among researchers about how the incidence of injuries should be measured in the field. Web-Appendix 1 includes the survey questionnaires from all surveys analyzed and Figure 2.12 illustrates a typical injury module.

Table 2.4 lists household injury surveys from Africa and identifies those surveys for which we had access to survey microdata. In order to standardize the estimates across the wide range of survey instruments, we developed methods for mapping across varying definitions. In particular, we used the World Health Surveys to estimate a recall curve for injury surveys and used the US National Health Interview Surveys to estimate the fraction of injury events that result in disability exceeding one-day. We mapped measurements of incidence of various medical care categories used in the surveys to the following three types: hospital admissions; care provided at a formal medical institution; all injuries regardless of care. The estimates of incidence extracted from this collection of surveys after these adjustments are shown in Web-Appendix 1.

CARE FOR ROAD TRAFFIC AND OTHER INJURIES ***(Questions to be asked to all respondents)***

Q6800	In the past 12 months, have you been involved in a road traffic accident where you suffered from bodily injury? *PROBE:* This could have been an accident in which you were involved either as the occupant of a motor vehicle, or when you were riding a motorcycle or bicycle, or walking.	1. Yes			5. No		
Q6801	When (in the last 12 months) did the accident happen?	1. Within the last 30 days	2. 1-2 months ago	3. 3-5 months ago	4. 6-12 months ago	8. DK	
Q6802	Did you receive any medical care or treatment for your injuries?	1. Yes			5. No		
Q6803	Where did you first receive care? ***READ CHOICES*** ***If care received from ambulance, hospital or outpatient facility, ask if it was government operated or private.***	1. On-site, ambulance	2. Hospital	3. Outpatient facility	4. Private physician	5. Traditional healer	6. Other
Q6804	Was it government operated or private?	1. Government operated	2. Private (including for-profit and not-for-profit)	8. DK			

Figure 2.12 Questions related with non-fatal road injuries in a typical household health survey
Source: 2003 World Health Surveys Questionnaire

No.	GBD REGION	COUNTRY	NAME OF SURVEY OR STUDY (YEAR)*	MICRODATA/ LIT REVIEW**
1	Sub-Saharan Africa, Central	Congo	WHS-COG (2003)	MICRODATA
2	Sub-Saharan Africa, East	Comoros	WHS-COM (2003)	MICRODATA
3		Djibouti	GSHS-11 (2007)	MICRODATA
4		Ethiopia	Ethiopia-CBIS (2006)	MICRODATA
5		Ethiopia	WHS-ETH (2003)	MICRODATA
6		Kenya	GSHS-3 (2003)	MICRODATA
7		Kenya	Nordberg et al. (2000)	LIT REV
8		Kenya	WHS-KEN (2003)	MICRODATA
9		Malawi	WHS-MWI (2003)	MICRODATA
10		Mozambique	Injury module in DHS (2003)	MICRODATA
11		Sudan	Sudan-SHHS (2010)	MICRODATA
12		Tanzania	GSHS-8 (2006)	MICRODATA
13		Tanzania	Moshiro et al. (2005)	LIT REV
14		Uganda	GSHS-7 (2003)	MICRODATA
15		Uganda	Kobusingye et al. (2008)	LIT REV
16		Zambia	GSHS-9 (2004)	MICRODATA
17		Zambia	WHS-ZMB (2003)	MICRODATA
18	Sub-Saharan Africa, South	Botswana	GSHS-1 (2005)	MICRODATA
19		Namibia	GSHS-5 (2003)	MICRODATA
20		Namibia	WHS-NAM (2003)	MICRODATA
21		South Africa	South Africa DHS (1998)	MICRODATA
22		South Africa	S. Africa WHS Sage (2008)	MICRODATA
23		South Africa	WHS-ZAF (2003)	MICRODATA
24		Swaziland	GSHS-6 (2003)	MICRODATA
25		Swaziland	WHS-SWZ (2003)	MICRODATA
26		Zimbabwe	GSHS-10 (2003)	MICRODATA
27		Zimbabwe	WHS-ZWE (2003)	MICRODATA
28	Sub-Saharan Africa, West	Burkina Faso	CWIQ (2003)	MICRODATA
29		Burkina Faso	WHS-BFA (2003)	MICRODATA
30		Chad	WHS-TCD(2003)	MICRODATA
31		Cote d'Ivoire	WHS-CIV (2003)	MICRODATA
32		Ghana	AMEND (2009)	LIT REV
33		Ghana	Ghana GSS5 (2006)	MICRODATA
34		Ghana	Ghana WHS Sage (2008)	MICRODATA
35		Ghana	Ghana-CWIQ (2003)	MICRODATA
36		Ghana	Ghana Mock (1995)	MICRODATA
37		Ghana	GSHS-2 (2007)	MICRODATA
38		Ghana	WHS-GHA (2003)	MICRODATA
39		Mali	WHS-MLI (2003)	MICRODATA
40		Mauritania	WHS-MRT (2003)	MICRODATA
41		Mauritius	GSHS-4 (2003)	MICRODATA
42		Nigeria	Nigeria Injury Survey (2006)	MICRODATA
43		Nigeria	Olawale et al. (2007)	LIT REV
44		Senegal	WHS-SEN (2003)	MICRODATA

Table 2.4 Household surveys of injury incidence in sub-Saharan Africa

** WHS: World Health Survey; GSHS: Global School-based Health Survey; DHS: Demographic and Health Survey; CWIQ: Core Welfare Indicators Questionnaire*

*** Indicates if microdata was available to us for analysis or if data extracted from published tables*

Hospital records

Hospital databases rarely cover entire national populations making them a poor source for estimating the population incidence of injuries. However, they contain detailed medical descriptions of the sequelae of road crashes, which are needed for estimating the disability burden of injuries. In our analysis of the burden of injuries, the primary use of hospital databases was to convert estimates of the incidence of external causes of injuries (e.g. road injury, drowning) into estimates of the incidence of sequelae of injuries (e.g. traumatic brain injury, hip fracture). In order to construct this mapping from external cause to sequelae, we needed access to hospital databases that track both external causes of injuries as well as sequelae. Further, in order to be able to construct age- and sex- specific mappings of external causes to sequelae, we needed access to these data at the level of unit records (microdata). Figure 2.13 shows the global availability of hospital records for such analysis. Most countries in this hospital database were from Western Europe, North America and from Latin America. However, the database included three sub-national hospital injury surveillance datasets from sub-Saharan Africa, one hospital each from Maputo city, Mozambique, Kampala, Uganda, and Lusaka, Zambia.

Figure 2.13 Geographic distribution of hospital datasets that were used for mapping estimates of non-fatal road injury incidence into estimates of the incidence of the injury sequelae in GBD-2010

Prospective studies on long-term disability following injuries

Most past work aimed at estimating the global and regional burden of injuries has relied on ad hoc assumptions about the long-term disability outcomes of injuries. However, recent studies that conducted prospective follow-up of victims make it possible to generate empirical evidence of health outcomes. We relied on four such studies (Table 2.5) to estimate the probability that an injury results in permanent reduction of functional capabilities. None of these studies were from sub-Saharan Africa or from developing countries. The use of disability outcomes data from high-income countries to estimate the burden of non-fatal injuries in developing countries is an important source of uncertainty in the GBD-2010 analysis.

The Medical Expenditure Panel Survey (MEPS) is a large-scale overlapping continuous panel survey of United States non-institutionalized population. The primary purpose of MEPS is to collect information on the use and cost of healthcare. Panels are two years long and are conducted in 5 rounds, which are conducted every 5 to 6 months. A new panel begins every year, while the last panel is in its second year. Each panel typically contains about 30-35 thousand individual respondents. In 2000, MEPS began collecting responses using the 12-Item Short Form Health Survey (SF-12) that assesses health related quality of life. We used pooled MEPS data from 2000 to 2009 for our analysis.

The Dutch Injury Surveillance System data come from a sample of injured patients who visited emergency departments in the Netherlands between 8 October 2001 and 31 December 2002. Follow-up data were collected via postal questionnaire at 2½, 5, 9, and 24 months after the injury. 10,612 individuals were included in the dataset from all ages. Health status was recorded using the EQ-5D form, which is a standardized instrument developed by the EuroQol group for clinical and economic appraisal of health status. The EQ-5D form has 5 questions with 3 levels of response, and therefore allows 243 possible health states.

The South Carolina Traumatic Brain Injury Follow-up Registry (SCTBIFR) includes a sample of South Carolina residents, age 15 or older, that were discharged from an acute care hospital in South Carolina between 1 January 1999 and 30 June 2002 with a traumatic brain injury-related hospitalization. 2118 individuals were included in the dataset. Follow-up was done one, two, and three years after the injury, and health status was recorded using the 36-Item Short Form Health Survey (SF-36), of which SF-12 is a shorter adaption. Conditions in SCTBIFR were recorded using ICD-9CM abstracted from medical records.

The National Study on Costs and Outcomes of Trauma (NSCOT) is a prospective study that examines the outcomes of trauma patients followed-up at 3 and 12 months. Original data included 5,191 patients with complete baseline data, of which 3,151 were interviewed at 12 months. SF-12 summary scores were given for both follow-ups. ICD-9CM codes were abstracted from medical records and pre-existing comorbidities were abstracted from medical records, the Charleston Comorbidity Questionnaire, and Medicare claims. The NSCOT included only patients with a diagnosis with a score 3 (severe) or higher on the Abbreviated Injury Scale (AIS).

Dataset	Country	Years	Follow-up	Health Measure Used
MEPS	USA	2000-2009	2 year panel survey in 5 rounds. Follow-up time from injury varies. SF-12 at rounds 2 and 4.	SF-12, EQ-5D
NSCOT	USA	2001-2002	3 month and 12 month	SF-12
DUTCH	NLD	2001-2004	2.5, 5,9,24 months	EQ-5D
SCTBIFR	USA	1995-2001	12, 24, 36 months.	SF-36

Table 2.5 Follow-up studies that were used in GBD-2010 to characterize the duration of disability following injuries

References

- Bhalla, K., Harrison, J., Abraham, J., Borse, N. N., Lyons, R., Boufous, S., et al. (2009). Data sources for improving estimates of the global burden of injuries: call for contributors. PLoS Medicine, 6(1), e1.
- Bhalla, K., Harrison, J. E., Shahraz, S., Fingerhut, L. A., Global Burden of Disease Injury Expert Group. (2010). Availability and quality of cause-of-death data for estimating the global burden of injuries. Bulletin of the World Health Organization, 88(11), 831–838.
- Hill, K., Lopez, A., Shibuya, K., & Jha, P. (2007). Interim measures for meeting needs for health sector data: births, deaths, and causes of death. The Lancet, 370(9600), 1726–1735.
- Mackenzie EJ, Rivara FP, Jurkovich GJ, et al. (2007). The National Study on Costs and Outcomes of Trauma. J Trauma; 63: S54–67; discussion S81–86.
- Mahapatra, P., Shibuya, K., Lopez, A., Coullare, F., Notzon, F., Rao, C., & Szreter, S. (2007). Civil registration systems and vital statistics: successes and missed opportunities. The Lancet, 370(9599), 1653–1663.
- Melse JM, Essink-Bot ML, Kramers PG, Hoeymans N. (2000). A national burden of disease calculation: Dutch disability-adjusted life-years. Dutch Burden of Disease Group. American Journal of Public Health; 90: 1241.
- MEPS, Agency for Healthcare Research and Quality. United States Medical Expenditure Panel Survey 2000-2009. Rockville, United States, Agency for Healthcare Research and Quality.
- Murray CJ, Rosenfeld LC, Lim SS, et al. (2012) Global malaria mortality between 1980 and 2010: a systematic analysis. The Lancet 4; 379: 413–31.
- Murray, C. J. L., Lopez, A., Feehan, D., Peter, S., & Yang, G. (2007). Validation of the symptom pattern method for analyzing verbal autopsy data. PLoS Medicine, 4(11), e327.
- South Carolina Traumatic Brain Injury Follow-up Registry (SCTBIFR). http://www.musc.edu/sctbifr/.

Chapter 3: Methods

Definitions

The definition of what is an injury, and what is not, poses a theoretical challenge that can have important implications for estimating the burden of injuries. The conception of injuries most commonly used by public health professionals refers to sudden and discernable damage to the body due to energy exchange. However, as discussed by Langley and Brenner (2004), this description leaves several issues unresolved. For instance, what constitutes damage to body, what is the threshold of energy exchange rate that separates a disease from an injury, should surgical incisions be considered injuries, and should body damage include psychological harm? Clearly, the answers to these questions can have a large effect on the public health burden attributed to injuries.

Although GBD-2010 aimed to use an energy definition of injuries, what is included in the definition is best understood by the operational decisions in the study. Following the most common approach in the injury community, GBD-2010 operationalized injuries as all of the pathologies that are included in the ICD-9 and ICD-10 chapters that bear the name of injury. Further, GBD-2010 defined a lower threshold of injury severity and restricted the scope of the definition to events that impeded usual activities for one day or longer. This injury threshold was operationalized by modeling three types of injuries: deaths due to injury, non-fatal injuries warranting hospitalization ("injury warranting hospital care") and non-fatal injuries warranting treatment by a health care professional but not hospitalization ("injury warranting other health care"). In this definition, an injury warranting care is an injury that would have received care if adequate medical facilities had been available. Thus, the injury thresholds used are an indicator of injury severity and not whether the cases in fact led to hospitalization or other health care.

The ICD-based external cause definitions of road injuries used in GBD-2010 are shown in Table 3.1. Note that our definitions do not distinguish between traffic and non-traffic injuries. Instead our definitions follow the logic that a road injury is one that involves a collision with a vehicle intended for use in road transportation. Thus, this definition of road injuries excludes injuries that involve vehicles not intended for road use, such as farm tractors and snowmobiles, even if such injuries occur while these vehicles are being operated on a road.

GBD Category	ICD10 Code	ICD9 Code
Road injury	V01-V04, V06, V09, V10-V19, V20-V29, V30-V79, V87.2-V87.3, V80, V82	E811.7, E812.7, E813.7, E814.7, E815.7, E816.7, E817.7, E818.7, E819.7, E822.7, E823.7, E824.7, E825.7, E826.0, E827.0, E828.0, E829.0 E800.3, E801.3, E802.3, E803.3, E804.3, E805.3, E806.3, E810.6, E811.6, E812.6, E813.6, E814.6, E815.6, E816.6, E817.6, E818.6, E819.6, E820.6, E821.6, E822.6, E823.6, E824.6, E825.6, E826.1 E810.2-E810.3, E811.2-E811.3, E812.2-E812.3, E813.2-E813.3, E814.2-E814.3, E815.2-E815.3, E816.2-E816.3, E817.2-E817.3, E818.2-E818.3, E819.2-E819.3, E820.2-E820.3, E821.2-E821.3, E822.2-E822.3, E823.2-E823.3, E824.2-E824.3, E825.2-E825.3 E810.0-E810.1, E811.0-E811.1, E812.0-E812.1, E813.0-E813.1, E814.0-E814.1, E815.0-E815.1, E816.0-E816.1, E817.0-E817.1, E818.0-E818.1, E819.0-E819.1, E820.0-E820.1, E821.0-E821.1, E822.0-E822.1, E823.0-E823.1, E824.0-E824.1, E825.0-E825.1 E810.4, E810.5, E811.4, E811.5, E812.4, E812.5, E813.4, E813.5, E814.4, E814.5, E815.4, E815.5, E816.4, E816.5, E817.4, E817.5, E818.4, E818.5, E819.4, E819.5, E820.4, E820.5, E821.4, E821.5, E822.4, E822.5, E823.4, E823.5, E824.4, E824.5, E825.4, E825.5, E826.3, E826.4, E827.3, E827.4, E828.4, E829.4
Pedestrian injury by road vehicle	V01-V04, V06, V09	E811.7, E812.7, E813.7, E814.7, E815.7, E816.7, E817.7, E818.7, E819.7, E822.7, E823.7, E824.7, E825.7, E826.0, E827.0, E828.0, E829.0
Pedal cycle vehicle	V10-V19	E800.3, E801.3, E802.3, E803.3, E804.3, E805.3, E806.3, E810.6, E811.6, E812.6, E813.6, E814.6, E815.6, E816.6, E817.6, E818.6, E819.6, E820.6, E821.6, E822.6, E823.6, E824.6, E825.6, E826.1
Motorized vehicle with two wheels	V20-V29	E810.2-E810.3, E811.2-E811.3, E812.2-E812.3, E813.2-E813.3, E814.2-E814.3, E815.2-E815.3, E816.2-E816.3, E817.2-E817.3, E818.2-E818.3, E819.2-E819.3, E820.2-E820.3, E821.2-E821.3, E822.2-E822.3, E823.2-E823.3, E824.2-E824.3, E825.2-E825.3
Motorized vehicle with three or more wheels	V30-V79, V87.2-V87.3	E810.0-E810.1, E811.0-E811.1, E812.0-E812.1, E813.0-E813.1, E814.0-E814.1, E815.0-E815.1, E816.0-E816.1, E817.0-E817.1, E818.0-E818.1, E819.0-E819.1, E820.0-E820.1, E821.0-E821.1, E822.0-E822.1, E823.0-E823.1, E824.0-E824.1, E825.0-E825.1
Road injury other	V80, V82	E810.4, E810.5, E811.4, E811.5, E812.4, E812.5, E813.4, E813.5, E814.4, E814.5, E815.4, E815.5, E816.4, E816.5, E817.4, E817.5, E818.4, E818.5, E819.4, E819.5, E820.4, E820.5, E821.4, E821.5, E822.4, E822.5, E823.4, E823.5, E824.4, E824.5, E825.4, E825.5, E826.3, E826.4, E827.3, E827.4, E828.4, E829.4

Table 3.1 ICD-based operational definition of road injuries in GBD-2010

Pre-analysis of Input Data

We undertook a substantial effort to harmonize the vast variety of data sources described in the previous chapter. Most of the data sources used in GBD-2010 are secondary data that were not originally collected for estimating the global incidence and burden of injuries. As a result, the data sources were provided to the project in a wide range of formats – including unit-record, detailed tabulations, summary tables, among others. Furthermore, many of the datasets were from administrative data systems not intended for health surveillance and had poorly coded information. For these reasons, it was essential to clean the data and map them to a common set of definitions prior to analysis.

A detailed description of how the data was pre-processed prior to analysis has been reported elsewhere (Lozano et al. 2012, and Vos et al. 2012). In summary, we undertook the following six steps to harmonize the collected data:

1. Assessing completeness of mortality data sources

We assessed the completeness of vital registration and sample registration data points using the most accurate variants of death distribution methods: synthetic extinct generations, the generalized growth balance method, and a hybrid of the two, as described in Wang et al (2012). Among adults, i.e. the age group most at risk of road injuries, there were few vital registration or sample registration data points with completeness below 70% in our data collection.

For small-scale studies that collect data through household recall (e.g. verbal autopsy studies), past work has shown that there is a substantial undercount of deaths. For our work, the parameter of primary interest was the proportion of deaths by various causes and we assumed that the patterns of recalled deaths are the same as deaths that are not recalled.

2. Mapping across different coding schemes used in the underlying data

Many of the data sets used in our analysis were coded using various revisions of ICD, which have evolved from ICD8 to ICD10 during the study period of 1980-2010. In addition there are national variants and condensed lists of ICD (such as the ICD-9 Basic Tabulation List) that were commonly used in the data. It should be noted that many of the variants and condensed versions of ICD do not code the subtypes of road injuries shown in Table 3.1. We developed mapping from these various classification schemes to the GBD-cause list.

3. Reattribution of poorly specified cause codes in mortality data

The various ICD revisions include many codes that should not be identified as underlying causes of death but are commonly used as the underlying cause of death on death certificates. In addition, there are commonly used ICD codes that have less specificity than the GBD-cause list. For instance, road injuries could be assigned to ICD10-X59 (“Accidental exposure to other and unspecified factors”). GBD-2010 addressed this issue by identifying causes that should not be assigned as underlying cause of death, including 2759 codes in ICD10 and 3382 codes in ICD9, and identifying potential underlying causes based on pathophysiology. Deaths coded to these were then reallocated based on published literature, expert judgment, statistical analysis, and proportionate allocation across target causes.

4. Age- and sex- splitting of data

Although GBD-2010 produced estimates for 40 age- sex groups, data was often provided to us in more aggregate age groups and with different age categories. In such cases, the data was split using the global observed pattern of relative risks of death for a cause by age and the local distribution of the population by age. Relative risks of death by age were computed for each cause using the entire pooled dataset on medically certified causes of death. Similarly, where studies report deaths for both sexes combined, a similar approach was used to allocate these deaths to age-sex groups.

5. Smoothing

When data are disaggregated by country, age-, sex- and cause-, the number of cases in some cells can be very low and have relatively large stochastic fluctuations. Therefore, in cases where multiple years for a country-cause-age group were observed with zero deaths, we used a standardized smoothing algorithm, essentially a type of moving average.

6. Outlier detection

Data from some sources appeared implausible when compared with the bulk of other available information. Such outliers can have substantial effects on time series estimates. Therefore, we identified outliers that met the following criteria: large inconsistency with other data for the same cause in the same country at the same time; large inconsistency with other data for similar countries; or disproportionate effect on time series estimation. Observations that were identified as outliers were excluded from subsequent analysis.

7. Adjusting for measurement biases in survey data

Household surveys that ask respondents about past injury events are framed in a variety of ways that can result in biases in the estimate. We adjusted for these definitional differences by constructing adjustment factors. For instance, surveys are known to underestimate incidence of non-fatal road injuries depending on the duration of the recall period. Therefore, we constructed a correction function for recall bias using data from the World Health Surveys, which included a question asking respondents about when the injury occurred. We applied this correction to standardize incidence estimates across the wide range of recall periods used in household surveys.

Analytical Strategy

Overall

GBD-2010 used six different modeling strategies for estimating mortality from various causes depending on the cause and the strength of the available data. We used Cause of Death Ensemble Modeling (CODEm) to estimate deaths from road injuries and the various road-user subtypes disaggregated by age, sex, country, and year for all countries from 1980 to 2010.

To estimate the burden of non-fatal outcomes of road injuries, we first constructed estimates of the incidence of injuries using household survey data, hospital data, and road injury mortality estimates. Further, we used hospital data to construct matrices mapping the proportion of cases of road injuries that resulted in a particular nature-of-injury, allowing us to estimate incidence by nature-of-injury. We constructed estimates of prevalence using estimated durations and proportions of cases that experience long-term disability and computed estimates of years lived with disability by applying disability weights.

The following sections provide more details of the modeling strategy of each of these aspects.

Mortality

Our estimates of deaths due to road injuries (and the road-user sub-categories) were constructed using the modeling tool CODEm, which has been used extensively in the GBD-2010 project for most major causes of death. In recent studies, the CODEm model has been used to analyze maternal mortality (Hogan et al. 2010), breast and cervical cancer mortality (Forouzanfar et al. 2011), and malaria mortality (Murray et al. 2012). The CODEm methodology has been described in detail by Foreman et al. (2012) and a detailed application to GBD-2010 is described by Lozano et al. (2012). In the following section, we summarize and highlight some key aspects that are relevant to the estimates of road injury mortality.

The CODEm modeling strategy is based on the following three steps. First, a large range of plausible statistical models is developed for each cause. All possible permutations of selected covariates are tested and only models where the sign on the coefficient for a covariate is in the expected direction are retained. Note that for n covariates, this requires testing 2n models. In addition, four families of statistical models are developed using covariates: mixed effects linear models of the log of the death rate, mixed effects linear models of the logit of the cause fraction, spatial-temporal Gaussian process regression (ST-GPR) models of the log of the death rate, and ST-GPR of the logit of the cause fraction. Following this, ensemble models, or blends of these various component models, are developed. Next, the validity of all component models and ensembles is evaluated by doing out-of-sample predictions. Thus, part of the data is excluded from the initial models and predicted values for the withheld data are compared with the actual observed data. The model or ensemble that performs best on such validations is finally selected.

Our mortality models are single-cause fraction models where the sum of estimated cause-specific mortality may not equal the all-cause mortality envelope. Thus, we re-scale deaths from all causes to match the all-cause envelope using a simple algorithm called CoDCorrect. The algorithm functions at the level of each draw from the posterior distribution of each cause, and accounts for uncertainty such that causes known with higher precision are affected less by the re-scaling than causes with large uncertainty. Each cause is processed by CodCorrect to fit in the mortality series of its parent cause at each level. Thus, for instance road injury subtypes are rescaled to fit within the estimates of the road injury envelope, which in turn is rescaled to fit within the transport injury envelope.

The choice of covariates and priors and road injuries were based on expert consultation and a review of the literature. A covariate that is suitable for these statistical models has a set of important characteristics: First, there should be a theoretical reason to expect a relationship between the covariate and road injuries. Second measurements of the covariate at the national level should be available for most countries. Finally, data for the covariate should be available for most country-years from 1980 to 2005.

Covariates were classified by level based on their causal distance between the covariate and the cause. Thus covariates that are the most proximal, such as alcohol, which directly influences the rate of road crashes, were considered as level 1 covariates. However, education is more distally related with road injury rates and was classified as a level 3 covariate. Covariate priors indicated the predicted direction in which a given covariate will be predictive. For example, it is expected that increased alcohol consumption will be associated with increased mortality rates from road crashes, so the prior direction is specified as positive. Based on these considerations, eleven covariates were used to model the mortality rate of road injuries and the road-user subtypes. These covariates, level and assumed direction for CODEm modeling are listed in Table 3.2. Lozano et al. (2012) have provided more details of the mortality analysis method as well as statistical performance metrics for the road injury models.

Finally, we convert the age- and sex- specific road injury mortality estimates produced by CODEm into years of life lost by multiplying deaths at each age by the age-specific reference standard life expectancy developed by Murray et al. (2012).

Cause name	Level	Covariate	Direction
Road injury	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 2 wheels (per capita)	Positive
	1	Vehicles - 2 wheels fraction (proportion)	Positive
	1	Vehicles - 2+4 wheels (per capita)	Positive
	1	Vehicles - 4 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Log Log LDI Squared Squared	-
	2	Population 15 to 30 (proportion)	Positive
	2	Population Density (300-500 ppl/sqkm, proportion)	-
	2	Population Density (500-1000 ppl/sqkm, proportion)	-
	3	Education (years per capita)	Negative
	3	Rainfall Quintile 5 (proportion)	Positive
RTI - Pedestrian	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 2 wheels fraction (proportion)	Positive
	1	Vehicles - 2+4 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Log Log LDI Squared Squared	-
	2	Population 15 to 30 (proportion)	Positive
	2	Population Density (300-500 ppl/sqkm, proportion)	-
	2	Population Density (500-1000 ppl/sqkm, proportion)	-
	3	Education (years per capita)	Negative
	3	Rainfall Quintile 5 (proportion)	Positive

Continued next page

Cause name	Level	Covariate	Direction
RTI - Bicyclist	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 2 wheels fraction (proportion)	Positive
	1	Vehicles - 2+4 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Log Log LDI Squared Squared	-
	2	Population 15 to 30 (proportion)	Positive
	2	Population Density (300-500 ppl/sqkm, proportion)	-
	2	Population Density (500-1000 ppl/sqkm, proportion)	-
	3	Education (years per capita)	Negative
	3	Rainfall Quintile 5 (proportion)	Positive
RTI - motorized two-wheeler rider	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 2 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Log Log LDI Squared Squared	-
	2	Population 15 to 30 (proportion)	Positive
	2	Population Density (300-500 ppl/sqkm, proportion)	-
	2	Population Density (500-1000 ppl/sqkm, proportion)	-
	3	Education (years per capita)	Negative
	3	Rainfall Quintile 5 (proportion)	Positive
RTI - occupant in motorized vehicle with 3 or more wheels	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 4 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Log Log LDI Squared Squared	-
	2	Population 15 to 30 (proportion)	Positive
	2	Population Density (300-500 ppl/sqkm, proportion)	-
	2	Population Density (500-1000 ppl/sqkm, proportion)	-
	3	Education (years per capita)	Negative
	3	Rainfall Quintile 5 (proportion)	Positive
RTI - other	1	Alcohol (liters per capita)	Positive
	1	Health System Access 2	Negative
	1	Vehicles - 2 wheels fraction (proportion)	Positive
	1	Vehicles - 2+4 wheels (per capita)	Positive
	2	Log LDI (I$ per capita)	-
	2	Population 15 to 30 (proportion)	Positive
	3	Rainfall Quintile 5 (proportion)	Positive

Table 3.2 Candidate covariates, level and assumed direction for CODEm modeling of road injuries and their road-user subtypes

Morbidity

Vos et al. (2012) provide a detailed description of the methods used for estimating the burden of non-fatal health outcomes. Figure 3.1 provides a schematic illustration of the steps followed in estimating the burden of non-fatal injuries. In the following section, we summarize and highlight key aspects of the methods relevant to estimating the burden of road injuries in GBD-2010.

The analysis of the morbidity resulting from non-fatal road injuries poses a special challenge because although road injuries and their subtypes are defined by the external cause (e.g. pedestrian struck by motorized vehicle), the functional limitations are determined by the nature of the injury, such as traumatic brain injury or long bone fractures. Thus, estimating the burden of non-fatal road injuries involves constructing estimates of the incidence of road injuries and the incidence of nature-of-injury. We accomplished this and constructed estimates of years lived with disability from road injuries in the following steps:

1. We estimated the incidence of external causes (road injuries and road-user subtypes) of non-fatal injuries using available incidence data from household surveys and hospital databases using DISMOD-MR (Box-1).

2. We constructed estimates of the incidence of road injury sequelae (i.e. nature-of-injury) using mappings developed from hospital data.

3. We estimated the probability of developing long-term functional impairment based on pooled data from four follow-up studies and constructed equivalent disability weights for each individual at 12 months after injury.

4. We estimated prevalence of injuries by accounting for duration and computed burden of non-fatal road injury estimates.

Estimating incidence of non-fatal road injuries

Our first step in assessing the burden of non-fatal road injuries was to construct estimates of the country-, year-, age-, sex-specific incidence of non-fatal road injury. We accomplished this using DisMod-MR, an integrative systems model of disease in a population that generates consistent estimates of injury prevalence, incidence, remission, and mortality for each cause of injury.

The primary source of our data for constructing these estimates was point estimates of road injury hospitalizations as reported in hospital databases and household surveys, and road injuries that did not receive medical care as reported in household surveys. In addition, we used mortality from road injuries estimated as described above, as a covariate in DisMod MR. In essence this introduces an injury pyramid approach to estimating non-fatal injuries from deaths, as is commonly done in the injury literature.

In order to characterize the entire spread of injury severity, we estimated the incidence of two types of non-fatal road injuries:

- *road injury warranting hospital admission*, i.e. road injury that would have been hospitalized had such medical facilities been available; and

- *road injury warranting other health care*, i.e. road injury that would have warranted health care but not hospitalization had such health care been available.

It is important to note that these estimates do not refer to actual care received for injuries. Instead they refer to injuries that would have received health care had there been no barriers to health care in the particular setting. In other words, these are injuries that would have received health care had they occurred in a society with full health system access.

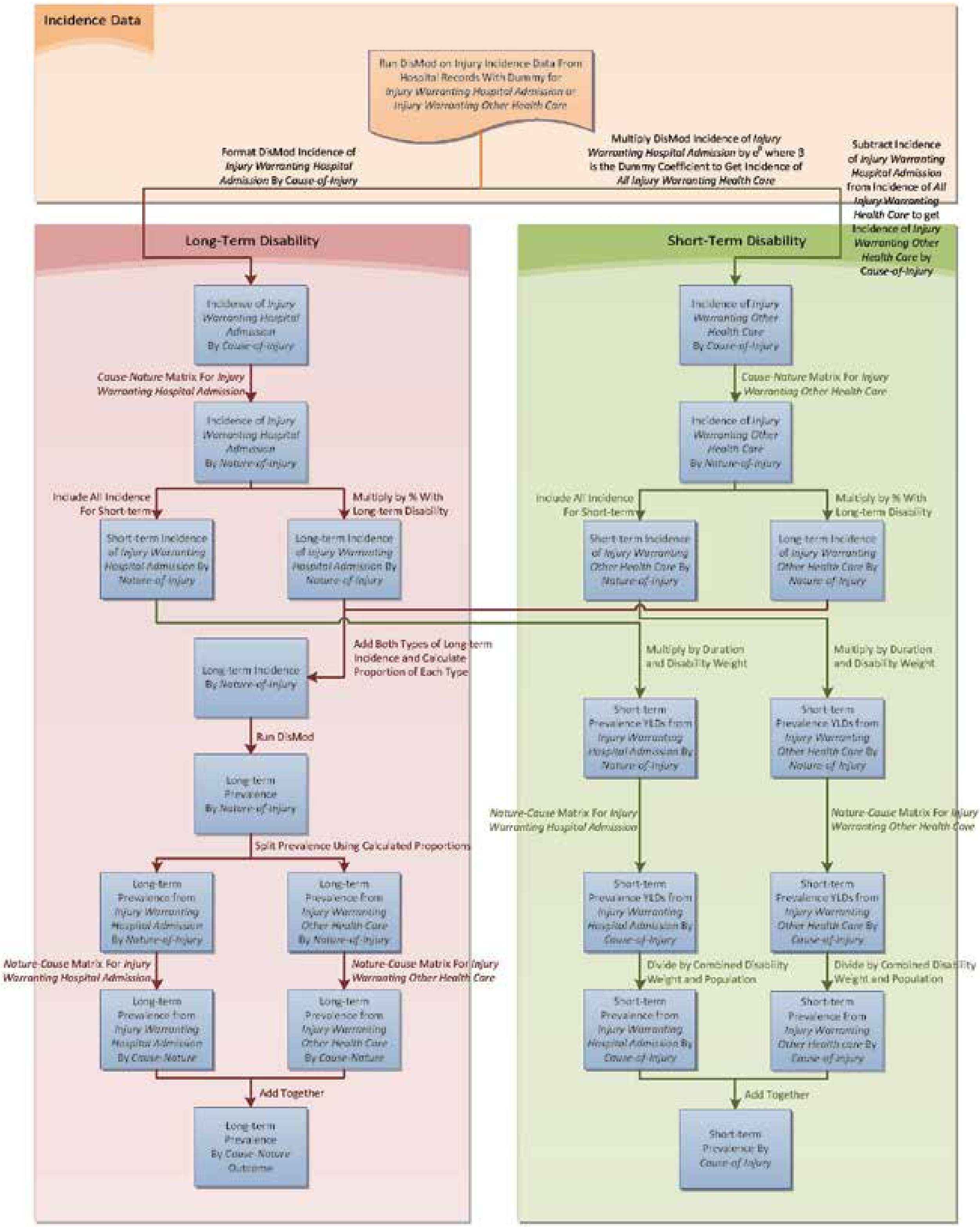


Figure 3.1 Schematic description of the steps followed in the analysis of the burden of non-fatal road injuries in GBD-2010

In order to produce estimates for these two types of injury severity, we included a "health care" dummy variable indicating whether a given data point for incidence represented cases resulting in hospitalization (dummy = 0) or cases seeking other health care (dummy = 1). Using the coefficient on the health care dummy and the incidence estimations from DisMod MR, we calculated incidence of road injury warranting hospital admission and incidence of *road injury warranting other health care*.

Box–1 DISMOD-MR

DisMod-MR is a Bayesian meta-regression tool developed specifically for GBD-2010. DisMod-MR estimates a generalized negative binomial model for all epidemiological data with two types of covariates (one set that predicts variation in true rates and one set related to measurement bias); super-region, region, and country random intercepts; and age-specific fixed effects. In cases where it is appropriate, one can assume that the incidence, remission, and excess mortality rates have been constant overtime, which allows data on incidence, prevalence, excess mortality, and cause-specific mortality to inform prevalence estimates.

The differential equations governing the relationship between the parameters of incidence, remission, mortality, prevalence, and duration are well characterized and have been used in previous rounds of the GBD.

DisMod-MR integrates over any observed age range so that data reported for any age group can inform the maximum likelihood estimate. In addition, there are study-level covariates that allow estimation from within the data of the relationship between different case definitions, data sampling, or other methodological variations. The analyst can set a reference value for these covariates so that DisMod-MR predictions are for the desired reference category. Study level covariates can also be included in the parameters of the gamma distribution of the negative binomial. As with any meta-regression tool, country-level covariates can be included that relate to variation in prevalence or other epidemiological parameters across countries.

DisMod-MR also allows the analyst to set prior distributions for the ranges of epidemiological parameters, the first derivative of parameters with respect to age over different age intervals, and the smoothness of estimates with respect to age. Estimation of posterior distributions at the region-sex-time period level allows for the regional age-sex pattern to vary if the data are strong.

Vos et al. (2012) provide more details about DisMod-MR.

Estimating incidence of road injury sequelae (nature-of-injury)

In order to construct the incidence of sequelae we used hospital data from 28 countries (from Southeast Asia; Central, Eastern, and Western Europe; Central, Southern, and Tropical Latin America; North Africa/Middle East; North America High Income; and East Sub-Saharan Africa) with dual coding of discharges by external cause and nature-of-injury following ICD9 and ICD10. We mapped ICD nature-of-injury codes in the hospital data to a summary list of GBD categories shown in Table 3.3.

We used negative binomial models to estimate the probability that a road injury would result in a particular sequela as a function of age, sex, and an indicator variable for developed versus developing countries. We created separate models for road injury warranting hospital admission and road injury warranting other health care. While the former relied on the full list of hospital databases, the latter relied on the US State Emergency Department Databases (SEDD) with data on ER discharges in Arizona, California, Florida, Iowa, Massachusetts, North Carolina, New Jersey, and Wisconsin from 2003 to 2008.

The result of this step in the analysis was a series of matrices, two for each age-sex-region corresponding to the need for hospital or other care. Each cell in this matrix gives the fraction of incident cases for each external injury cause that has a particular nature-of-injury. We multiplied these fractions by incidence estimates of road injuries to obtain the incidence of nature-of-injury resulting from road injury.

Estimating incidence of permanent and short-term disability

We estimated the proportion of each road injury sequelae that go on to have long-term disability in the following steps. First, we produced a pooled dataset of health status measures gathered from four prospective follow-up surveys: the Dutch Injury Surveillance System, (Melse et al., 2000) South Carolina Traumatic Brain Injury Follow-up Registry, (SCTBIFR, 2012), the National Study on Costs and Outcomes of Trauma, (Mackenzie et al. 2007), and the Medical Expenditure Panel Survey 2000-2009 (MEPS, 2012). These data allowed us to track the relative health of individuals suffering different injuries with a one-year follow-up.

The analysis was complicated by the need to crosswalk between the health status measures used in the four surveys. We accomplished this using the 2000-2003 MEPS, which included EQ-5D responses in addition to the SF-12 measures. Also, in order to properly compare these measures with the nature-of-injury disability weights to be used in YLD calculation, it was necessary to further crosswalk to disability weight space. Therefore, we estimated the effect of each injury on disability after a year using a regression and comorbidity correction utilizing uninjured individuals from MEPS as a baseline population. The disability weights evaluated by the GBD Disability Weight Survey (Salomon et al. 2011) for each type of injury were assumed to be the "full" disability after a year. The model estimated disability weight after a year was then divided by this "full" disability, which resulted in the estimated probability of long-term impairment.

	Sequelae Name	ICD10	ICD9
N1	Open wound, superficial injuries and dislocations	S00-S01, S03-S03.5, S05, S08-S10, S11.1-S11.9 S13, S15-S16, S19-S21 S23, S29.0, S30-S31 S32.2 S33, S39.0 S40-S41 S45-S46 S50-S51 S53.0-S53.4 S55-S56 S60-S61, S63 S65-S66, S70-S71, S73.1, S75-S76, S80-S81, S85-S86, S90-S91, S93.0-S93.6, S95-S96, S99(ex S99.7), T00-T01, T03, T06.3-T06.4, T09.0-T09.2, T09.5, T11.0-T11.2 T11.4-T11.5, T13.0-T13.2,T13.5,T14.0-T14.1,T14.3, T14.5-T14.6 T15-T17,T33-T35,T90.1, T90.4,T92.0,T92.3,T92.5, T93.0,T93.3, T93.5	830-8301 832-83412 837-83952 83969 83979-840 8403 8405-843 845-848 86401 86411 8700-87362 87364-87372 87374-8739 8742-884 890-894 900-9009 903-9049 9056-9058 9060-9063 9104-9249 930-9349 950 9910-9913
N2	Injury Requiring Urgent Care	S07, S17, S38.0-S38.3, S47, S57, S67, S77, S87, S97, T04, T14.7 T18-T19, T36-T65, T67-T70, T73-T74, T75.0 T75.2-T75.8, T78-T85, T88, T91.5,T92.6,T93.6, T96-T97	9064 925-929 9350-9399 960-990 9914-9940 9942-9946 9948-9999
N3	Injury Requiring Emergency Care	S35-S37, S39.6-S39.9, T27.0-T27.7, T71, T75.1	863-86400 86402-86410 86412-8691 902-9029 9471 9941 9947
N4	Fracture of clavicle, scapula, humerus, or skull	S02.0-S02.1, S02.7, S02.9, S42, S49.7, T02.0, T90.2	800-801 8030 8035 8040 8045 810-812
N5	Fracture of sternum, rib, or face bone	S02, S02.2-S02.6, S02.8, S22, S22.2-S22.3, S22.8-S22.9	802 80701-80711 8072-8073 825-826 87363 87373
N6	Fracture of wrist,other distal hand, foot except ankle	S62, S69, S69.7-S69.9, S92, S99.7, T92.2	814-8191 827-8271
N7	Fracture of radius or ulna	S52, S59.7-S59.9 T02.2, T02.4, T10, T92.1	813 9052
N8	Fracture of femur	S72, S72.3-S72.9	821
N9	Fracture of Hip	S72.0-S72.2, T93.1	820 9053
N10	Fracture of patella, tibia, fibula, or ankle	S82, S89.7, T02.3, T02.5-T02.6, T12, T12.0-T12.1	822-824 9054
N11	Fracture of pelvis	S32.1, S32.3-S32.8	8056-8057 808-8091
N12	Long term outcome of dislocation of hip/knee/shoulder	S43 S730 S83	831 835-836 83961 83971 8400-8402 8404 844
N14	Burns, <20% total burned surface area without lower airway burns	T20-T27 T28-T30 T310-T311 T320-T321	9100-9103 940-9470 9472-9481 949
N16	Burns, ≥ 20% TBSA or ≥ 10% TBSA if incl. head/neck or hands/wrist	T312-T319 T322-T329 T66 T95	9065-9069 9482-9489
N17	Amputation of both lower limbs or both upper limbs	T050-T055	8876-8877 8962-8963 8976-8977
N19	Amputation of one lower limb or one upper limb	S48 S58-S589 S68 S683-S689 S78 S88 S98-S980 S983-S984 T056 T116 T136	8870-8875 8960-8961 8970-8975
N20	Amputation of finger(s) (with/without thumb or toe)	S680-S682 S981-S982	885-886 895
N21	Injured nerves	S04 S44 S54 S64 S74 S84 S94 T062 T113 T133 T144 T903 T924 T934	9073-9079 951 953-957
N22	Spinal cord lesion neck lvl	S14 T060	8060-8061 9520
N23	Fracture of vertebral column	S12 S220-S221 S320 T911	805-8055 8058-8059 9051
N24	Spinal cord lesion below neck level	S24 S34 T061 T08 T913	8062-8069 9072 9521-9529
N27	Severe traumatic brain Inj	S06 T905	9070
N28	Severe chest injury	S110 S224-S225 S25-S28 S297 T914	80700 80712-80719 8074-8076 860-862 8740-8741 901 9080

Table 3.3 ICD codes corresponding to GBD-2010 sequelae of injuries

Next, we multiplied the incident nature-of-injury cases by the probabilities of long-term injury for *injury warranting hospital admission* and *injury warranting other health care* by *nature-of-injury* category, to construct estimates of long-term injury.

For short-term incidence by nature-of-injury, we included all cases of *injury warranting hospital admission* and *injury warranting other health care*. Dividing cases by population gave us our short-term incidence, which we kept divided between short-term incidence of *injury warranting hospital admission* and short-term incidence of *injury warranting other health care*. This was necessary so that we could later use type-specific disability weights and nature-cause matrices to more accurately estimate short-term prevalent YLDs.

Computing burden estimates (YLD)

Finally, with estimates of short-term and long-term nature-of-injury incidence, we proceeded towards estimating their associated burden in YLDs. We summed both types of long-term incidence and applied DisMod-MR to estimate long-term nature-of-injury prevalence, assuming remission was equal to 0 and using relative-risk of mortality and standardized mortality ratio data from literature reviews, as available.

For short-term disabilities, we directly calculated prevalent YLDs arising from both *injury warranting hospital admission* and *injury warranting other health care* for each nature-of-injury category by first multiplying short-term nature-of-injury duration in years to get prevalence. We then multiplied prevalence by population to get prevalent cases and multiplied prevalent cases by short-term nature-of-injury disability weights to get prevalent YLD.

References

- Abou Zahr, C, Cleland, J., Coullare, F, et al. (2007) Who Counts? 4 The way forward. Lancet, vol. 370 pp. 1744-1746.
- Foreman K, Lozano R, Lopez A, Murray C, (2012). Modeling causes of death: an integrated approach using CODEm. Population Health Metrics; 10: 1.
- Forouzanfar MH, Foreman KJ, Delossantos AM, et al. (2011) Breast and cervical cancer in 187 countries between 1980 and 2010: a systematic analysis. Lancet 22; 378 (9801): 1461–84.
- Hogan, MC, Foreman, KJ, Naghavi, M, Ahn, SY, Wang, M, Makela, SM, et al. (2010). Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress towards Millennium Development Goal 5. Lancet, 375(9726), 1609–1623.
- Langley, J & Brenner, R (2004). What is an injury? Injury Prevention, 10(2), 69-71.
- Lozano R, Naghavi M, Foreman K, et al. (2012). Global and regional mortality from 235 causes of death for 20 age-groups in 1990 and 2010: A systematic analysis, Lancet, 380, 2095-2128.
- Mackenzie EJ, Rivara FP, Jurkovich GJ, et al. (2007). The National Study on Costs and Outcomes of Trauma. J Trauma; 63: S54–67; discussion S81–86.
- Melse JM, Essink-Bot ML, Kramers PG, Hoeymans N. (2000). A national burden of disease calculation: Dutch disability-adjusted life-years. Dutch Burden of Disease Group. American Journal of Public Health; 90: 1241.
- MEPS, Agency for Healthcare Research and Quality. United States Medical Expenditure Panel Survey 2000-2009. Rockville, United States, Agency for Healthcare Research and Quality.
- Murray, CJL, Lopez, A, Feehan, D et al. (2007) Validation of the symptom pattern method for analyzing verbal autopsy data. PLoS Medicine, 4 (11) pp. e327.
- Murray CJ, Rosenfeld LC, Lim SS, et al. (2012). Global malaria mortality between 1980 and 2010: a systematic analysis. The Lancet 4; 379: 413–31.
- Murray, CJL, Vos, T, Lozano, R, Naghavi, M, Flaxman, AD, Michaud, C, et al. (2012). Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet, 380(9859), 2197–2223.
- Naghavi M, Makela S, Foreman K, O'Brien J, Pourmalek F, Lozano R. (2010). Algorithms for enhancing public health utility of national causes-of-death data. Population Health Metrics 2010; 8: 9.
- Salomon J, Vos T, Hogan D, et al. (2012). Common values in assessing health outcomes from disease and injury: Global Burden of Disease 2010 disability weights measurement study. Lancet, 380:2129-43.
- South Carolina Traumatic Brain Injury Follow-up Registry (SCTBIFR). http://www.musc.edu/sctbifr/.
- Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., et al. (2012). Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010.The Lancet, 380(9859), 2163–2196.
- Wang H, Dwyer-Lindgren L, Lofgren KT, et al. 2012. Age- and Sex-Specific Mortality for 187 Countries, 1970-2010: A Systematic Analysis, The Lancet, 380: 2071–94.

Chapter 4: Results

Burden of road injuries compared with other diseases

Road injuries killed an estimated 231,000 (95%UI: 180,000-306,000) people in sub-Saharan Africa in 2010, accounting for almost one-fifth of the global road injury death toll (Table 4.1). The road injury death rate in sub-Saharan Africa, 27.0 per 100,000 people, was 40% higher than the global road injury death rate. In addition to deaths, there were over 8 million non-fatal injuries, of which 885,000 were severe enough to warrant hospital admission if adequate access to medical care were available to the victims. The combined burden of non-fatal road injuries in sub-Saharan Africa exceeded 14 million healthy life years lost.

Approximately half of the road injury death toll of sub-Saharan Africa occurred in the Western region (Table 4.1). This is partly because it is the most populous sub-region. More importantly, the Western region had a substantially higher road injury rate of 34.4 per 100,000, 27% higher than the sub-Saharan Africa average and 78% higher than the global average. The Southern region had the lowest road injury death rate. However, we expect that the road injury burden in this region has been substantially underestimated in the GBD-2010 analysis because of methodological difficulties in processing the vital registration data available from the region.

		Sub-Saharan Africa				
	Global	Central	Eastern	Southern[3]	Western	Total
Deaths [95% UI]	1,328,535 [1.0M-1.7M]	22,761 [13k-54k]	83,614 [67k-112k]	8,962 [6k-11k]	115,680 [88k-138k]	231,017 [180k-306k]
Death rate (per 100k)	19.3	23.6	23.6	12.8	34.4	27.0
% of all-cause deaths	2.6%	2.0%	2.8%	1.2%	3.4%	2.8%
Severe non-fatal inj.[1]	9,150,864	109,601	355,719	69,126	350,870	885,316
Total non-fatal inj.[2]	78,163,025	964,848	3,267,240	584,499	3,369,311	8,185,898
DALYs [95% UI]	76,755,034 [62M-95M]	1,582,391 [0.9M-3.1M]	4,697,452 [3.7M-6.2M]	605,172 [0.4M-0.7M]	7,271,493 [5.5M-8.7M]	14,156,508 [11M-18M]
DALYs rate (per 100k)	1114	1640	1322	859	2164	1652
% of all-cause DALYs	3.0%	2.2%	2.3%	1.4%	2.9%	2.5%

Table 4.1 Deaths and healthy life years lost (DALYs) due to road injuries in sub-Saharan Africa in 2010

[1] Non-fatal injuries severe enough to warrant hospital admission if adequate access to medical care was available.

[2] Non-fatal injuries severe enough to warrant any medical care if adequate access to care was available.

[3] Our estimates of road injury deaths in Southern SSA are likely too low. For instance, in South Africa, which has 71% of the regional population, the road injury death rate based on national traffic police statistics is 2.3 times our estimate. See also footnote on Page 72.

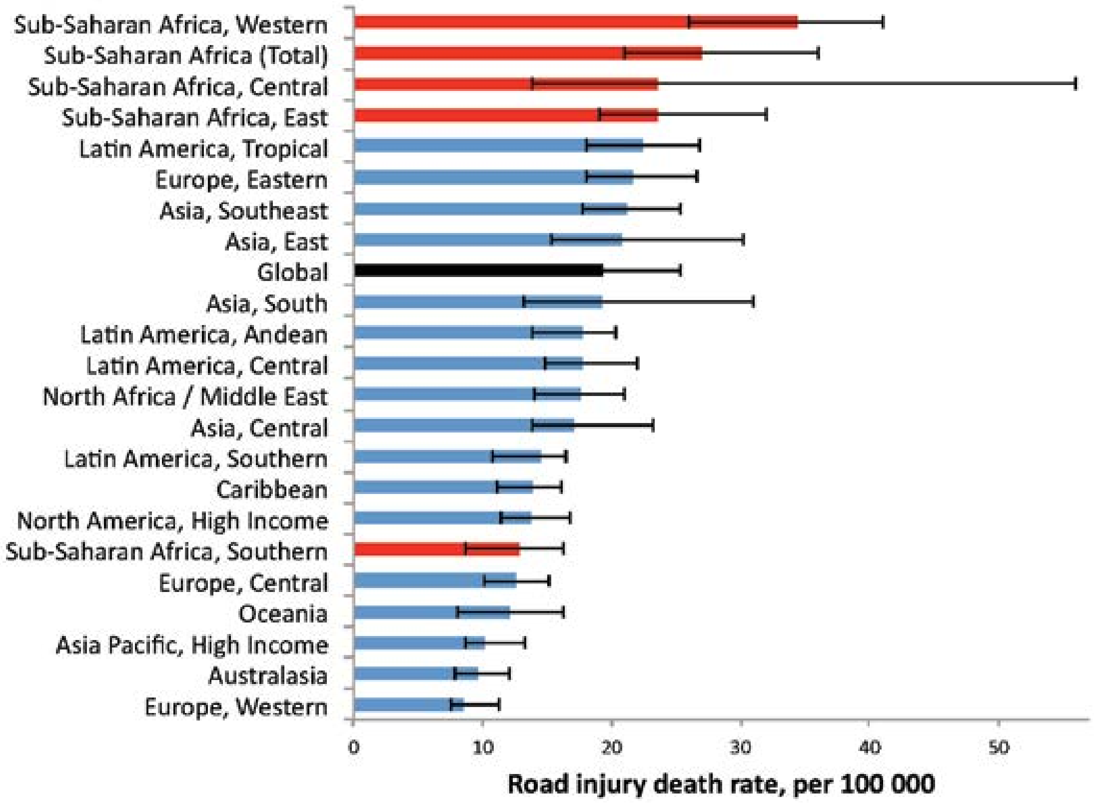


Figure 4.1 Road injury death rates in 2010 in the four regions of sub-Saharan Africa compared with other global regions.
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

In fact, sub-Saharan Africa has the highest road injury death rate of all regions in the world (Figure 4.1). Western, Central and Eastern sub-Saharan Africa are the three least safe regions of the world. The road injury death rates in Western sub-Saharan Africa are more than four times that in Western Europe, which is the region with the lowest road injury death rate globally.

The relative importance of road injuries to health in sub-Saharan Africa is similar to the global importance of the problem. Road injuries accounted for 2.5% of the total healthy life lost in the region, slightly less than the global average of 3.0% (Table 4.1). On the other hand, they accounted for 2.8% of all deaths in sub-Saharan Africa, slightly more than the global average of 2.6%. In the Western region, they accounted for 3.4% of all deaths, substantially higher than the global average.

Figure 4.2 illustrates the ranking of road injuries as a public health issue relative to other diseases in sub-Saharan Africa. Road injuries are the 8th leading cause of death in sub-Saharan Africa. They are also the 8th leading cause of death globally, and in developing countries. In contrast, road injuries are the 17th leading cause of death in developed countries even though they have dramatically higher motorization rates. Road injuries rank among the top 10 cause of death in the Western and Eastern regions, ranking relatively low only in the Southern region, where our models underestimate road injury deaths.

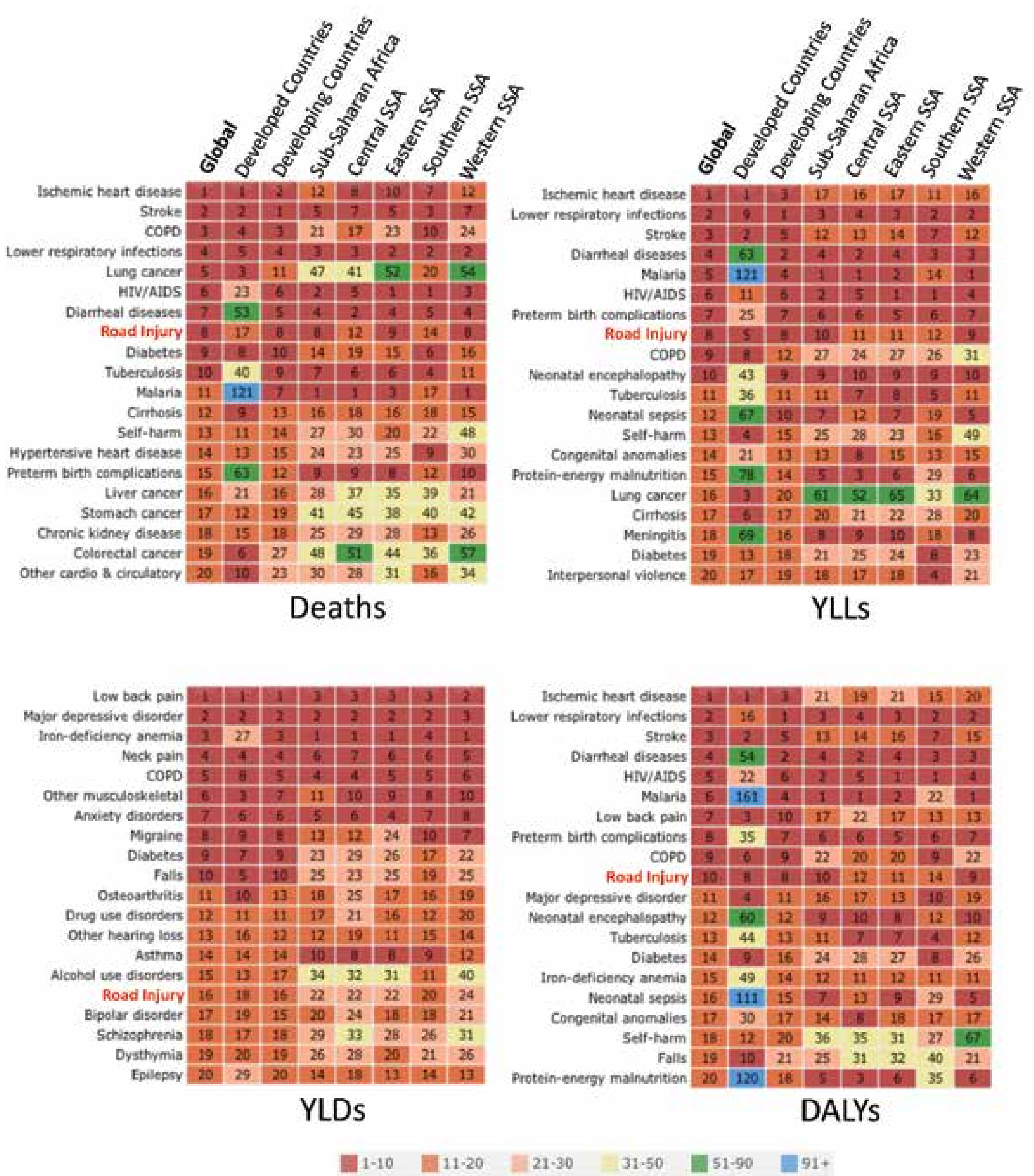
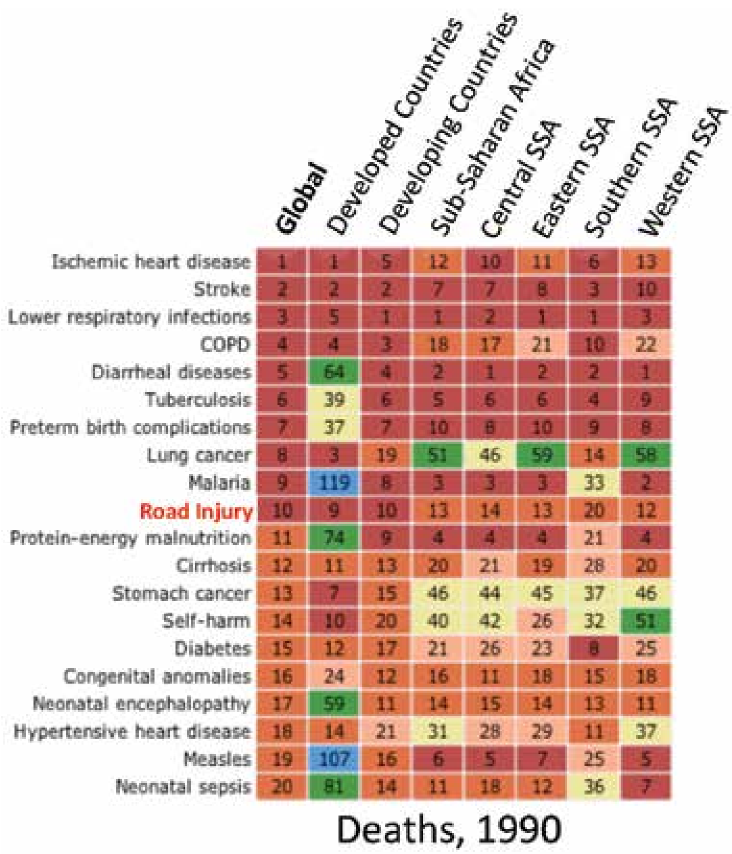


Figure 4.2 Rankings of causes of death, premature mortality (YLL), years lived with disability (YLD), and healthy life lost (DALYs) in sub-Saharan Africa regions in 2010. Colors in the heat map show how high a cause ranks in a region.
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

Notably, the health loss due to road injuries in sub-Saharan Africa exceeds that from tuberculosis and maternal disorders, two conditions that receive substantial attention from the global health and development community. As Figure 4.2 illustrates, road injuries are the 10th leading cause of healthy life years lost (DALYs) in sub-Saharan Africa ahead of tuberculosis, ranked 11th, and maternal disorders, ranked 15th (not shown in Figure 4.2 because it only includes the top 20 global causes). Similarly, road injuries are the 10th leading cause of premature mortality (YLLs) in sub-Saharan Africa, ahead of tuberculosis, ranked 11th, and maternal disorders, ranked 14th. Among leading causes of death, road injuries rank one place behind tuberculosis with a death toll that is only about 20% smaller, but seven places ahead of maternal disorders with almost twice as many deaths.

Transition in health and the growing importance of road injuries

Road injuries are emerging as a leading public health problem in sub-Saharan Africa against the backdrop of an ongoing transition in population health, away from mostly infectious disease in children to non-communicable disease and injuries that affect adults. Figure 4.3 shows the ranking of causes of death in 1990 in sub-Saharan Africa. Comparing this with Figure 4.2 shows that over the last two decades, road injuries have risen substantially in the cause rankings. In 1990, road injuries were among the top 10 causes of death in global rankings as well as in developing countries. However, road injuries were not among the top 10 causes of death in any of the sub-Saharan Africa regions in 1990. In contrast, over the same period, several other diseases, such as tuberculosis, malaria, and diarrheal diseases show substantial declines in the rankings.



	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	5	12	10	11	6	13
Stroke	2	2	2	7	7	8	3	10
Lower respiratory infections	3	5	1	1	2	1	1	3
COPD	4	4	3	18	17	21	10	22
Diarrheal diseases	5	64	4	2	1	2	2	1
Tuberculosis	6	39	6	5	6	6	4	9
Preterm birth complications	7	37	7	10	8	10	9	8
Lung cancer	8	3	19	51	46	59	14	58
Malaria	9	119	8	3	3	3	33	2
Road Injury	10	9	10	13	14	13	20	12
Protein-energy malnutrition	11	74	9	4	4	4	21	4
Cirrhosis	12	11	13	20	21	19	28	20
Stomach cancer	13	7	15	46	44	45	37	46
Self-harm	14	10	20	40	42	26	32	51
Diabetes	15	12	17	21	26	23	8	25
Congenital anomalies	16	24	12	16	11	18	15	18
Neonatal encephalopathy	17	59	11	14	15	14	13	11
Hypertensive heart disease	18	14	21	31	28	29	11	37
Measles	19	107	16	6	5	7	25	5
Neonatal sepsis	20	81	14	11	18	12	36	7

Deaths, 1990

Figure 4.3 Ranking of cause of death in sub-Saharan Africa regions in 1990

Figure 4.4 illustrates the shifting disease pattern and its links with economic development by comparing four regions that have substantially different levels of industrialization – sub-Saharan Africa, India, China and economically developed countries. The figure is a tree map, which is essentially a square pie chart. The area of the rectangles is proportional to deaths due to a particular cause group. The figure broadly illustrates that as regions industrialize, the proportion of deaths due to communicable, maternal and nutritional disorders (i.e. Group A diseases, shown in red) steadily declines. Simultaneously, the proportion of deaths due to non-communicable diseases (Group B, blue) and Injuries (Group C, green) increases. Therefore, while Group A diseases comprise 66% of all deaths in sub-Saharan Africa and 35% in India, they only comprise 6% of all deaths in China and developed countries. In contrast, Groups B and C comprise 34% (9% injuries) of all deaths in sub-Saharan Africa, 65% (11% injuries) in India, 94% (10% injuries) in China, and 94% (7% injuries) in developed countries. However, it is important to note that the relative proportion of injuries, especially road injuries, varies comparatively less through the health transition. Road injuries comprise 2.8% of all deaths in Africa, 2.8% in India, 3.4% in China, and only 1.2% in developed countries. Thus, the relative importance of road injuries to the health agenda in sub-Saharan Africa is similar to that in India and China, which are already devoting substantial attention to road safety policy.

Road injury deaths now comprise a relatively large proportion of all deaths in sub-Saharan Africa partly because road deaths in the region are rapidly increasing (Figure 4.5). The global road death toll has risen by 46% over the last two decades. However, road deaths in sub-Saharan Africa grew almost twice as fast, rising by 84%. The Western and Southern regions of sub-Saharan Africa experienced the highest increases of all regions in the world with a rise of 111% and 102%, respectively. It should be noted that a substantial portion of these increases are simply a result of population growth. Road injury death rates in sub-Saharan Africa rose only by 10% over this period, from 24.4 to 26.9 per 100,000. Thus, the rapid increase in the road death toll is partly due to successes in controlling diseases of childhood resulting in an increasing number of young adults who are most vulnerable to injuries in road traffic crashes.

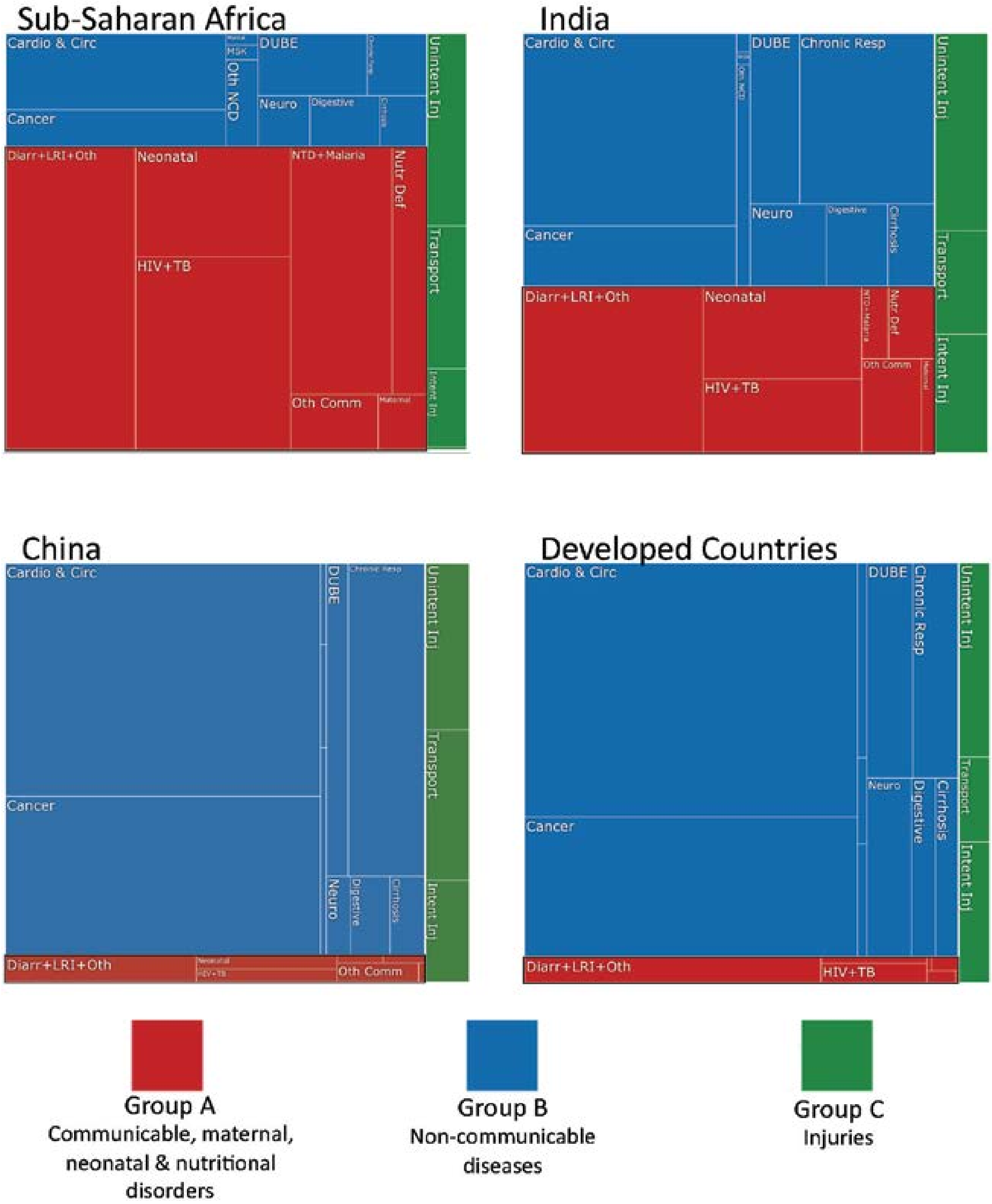


Figure 4.4 Tree map illustrating the transition in causes of death that occurs with economic development. The area of the rectangles represents the relative proportion of deaths that are due to various cause groups in each country or region in 2010.

Figure 4.5 Regional trends in road injury deaths in the four regions of sub-Saharan Africa over the last two decades compared with other global regions

In contrast to the rising death toll in sub-Saharan Africa, road deaths in all high-income regions have declined substantially over the last two decades. In Western Europe, road injury death toll declined by 43%, with a similar decline in death rates. In fact, road injury death rates have been declining in most developed countries since the early 1970s, when most Western nations established road safety agencies that instituted road safety programs targeting vehicles, highways, and road users using a broad safe systems approach for safety management.

Uncertainty in estimates of burden and cause rankings of road injuries

Figures 4.6 illustrate the uncertainty in our estimates of the burden of road injuries relative to other causes in sub-Saharan Africa. 95% uncertainty intervals are shown for deaths and healthy life lost for each cause in 2010, ordered by the mean rank of every cause. The two leading causes of death and DALYs (malaria and HIV/AIDS) have substantial overlap in their uncertainty intervals. The top four causes (i.e. also including lower respiratory infections and diarrheal diseases) are separated by a substantial gap from the next eight causes. Uncertainty in our estimates of deaths from road injuries in sub-Saharan Africa in 2010 ranges from 180,000 to 306,000 deaths. This range overlaps substantially with deaths from stroke (ranked 5th), protein-energy malnutrition, tuberculosis, preterm birth complications, meningitis, and ischemic heart disease (ranked 12th). Similarly, uncertainty in our estimates of healthy life years lost due to road injuries ranges from 11.2 million to 18.2 million DALYs. This range overlaps substantially with DALYs from protein-energy malnutrition (ranked 5th), neonatal sepsis, meningitis, preterm birth complications, neonatal encephalopathy, tuberculosis, and iron-deficiency anemia (ranked 12th).

The implications of the relative uncertainty in estimates on cause ranks are illustrated in Figure 4.7. Road injuries are the 8th leading cause of death in sub-Saharan Africa and the 95% uncertainty interval in the cause rank ranges from 7 to 12. Similarly, road injuries are the 10th leading cause of DALYs in sub-Saharan Arica and the 95% uncertainty interval in the cause rank ranges from 7 to 12.

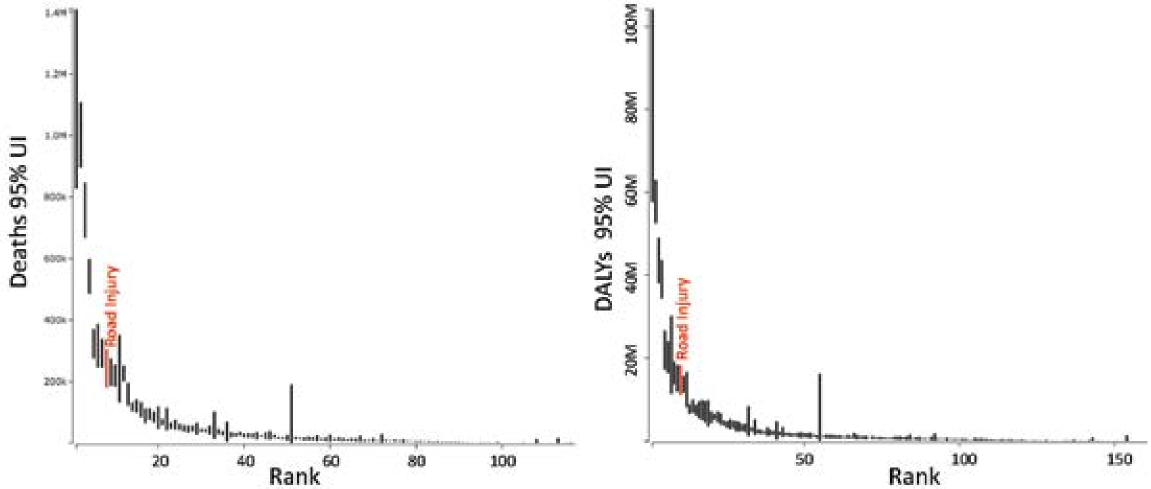


Figure 4.6 Deaths and DALYs with 95% uncertainty intervals versus rank by cause in sub-Saharan Africa in 2010

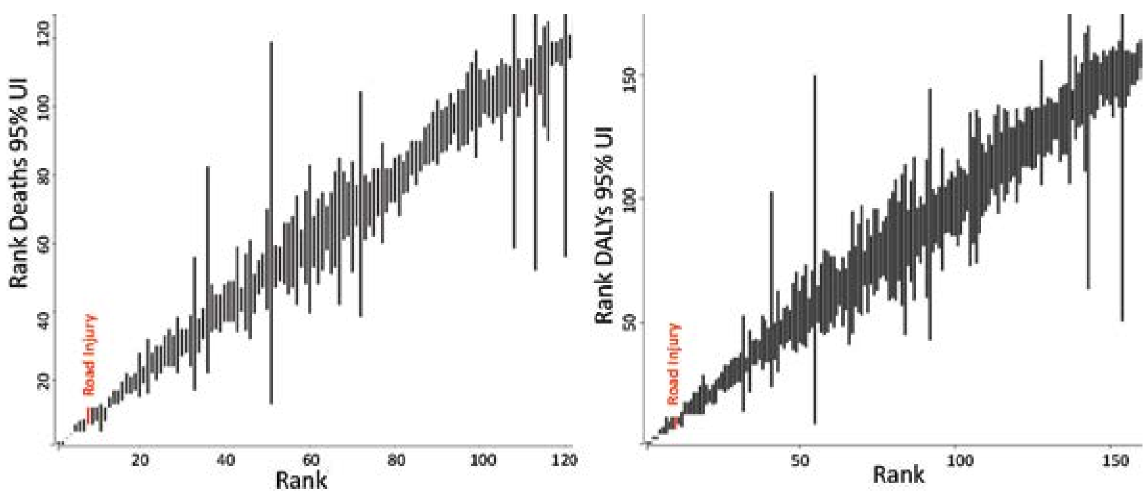


Figure 4.7 Uncertainty in rank of deaths and DALYs with 95% uncertainty intervals versus mean rank by cause in sub-Saharan Africa in 2010

Relative burden of road injuries among males and females

Road injuries kill more men than women, and hence the problem ranks as a higher priority for male health, in all regions of the world. Road injuries are the 7th leading cause of death for males in sub-Saharan Africa compared with 13th for females. They are a top-10 cause of death for males in all sub-regions of sub-Saharan Africa, with the exception of the Central region, where they rank 11th. In the Western region, which has the highest road injury death rate globally, road injuries are the 5th leading cause of death among males. Overall, road injuries kill more than twice as many men in sub-Saharan Africa than interpersonal violence (ranked 14th, 67,000 deaths).

However, among female deaths, road injuries rank substantially higher in sub-Saharan Africa than globally. They are the 13th leading cause of death for females in sub-Saharan Africa overall and in the Western and Eastern regions. However, globally, road injuries are the 18th leading cause of death for females. The high relative rank of road injuries for females in sub-Saharan Africa is partly due to high female road injury death rates in the region (Figure 4.9). For instance the road injury death rate for females in Western sub-Saharan Africa (22.5 per 100,000) is more than twice the global average for females (9.6 per 100,000) and almost five times the female road injury rate in Western Europe (4.6 per 100,000). The importance of road safety as a health priority for women in sub-Saharan Africa has received relatively little policy attention.

Male Deaths

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	1	12	8	10	7	12
Stroke	2	2	2	8	7	6	6	10
COPD	3	4	3	20	17	20	11	22
Lower respiratory infections	4	5	4	3	3	3	3	2
Lung cancer	5	3	10	39	37	52	17	44
Road Injury	6	13	5	7	11	7	10	5
HIV/AIDS	7	21	6	2	5	1	1	3
Tuberculosis	8	32	7	5	6	5	2	13
Diarrheal diseases	9	56	8	4	2	4	5	4
Cirrhosis	10	8	11	15	15	14	16	14
Malaria	11	111	9	1	1	2	20	1
Diabetes	12	12	13	16	20	15	8	16
Self-harm	13	7	15	24	24	17	18	37
Liver cancer	14	17	14	26	28	34	35	20
Preterm birth complications	15	54	12	9	9	9	13	9
Stomach cancer	16	10	16	41	46	36	36	46
Hypertensive heart disease	17	19	18	36	34	42	12	50
Chronic kidney disease	18	15	21	30	33	29	14	35
Colorectal cancer	19	6	30	48	49	48	34	53
Interpersonal violence	20	29	17	14	14	16	4	21

Female Deaths

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	2	9	9	10	6	12
Stroke	2	2	1	5	6	5	2	5
Lower respiratory infections	3	3	3	3	4	2	3	2
COPD	4	5	4	24	20	25	13	27
Diarrheal diseases	5	42	5	4	2	4	5	4
Diabetes	6	11	7	14	14	15	4	15
HIV/AIDS	7	33	6	1	5	1	1	3
Malaria	8	119	8	2	1	3	18	1
Hypertensive heart disease	9	10	11	17	18	18	8	24
Lung cancer	10	7	14	53	48	54	28	68
Breast cancer	11	6	19	25	31	24	17	35
Tuberculosis	12	55	9	8	7	7	7	11
Preterm birth complications	13	59	10	11	10	9	12	10
Chronic kidney disease	14	12	15	23	25	23	15	17
Other cardio & circulatory	15	9	22	28	26	28	16	33
Colorectal cancer	16	8	29	47	49	42	33	54
Cirrhosis	17	13	18	20	23	19	23	21
Road Injury	18	22	13	13	17	13	21	13
Alzheimer's disease	19	4	41	64	68	66	37	63
Protein-energy malnutrition	20	60	12	6	3	6	34	6

1-10 | 11-20 | 21-30 | 31-50 | 51-90 | 91+

Figure 4.8 Ranking of cause of death for males and females in sub-Saharan African regions in 2010
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

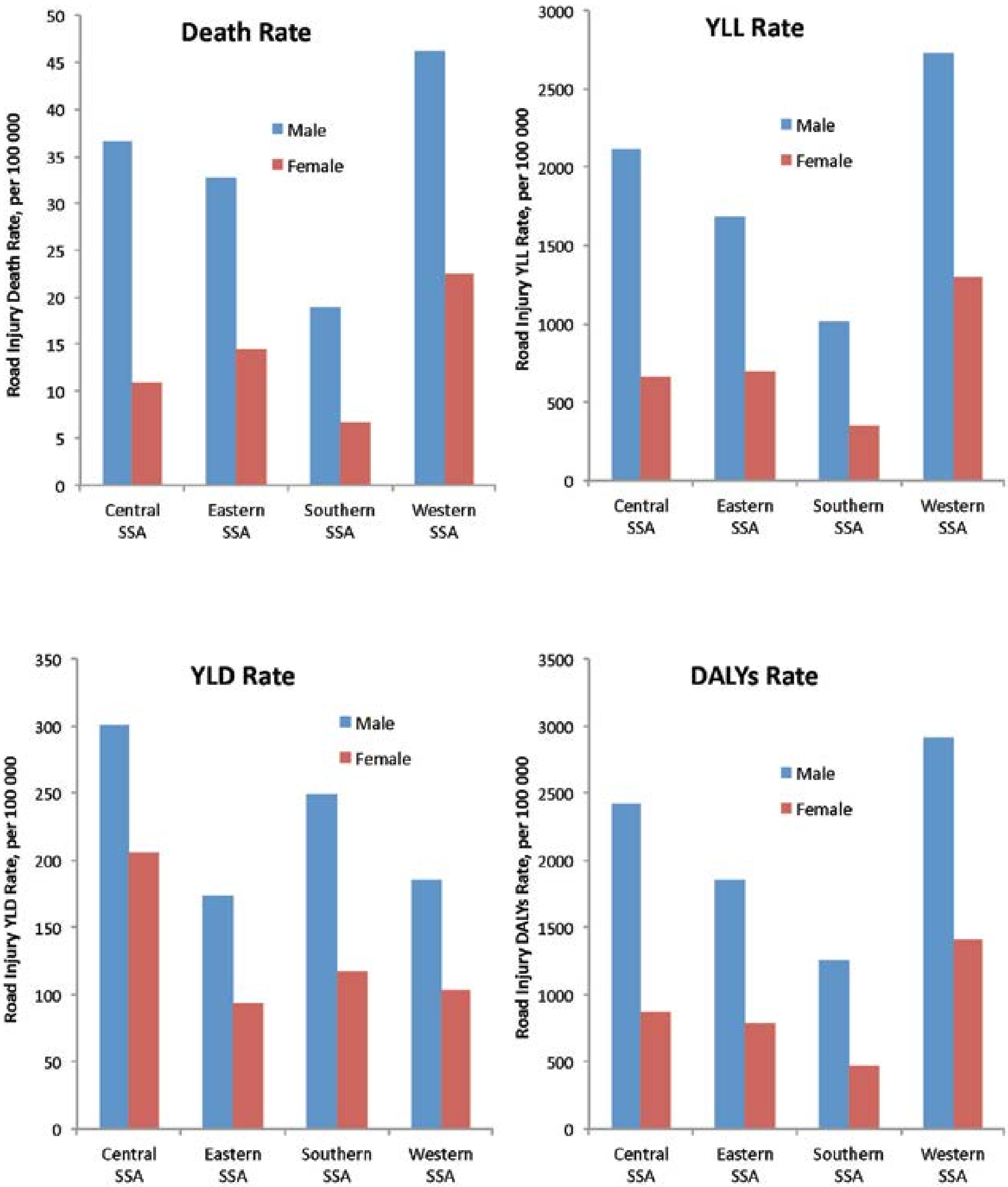


Figure 4.9 Rate of deaths, premature mortality, years lived with disability, and healthy life years lost among men and women in sub-Saharan African regions in 2010

See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

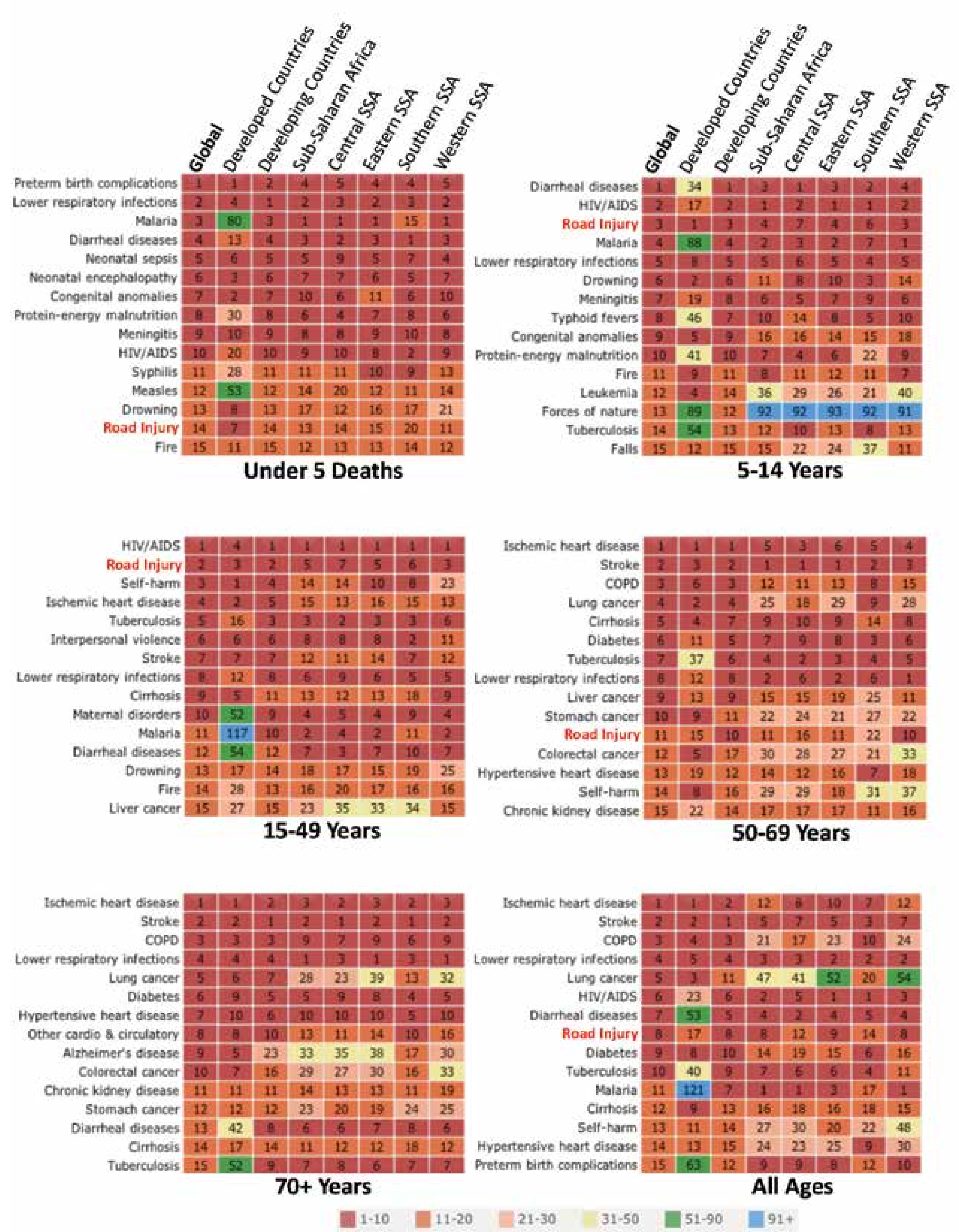
Figure 4.9 illustrates the relative risk of male and female deaths and disability from road injuries in the regions of sub-Saharan Africa. The ratio of male to female deaths varies from 2.0 in the Western region to 3.4 in the Central region, compared with 3.0 globally. The ratio of premature mortality, YLLs, varies similarly from 2.1 in the Western region to 3.2 in the Central region. In contrast, the male-female difference is comparatively smaller for years lived with disability, varying from 1.5 in the Central region to 2.1 in the Southern region. Finally, the ratio of male to female healthy life years lost, DALYs, varies from 2.1 in the Western region to 2.8 in the Central region.

Relative burden of road injuries by age group

Road injuries are widely recognized to be a leading health problem for young adults worldwide. Among children aged 5-14 years, road injuries are the 3rd leading cause of death globally, the 4th leading cause in sub-Saharan Africa, and a top 10 cause in all its sub-regions (Figure 4.10). Among adults aged 15-49 years, road injuries are the 2nd leading cause of death globally, the 5th leading cause in sub-Saharan Africa, and a top-10 cause in all its sub-regions. Among older adults aged 50-69 years, road injuries rank comparatively lower, ranking 11th globally as well as in sub-Saharan Africa.

Figure 4.10 also demonstrates the importance of road injuries as a health issue for young children. Road injuries are the 14th leading cause of death among children under 5 years globally, 13th leading cause in sub-Saharan Africa, and a top-20 cause in all of its sub regions. In fact, road injuries emerge as a leading cause after the first year of life in sub-Saharan Africa. Road injuries are the 8th leading cause of deaths among children 1-4 years old in sub-Saharan Africa, ranking as high as 6th in the Western region. Similarly, road injuries are the 9th leading cause of healthy life years lost among children in sub-Saharan Africa. Although improving the health of children is a priority for international development efforts and one of the United Nations Millennium Development Goals, road safety has largely been ignored in the global child health agenda.

Road injuries are not usually considered a leading health issue for the elderly because they rank low in rankings of causes in most global regions. They do not appear in the top 20 global causes listed in Figure 4.10 for adults aged 70+ years. However, this is because Figure 4.10 shows causes sorted by their global ranking. Figure 4.11 shows causes for death and DALYs sorted by their ranking in sub-Saharan Africa for this age group. Remarkably, road injuries are the 12th leading cause of death among the elderly in sub-Saharan Africa, compared with 26th globally. Similarly, they are the 14th leading cause of DALYs among the elderly in sub-Saharan Africa, compared with 23rd globally. The importance of road safety for the health of the elderly in sub-Saharan Africa has not been acknowledged in the past.



Under 5 Deaths

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Preterm birth complications	1	1	2	4	5	4	4	5
Lower respiratory infections	2	4	1	2	3	2	3	2
Malaria	3	80	3	1	1	1	15	1
Diarrheal diseases	4	13	4	3	2	3	1	3
Neonatal sepsis	5	6	5	5	9	5	7	4
Neonatal encephalopathy	6	3	6	7	7	6	5	7
Congenital anomalies	7	2	7	10	6	11	6	10
Protein-energy malnutrition	8	30	8	6	4	7	8	6
Meningitis	9	10	9	8	8	9	10	8
HIV/AIDS	10	20	10	9	10	8	2	9
Syphilis	11	28	11	11	11	10	9	13
Measles	12	53	12	14	20	12	11	14
Drowning	13	8	13	17	12	16	17	21
Road Injury	14	7	14	13	14	15	20	11
Fire	15	11	15	12	13	13	14	12

5-14 Years

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Diarrheal diseases	1	34	1	3	1	3	2	4
HIV/AIDS	2	17	2	1	2	1	1	2
Road Injury	3	1	3	4	7	4	6	3
Malaria	4	88	4	2	3	2	7	1
Lower respiratory infections	5	8	5	5	6	5	4	5
Drowning	6	2	6	11	8	10	3	14
Meningitis	7	19	8	6	5	7	9	6
Typhoid fevers	8	46	7	10	14	8	5	10
Congenital anomalies	9	5	9	16	16	14	15	18
Protein-energy malnutrition	10	41	10	7	4	6	22	9
Fire	11	9	11	8	11	12	11	7
Leukemia	12	4	14	36	29	26	21	40
Forces of nature	13	89	12	92	92	93	92	91
Tuberculosis	14	54	13	12	10	13	8	13
Falls	15	12	15	15	22	24	37	11

15-49 Years

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
HIV/AIDS	1	4	1	1	1	1	1	1
Road Injury	2	3	2	5	7	5	6	3
Self-harm	3	1	4	14	14	10	8	23
Ischemic heart disease	4	2	5	15	13	16	15	13
Tuberculosis	5	16	3	3	2	3	3	6
Interpersonal violence	6	6	6	8	8	8	2	11
Stroke	7	7	7	12	11	14	7	12
Lower respiratory infections	8	12	8	6	9	6	5	5
Cirrhosis	9	5	11	13	12	13	18	9
Maternal disorders	10	52	9	4	5	4	9	4
Malaria	11	117	10	2	4	2	11	2
Diarrheal diseases	12	54	12	7	3	7	10	7
Drowning	13	17	14	18	17	15	19	25
Fire	14	28	13	16	20	17	16	16
Liver cancer	15	27	15	23	35	33	34	15

50-69 Years

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	1	5	3	6	5	4
Stroke	2	3	2	1	1	1	2	3
COPD	3	6	3	12	11	13	8	15
Lung cancer	4	2	4	25	18	29	9	28
Cirrhosis	5	4	7	9	10	9	14	8
Diabetes	6	11	5	7	9	8	3	6
Tuberculosis	7	37	6	4	2	3	4	5
Lower respiratory infections	8	12	8	2	6	2	6	1
Liver cancer	9	13	9	15	15	19	25	11
Stomach cancer	10	9	11	22	24	21	27	22
Road Injury	11	15	10	11	16	11	22	10
Colorectal cancer	12	5	17	30	28	27	21	33
Hypertensive heart disease	13	19	12	14	12	16	7	18
Self-harm	14	8	16	29	29	18	31	37
Chronic kidney disease	15	22	14	17	17	17	11	16

70+ Years

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	2	3	2	3	2	3
Stroke	2	2	1	2	1	2	1	2
COPD	3	3	3	9	7	9	6	9
Lower respiratory infections	4	4	4	1	3	1	3	1
Lung cancer	5	6	7	28	23	39	13	32
Diabetes	6	9	5	5	9	8	4	5
Hypertensive heart disease	7	10	6	10	10	10	5	10
Other cardio & circulatory	8	8	10	13	11	14	10	16
Alzheimer's disease	9	5	23	33	35	38	17	30
Colorectal cancer	10	7	16	29	27	30	16	33
Chronic kidney disease	11	11	11	14	13	13	11	19
Stomach cancer	12	12	12	23	20	19	24	25
Diarrheal diseases	13	42	8	6	6	7	8	6
Cirrhosis	14	17	14	11	12	12	18	12
Tuberculosis	15	52	9	7	8	6	7	7

All Ages

	Global	Developed Countries	Developing Countries	Sub-Saharan Africa	Central SSA	Eastern SSA	Southern SSA	Western SSA
Ischemic heart disease	1	1	2	12	8	10	7	12
Stroke	2	2	1	5	7	5	3	7
COPD	3	4	3	21	17	23	10	24
Lower respiratory infections	4	5	4	3	3	2	2	2
Lung cancer	5	3	11	47	41	52	20	54
HIV/AIDS	6	23	6	2	5	1	1	3
Diarrheal diseases	7	53	5	4	2	4	5	4
Road Injury	8	17	8	8	12	9	14	8
Diabetes	9	8	10	14	19	15	6	16
Tuberculosis	10	40	9	7	6	6	4	11
Malaria	11	121	7	1	1	3	17	1
Cirrhosis	12	9	13	16	18	16	18	15
Self-harm	13	11	14	27	30	20	22	48
Hypertensive heart disease	14	13	15	24	23	25	9	30
Preterm birth complications	15	63	12	9	9	8	12	10

Figure 4.10 Rankings of cause of death by age group in sub-Saharan African regions in 2010
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

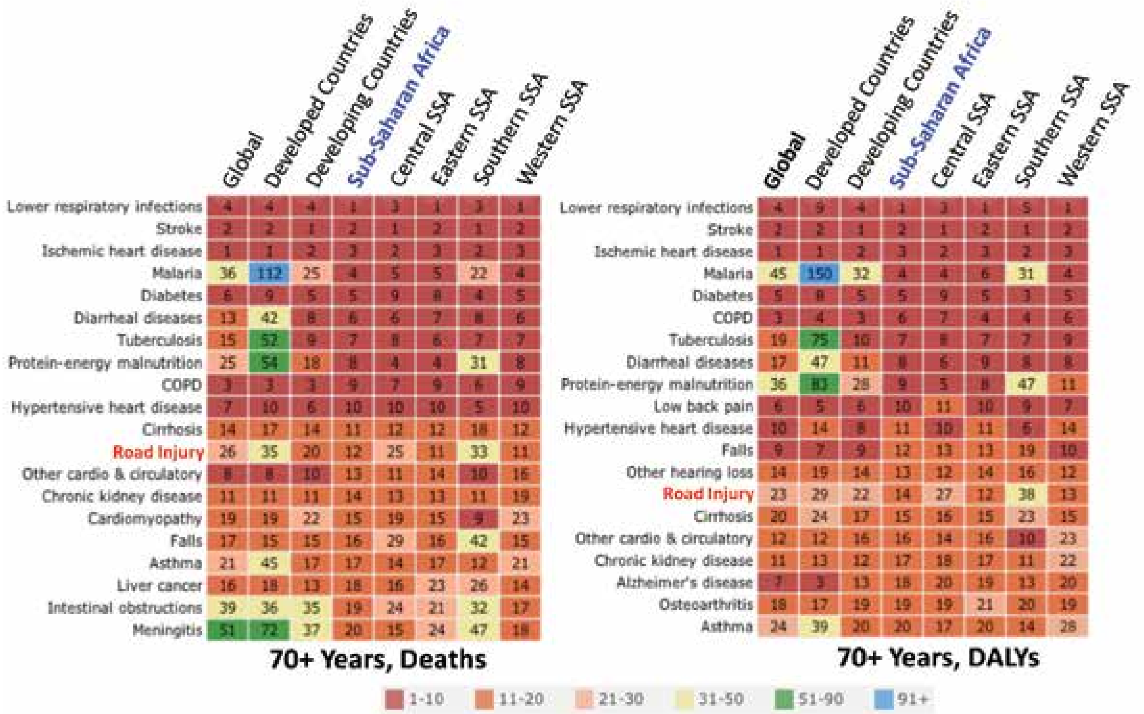
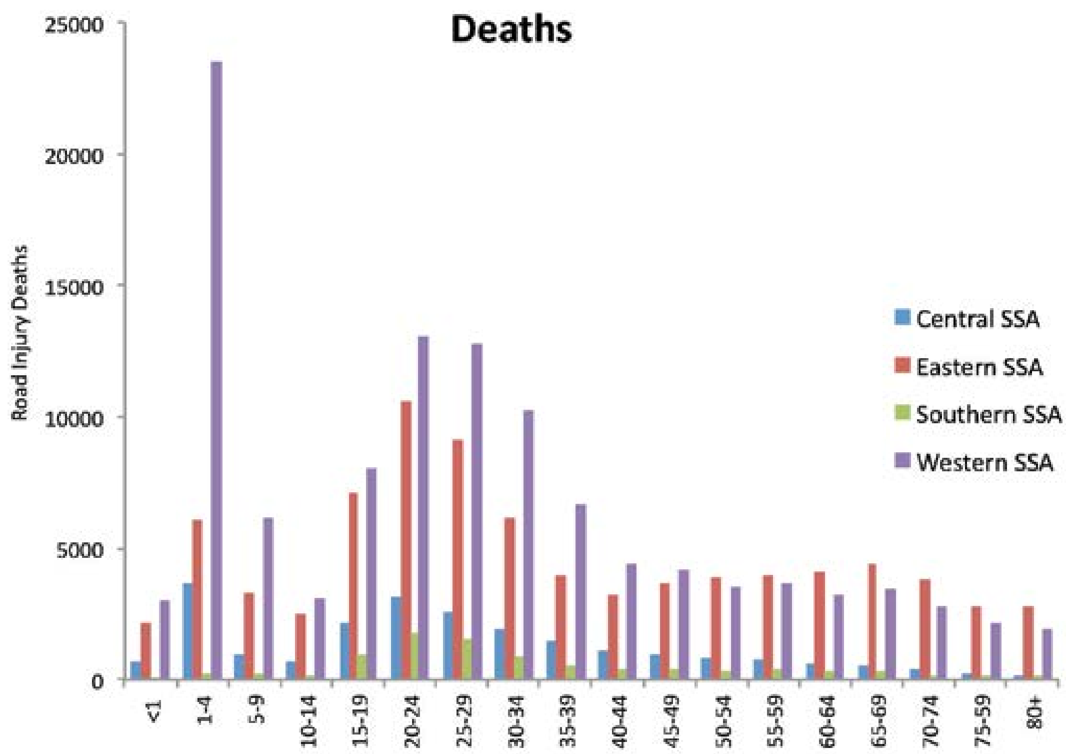


Figure 4.11 Leading causes of death and healthy life years lost among the elderly (70+ years) in sub-Saharan Africa regions
Unlike previous figures, causes in this heat map are sorted by their ranking in sub-Saharan Africa rather than by their global ranking.

Figures 4.12 through 4.15 illustrate the age distribution of the incidence and rate of deaths, YLLs, YLDs and DALYs in the sub-Saharan African regions. Broadly, the age profile of deaths and YLLs (Figure 4.12-13) is typical of the road injury burden globally. Road injury death counts in most regions have an age distribution that peaks among young adults and then declines with age. Death rates rise with age during the first two decades of life, then decline, and rise again with age. However, Figures 4.12-13 show one notable difference from the expected age profile. Road injury mortality rates among children aged 1-4 years are substantially higher in the Western region than expected. Deaths are highest in this age group and the death rate exceeds that for young adults. The high death toll explains the relatively high ranking of road injuries in the cause rankings for children in Western sub-Saharan Africa (Figure 4.10). Road injuries are the 6th leading cause among 1-4 year olds in the region, compared with 9th globally.

Figure 4.14 shows that the incidence and rate of disability from non-fatal injuries has a unimodal pattern that peaks among adults before declining with age. However, YLDs contribute a relatively small proportion to the total healthy life lost. As a result the age profile of DALYs (Figure 14) broadly resembles the age profile of YLLs (Figure 15).



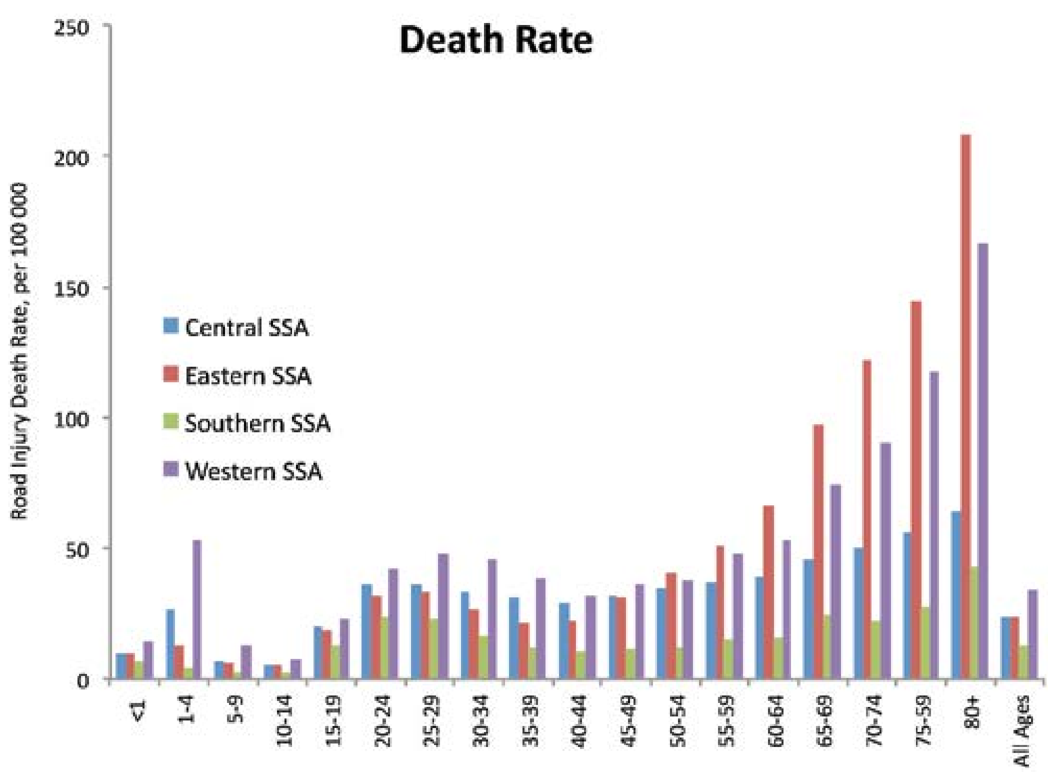


Figure 4.12 Age distribution of deaths and death rate in sub-Saharan African regions in 2010

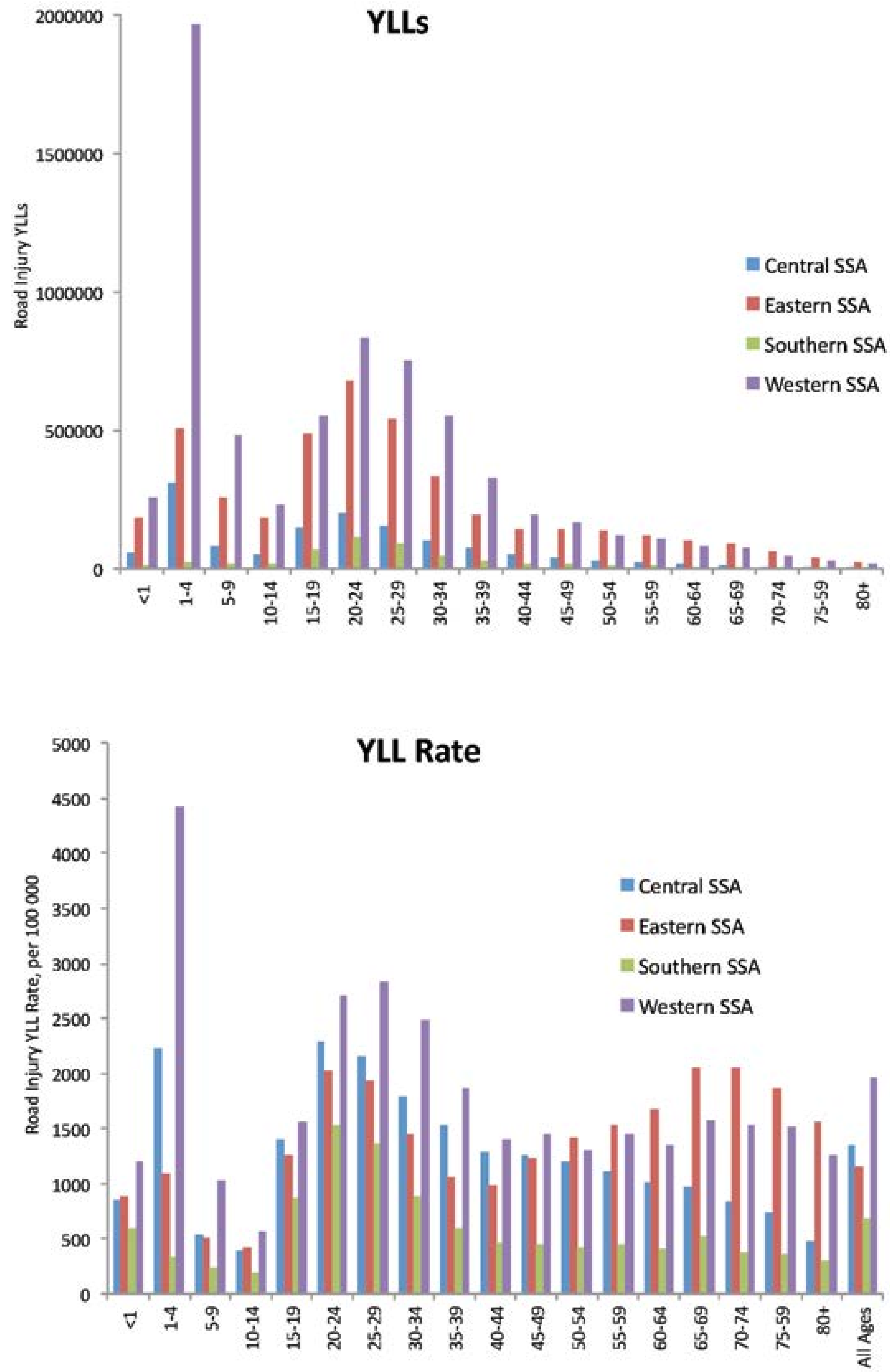
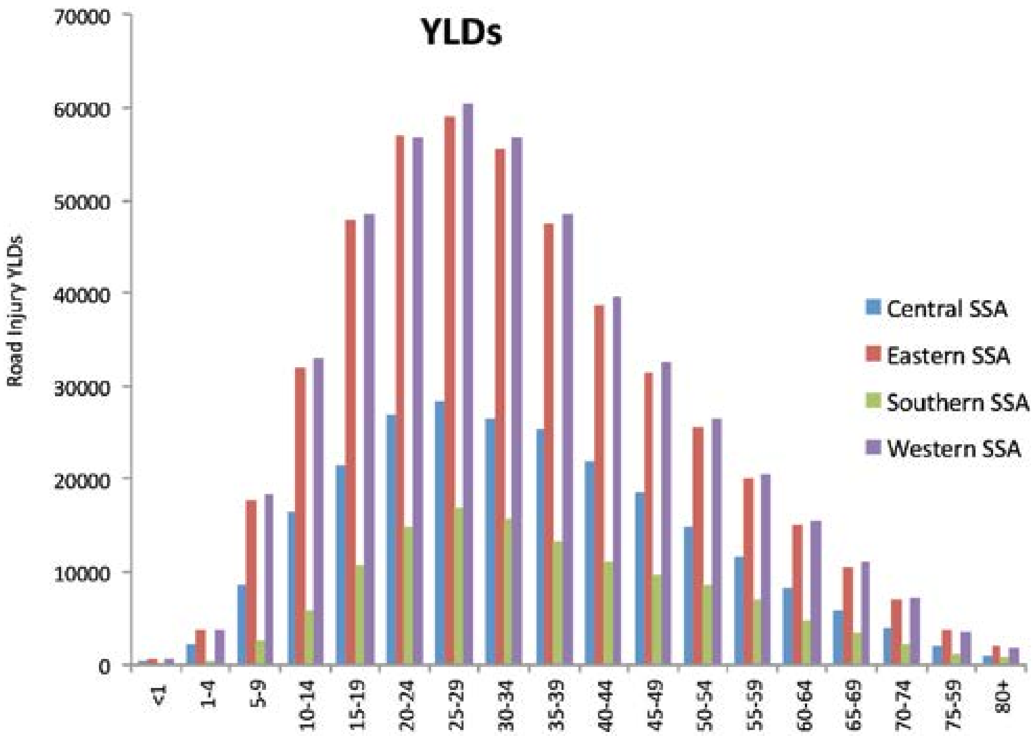


Figure 4.13 Age distribution of premature mortality and premature mortality rate in sub-Saharan African regions in 2010



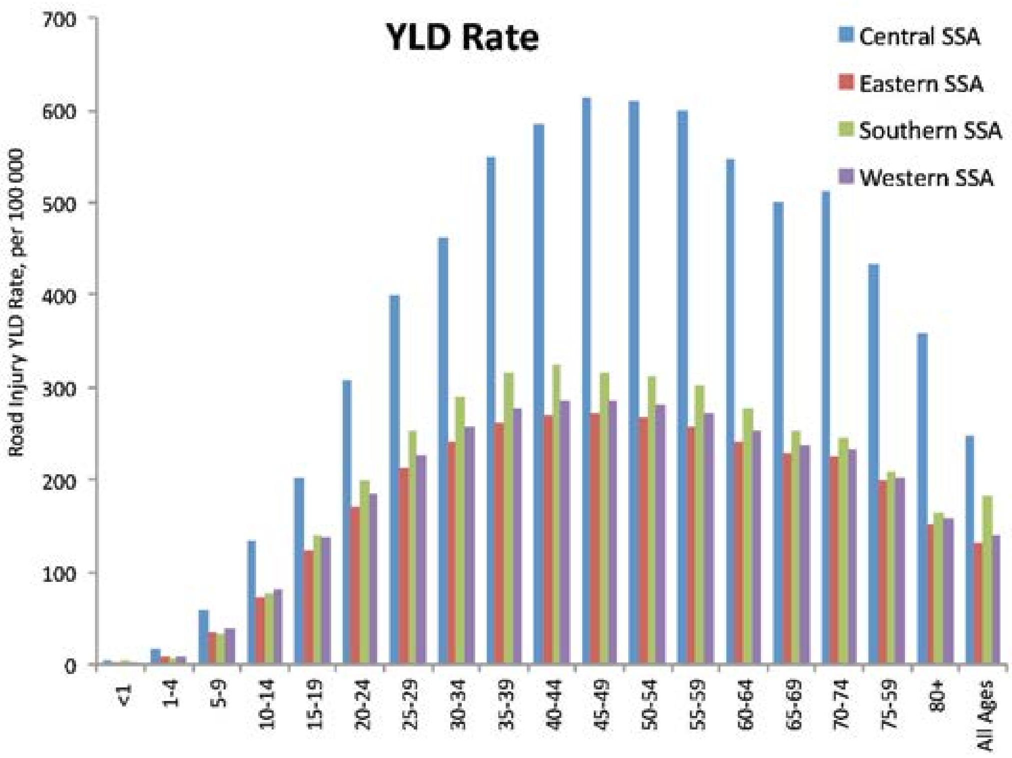
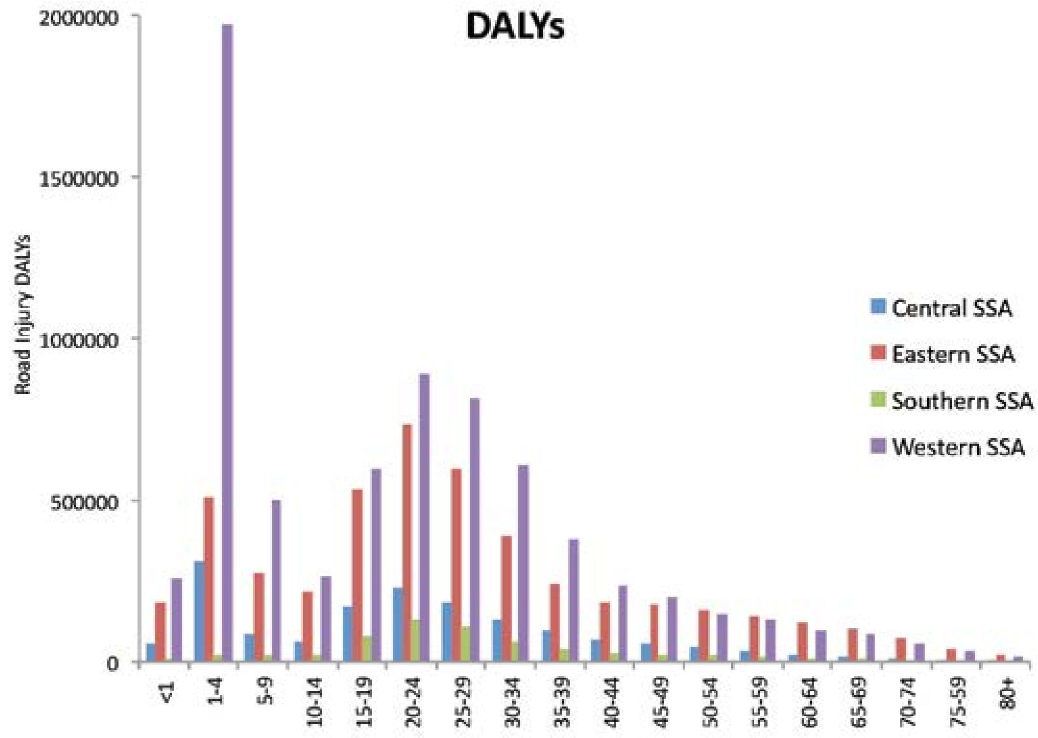


Figure 4.14 Age distribution of YLDs and YLD rate in sub-Saharan African regions in 2010
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.



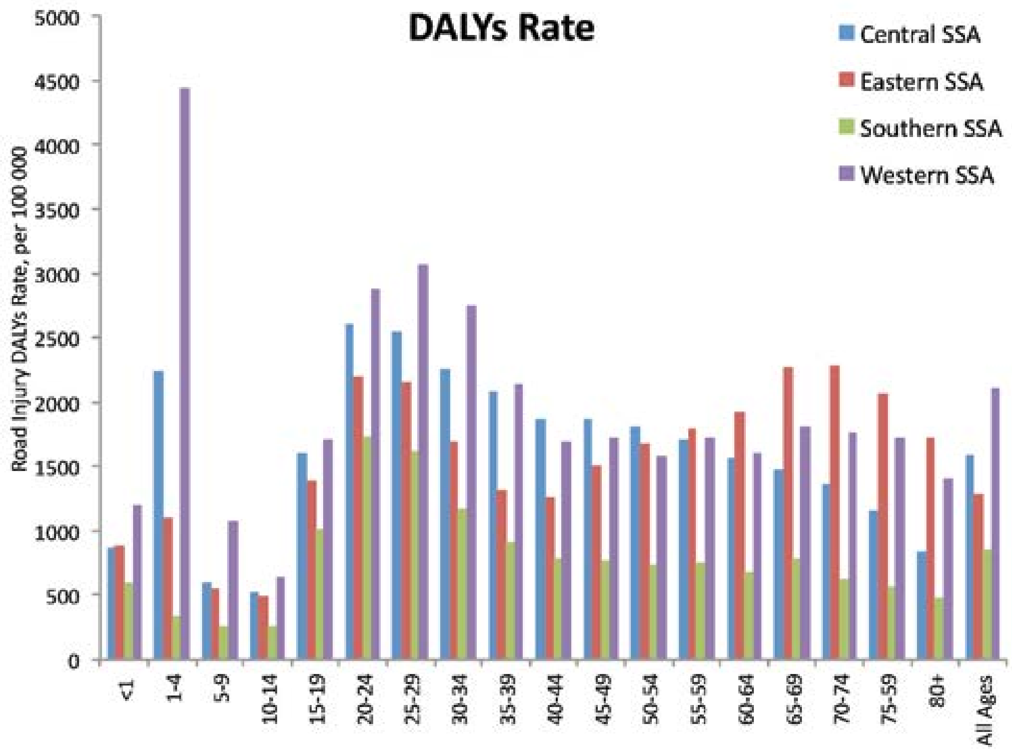


Figure 4.15 Age distribution of DALYs and DALYs rate in sub-Saharan African regions in 2010
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

Distribution of road injuries by type of road-user

Figures 4.16-4.18 illustrates the distribution of road injury deaths and burden by the victim's mode of transport. The pedestrian death rate in Western sub-Saharan Africa, 13.4 per 100,000, is the highest in the world, 8 times the rate in Western Europe (Figure 4.16). The road user distribution of deaths and DALYs varies substantially across regions. However, the distribution of deaths does not differ much from that of DALYs in any given region. Pedestrians comprise 44% of road injury deaths in sub-Saharan Africa overall, 55% in the Central region, and 50% in the Eastern region (Figure 4.17). In contrast, pedestrians account for only 35% of global road deaths. Taken together with bicyclists, non-motorized road users comprise half of all victims of fatal road injuries in sub-Saharan Africa, 60% in the Eastern region, and 58% in the Central region. Non-motorized modes comprise 42% in the Western region and 40% in the Southern region, similar to the global average of 41%. As expected from the lower level of motorization in sub-Saharan Africa, occupants of cars, buses, and trucks comprise a smaller proportion of road deaths. Vehicle occupants (3+ wheels) were victims in 30% of the fatalities in sub-Saharan Africa compared with the global average of 36%. In the Central and Southern regions, the proportion of occupants was even lower at 26%. Finally, motorcycle riders comprise 17% of deaths in the Southern and Western regions. The motorcyclist death rate in Western sub-Saharan Africa is the highest in the world, slightly higher than the rate in Southeast Asia.

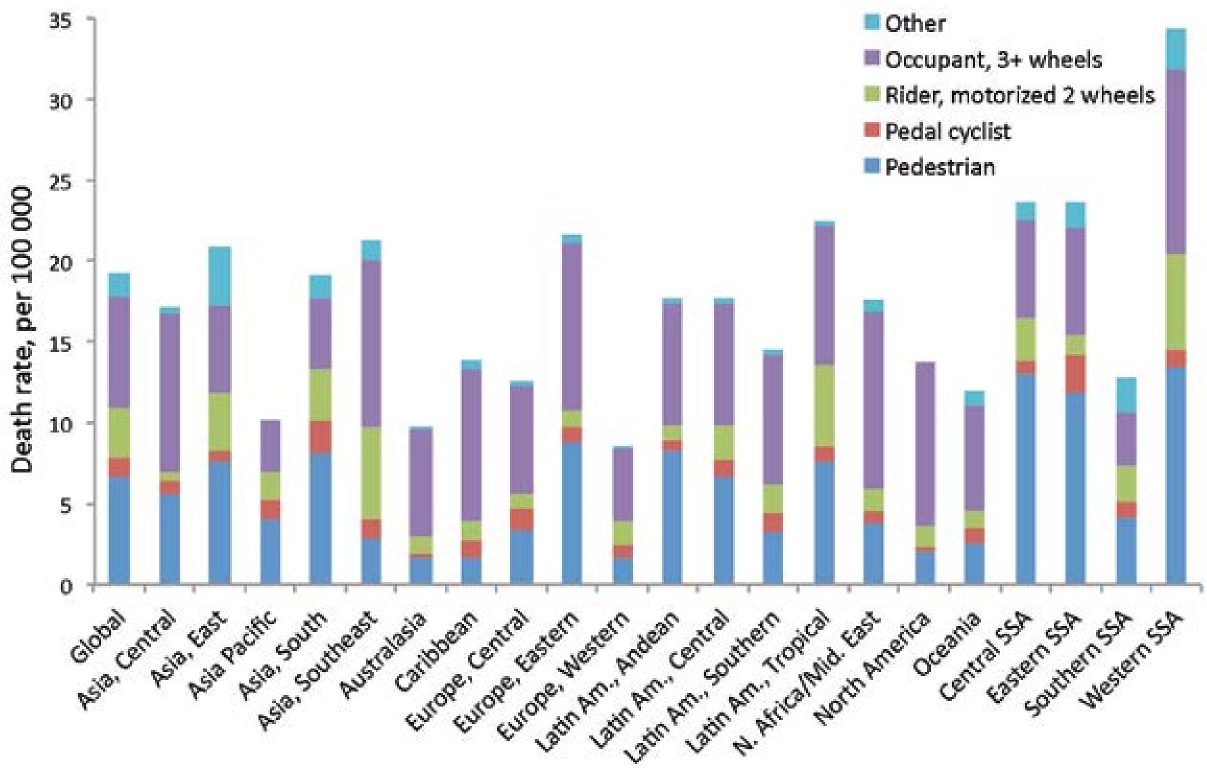


Figure 4.16 Road injury death rates in global regions in 2010 disaggregated by road-user categories
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1.

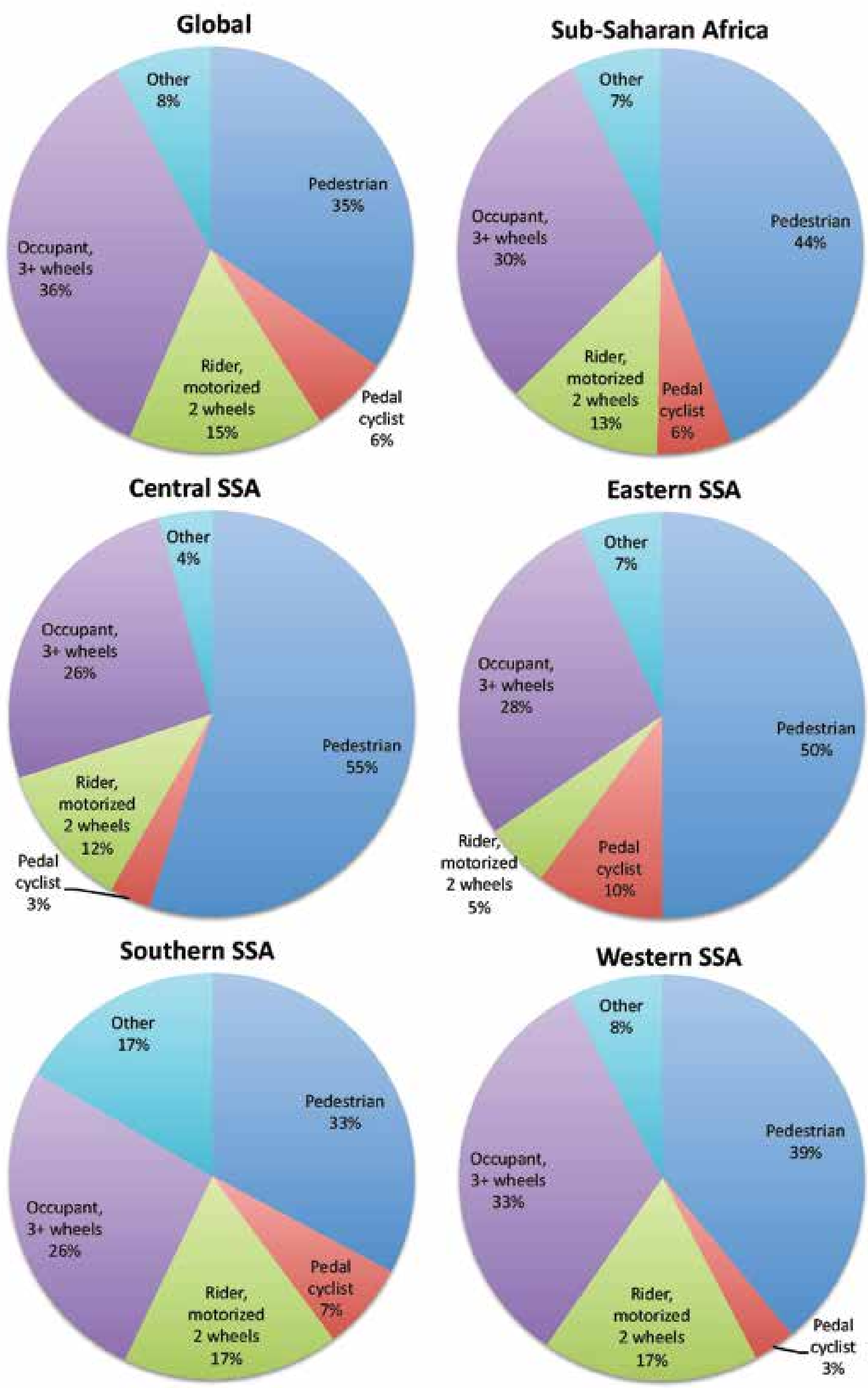


Figure 4.17 Road user distribution of road injury deaths in sub-Saharan African regions in 2010

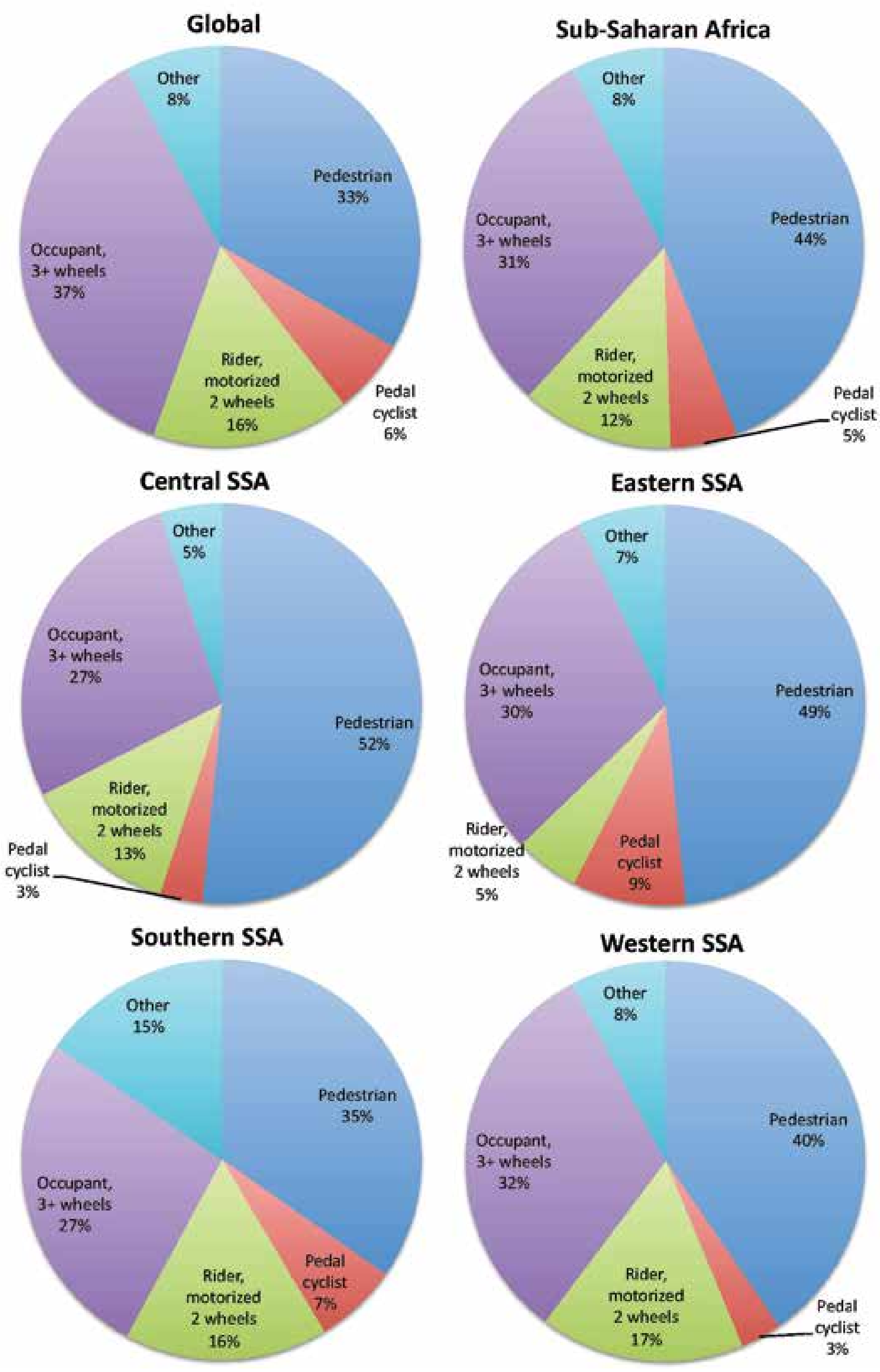


Figure 4.18 Road user distribution of road injury DALYs in sub-Saharan African regions in 2010

Country estimates of the burden of road injuries

Figures 4.19-4.20 show rankings of causes of death in countries in sub-Saharan Africa. In more than half the countries (26 of 48 countries) deaths from road injuries rank among the top 10 causes. In six countries (Botswana, Djibouti, Gabon, Mauritania, Nigeria, Zimbabwe), road injuries ranked in the top 5 causes of death.

National road injury death rates in sub-Saharan Africa are among the highest in the world (Figure 4.21). Six countries from the region are among the ten countries with the highest road injury death rates globally. These include Nigeria, which has a death rate of 52.4 per 100,000 people, the highest of any country, and Mozambique, death rate of 46.7 per 100,000, the third highest of any country. Figures 4.21 also shows the death rates among the safest countries in the world, which include Sweden, UK, and the Netherlands, whose high safety performance has been discussed extensively by road safety researchers. These countries have a death rate of approximately 3 per 100,000, 15 times smaller than that of Nigeria and Mozambique.

Four countries, Nigeria, Ethiopia, South Africa[1], and Sudan, together account for half of all road injury fatalities in sub-Saharan Africa. The importance of road safety for Nigeria, which accounts for approximately one-fifth of the population of sub-Saharan Africa, deserves particular consideration. In 2010, Nigeria had 75,000 fatalities, approximately one-third of the total for sub-Saharan Africa. Road traffic deaths in Nigeria ranked ahead of neonatal sepsis, preterm birth complications, protein-energy malnutrition, neonatal encephalopathy, and meningitis, which are among the most important causes of infant deaths. Similarly, road injury deaths in Nigeria killed more than three times as many people as maternal disorders, and almost twice as many people as tuberculosis.

The importance of road safety to the health agenda in sub-Saharan Africa has emerged in the last two decades. While road injuries are now the 8th leading cause of death in the region, they were the 13th leading cause of death in 1990. This increase in the relative rank is also evident in the country level statistics. In Nigeria, road injuries are now the 5th leading cause of death, up from 11th in 1990. In Ethiopia, they are the 9th leading cause of death, up from 13th in 1990.

1. The GBD-2010 estimates for road injury deaths in South Africa (4,500 deaths) are about one-third of the official national statistics. The GBD estimates for South Africa rely predominantly on national vital registration data. We expect that GBD-2010 underestimated road injury deaths in South Africa because of analytical problems in fitting the cause of death patterns, which are heavily biased towards deaths from HIV/AIDS. Since South Africa is the most populous country in the Southern sub-Saharan Africa and the predominant source of cause of death data in this region, we expect that the road injury deaths for the entire Southern region are underestimated in GBD-2010. In this report, whenever we present national estimates of road injury deaths and death rates for South Africa, we use the official national statistics. However, all regional estimates shown, including for the Southern region are from GBD-2010. See also note about sub-Saharan Africa South estimates accompanying Table 4.1.

	Angola	Central African Republic	Congo	Democratic Republic of the Congo	Equatorial Guinea	Gabon	Central Sub-Saharan Africa
Malaria	2	3	2	1	2	2	1
Diarrheal diseases	1	2	5	2	4	7	2
Lower respiratory infections	3	4	3	4	3	3	3
Protein-energy malnutrition	5	5	8	3	7	8	4
HIV/AIDS	4	1	1	5	1	1	5
Tuberculosis	9	6	9	6	15	13	6
Stroke	6	7	4	7	9	4	7
Ischemic heart disease	8	8	6	9	8	6	8
Preterm birth complications	10	13	10	8	10	11	9
Meningitis	11	10	12	10	11	16	10
Congenital anomalies	12	14	11	11	5	14	11
Road Injury	7	11	7	16	6	5	12
Neonatal encephalopathy	15	19	17	12	13	19	13
Maternal disorders	13	9	16	15	12	15	14
Neonatal sepsis	19	23	20	14	21	23	15
Interpersonal violence	31	21	19	13	19	17	16
COPD	16	12	13	18	14	10	17
Cirrhosis	18	16	15	17	18	9	18
Diabetes	17	18	14	19	17	12	19
Syphilis	14	15	42	21	16	38	20

Central SSA

1-10 | 11-20 | 21-30 | 31-50 | 51-90 | 91+

	Burundi	Comoros	Djibouti	Eritrea	Ethiopia	Kenya	Madagascar	Malawi	Mauritius	Mozambique	Rwanda	Seychelles	Somalia	Sudan	Tanzania	Uganda	Zambia	Eastern Sub-Saharan Africa
HIV/AIDS	2	118	1	7	8	1	8	1	5	1	3	14	6	3	1	1	1	1
Lower respiratory infections	4	1	2	1	1	2	3	2	6	3	2	2	1	1	3	3	3	2
Malaria	1	2	11	3	3	3	2	3	121	2	1	120	2	4	2	2	2	3
Diarrheal diseases	5	4	5	2	2	4	4	4	43	5	6	20	3	2	4	7	6	4
Stroke	6	3	3	5	6	6	1	5	3	6	4	3	7	5	7	6	5	5
Tuberculosis	3	5	9	4	4	7	9	6	57	4	5	48	5	12	5	4	8	6
Protein-energy malnutrition	7	8	7	6	5	5	6	7	30	12	11	33	4	7	6	12	4	7
Preterm birth complications	12	6	8	12	7	9	7	13	18	9	7	30	10	8	9	9	15	8
Road Injury	9	7	4	11	9	10	12	9	12	7	9	8	12	6	10	11	12	9
Ischemic heart disease	8	9	6	8	11	12	5	8	1	15	8	1	11	9	13	13	9	10
Meningitis	11	15	10	10	10	11	18	15	53	10	14	23	8	10	22	5	7	11
Neonatal sepsis	13	10	15	13	13	8	11	10	62	8	10	68	14	11	12	10	14	12
Neonatal encephalopathy	15	11	14	14	18	13	15	12	48	11	12	53	15	13	8	8	10	13
Maternal disorders	10	14	13	9	14	14	13	11	77	14	19	67	9	14	11	16	22	14
Diabetes	14	13	12	15	15	15	14	17	2	16	15	9	16	15	15	17	16	15
Cirrhosis	16	23	16	18	12	19	17	16	8	20	16	6	18	20	18	14	17	16
Syphilis	37	12	63	29	26	22	10	27	99	13	21	82	36	21	14	15	11	17
Fire	17	18	19	17	20	20	25	18	32	21	18	31	17	22	17	19	18	18
Epilepsy	19	17	17	16	21	18	23	21	42	18	17	29	19	19	20	22	19	19
Self-harm	18	21	21	21	22	17	27	19	16	17	22	11	24	16	16	23	23	20

Eastern SSA

Figure 4.19 Rankings of cause of death in countries in Central and Eastern sub-Saharan Africa in 2010

	Botswana	Lesotho	Namibia	South Africa	Swaziland	Zimbabwe	Southern Sub-Saharan Africa
HIV/AIDS	1	1	1	1	1	1	1
Lower respiratory infections	9	2	3	5	2	2	2
Stroke	2	6	2	2	4	5	3
Tuberculosis	3	5	5	4	5	3	4
Diarrheal diseases	6	4	4	7	3	4	5
Diabetes	7	7	7	3	7	13	6
Ischemic heart disease	4	8	6	8	8	7	7
Interpersonal violence	5	3	8	6	6	17	8
Hypertensive heart disease	10	12	9	9	10	8	9
COPD	24	9	10	12	9	11	10
Mechanical forces	11	11	12	10	11	30	11
Preterm birth complications	13	10	13	14	14	12	12
Chronic kidney disease	20	19	22	11	21	18	13
Road Injury	8	21	16	17	13	10	14
Cardiomyopathy	15	17	14	13	16	22	15
Other cardio & circulatory	14	18	15	15	19	19	16
Malaria	16	122	11	65	15	6	17
Cirrhosis	18	24	27	22	12	14	18
Neonatal encephalopathy	21	15	19	18	23	23	19
Lung cancer	23	26	20	16	28	32	20

Southern SSA

1-10 | 11-20 | 21-30 | 31-50 | 51-90 | 91+

	Benin	Burkina Faso	Cameroon	Cape Verde	Chad	Cote d'Ivoire	The Gambia	Ghana	Guinea	Guinea-Bissau	Liberia	Mali	Mauritania	Niger	Nigeria	Sao Tome and Principe	Senegal	Sierra Leone	Togo	Western Sub-Saharan Africa
Malaria	1	1	2	123	3	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1
Lower respiratory infections	2	2	3	3	2	2	2	2	2	2	3	2	1	3	2	3	2	2	2	2
HIV/AIDS	6	5	1	4	4	3	3	3	7	6	4	8	9	10	3	4	9	6	3	3
Diarrheal diseases	4	3	4	8	1	4	5	11	3	3	2	3	2	1	4	6	3	5	4	4
Protein-energy malnutrition	10	6	11	22	5	9	11	7	6	7	6	4	11	4	7	8	21	3	7	5
Neonatal sepsis	9	10	9	14	7	10	6	6	10	11	7	5	6	7	6	7	4	12	9	6
Stroke	3	8	5	1	8	5	4	4	4	5	8	9	4	8	10	2	8	7	5	7
Road Injury	13	7	6	6	11	8	9	8	14	12	16	13	5	15	5	12	24	13	12	8
Meningitis	5	4	8	21	6	7	7	9	5	4	9	7	10	5	9	17	6	9	8	9
Preterm birth complications	8	9	10	19	9	11	6	10	11	10	10	6	7	9	8	9	7	4	11	10
Tuberculosis	11	12	12	13	10	12	13	13	12	9	5	11	13	6	11	16	5	8	10	11
Ischemic heart disease	7	11	7	2	12	6	10	5	8	8	13	12	8	11	13	5	10	11	6	12
Neonatal encephalopathy	12	14	15	34	13	14	14	14	9	13	12	10	14	13	12	11	12	10	13	13
Maternal disorders	15	19	16	61	15	16	15	16	13	14	11	14	12	12	15	27	13	14	18	14
Cirrhosis	16	15	14	20	17	13	19	12	17	17	18	21	16	23	17	15	16	16	15	15
Diabetes	14	16	13	7	19	15	17	15	16	15	17	17	15	21	16	13	11	17	14	16
Fire	21	18	22	30	21	22	23	36	21	22	21	19	23	18	14	28	30	24	23	17
Epilepsy	17	17	17	10	22	18	18	17	19	18	20	16	17	17	20	18	14	18	17	18
Congenital anomalies	18	13	18	35	18	17	16	21	18	16	19	27	18	19	21	14	23	20	16	19
Falls	20	20	19	16	24	19	21	24	24	20	24	25	22	24	18	20	18	21	21	20

Western SSA

Figure 4.20 Rankings of cause of death in countries in Southern and Western sub-Saharan Africa in 2010
See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1 and footnote on Page 72.

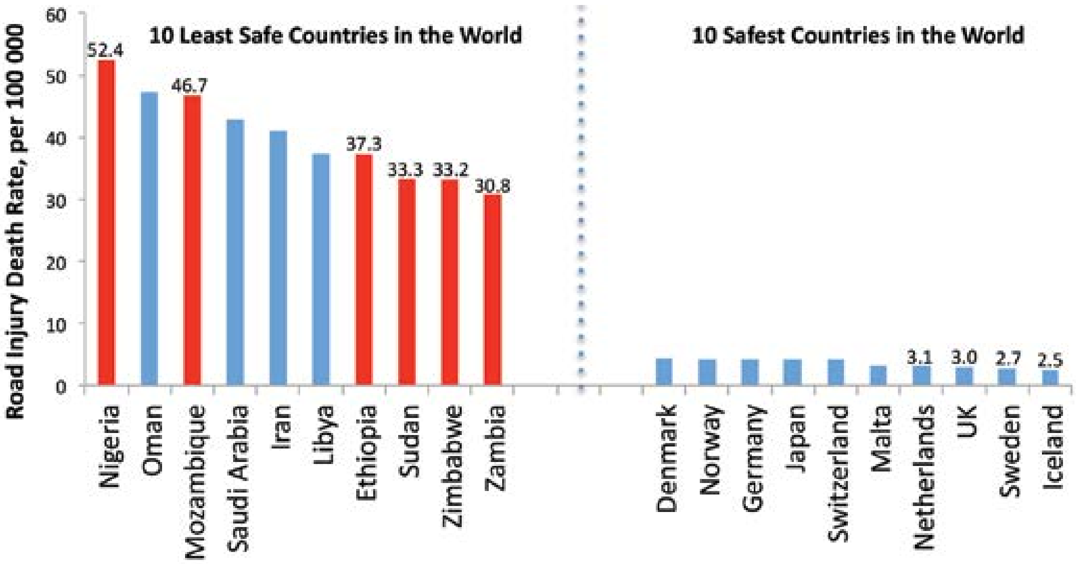


Figure 4.21 Safest and most dangerous countries in the world in 2010

Note: Only countries with at least three local measurements of road traffic injury incidence were included in this figure. A few countries (such as Angola, Equatorial Guinea, and Gabon) have higher estimates but were excluded from this figure because of insufficient data. Estimates shown are from GBD-2010 except for countries that report to the International Road Traffic Accident Database (IRTAD).

Our estimates of the national road injury deaths in sub-Saharan Africa are substantially higher than official government statistics (Figure 4.22). Underreporting in many countries in sub-Saharan Africa exceeds 500%. In Nigeria, for instance, official government statistics only reported 4,065 deaths in 2010. The official statistics for Nigeria correspond to a death rate of 2.5 per 100,000, which is the same as that of Iceland, the safest country in the world (Figure 4.21). Since the national Federal Road Safety Corps (FRSC) only reports deaths that occur within 24 hours of the crash, the 2013 WHO Global Status Report on Road Safety corrected this estimate to 5,279 deaths to account for deaths that occur after this period. However, even this figure is 14 times smaller than our estimate of 75,000 deaths.

Underreporting of road deaths is getting increase attention in global road safety efforts. However, much of this work focuses on standardizing definitions, such as counting all deaths that occur within 30 days of a crash. However, our results highlight that definitions account for a small fraction of the deaths that are missed in official statistics. Instead, it is likely that most countries in sub-Saharan Africa simply do not have the capacity to know about most crashes.

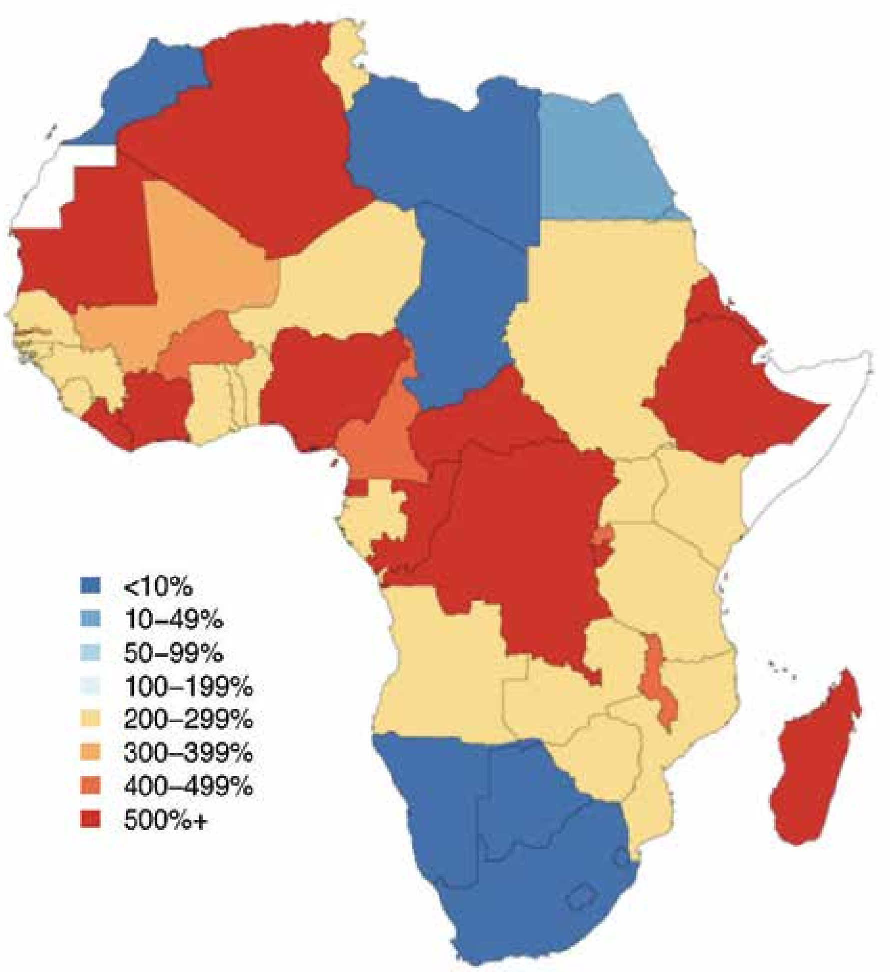


Figure 4.22 Underreporting of deaths from road injuries in official government statistics in sub-Saharan Africa in 2010

- *Percent underreporting is calculated as 100*(Our estimate-official statistics)/(official statistics).*
- *Official statistics are the 30-day adjusted country reported statistics from the 2013 World Health Organization's Global Status Report on Road Safety.*
- *See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1 and footnote on Page 72.*

Chapter 5: Discussion

Results from the GBD project are the only systematic and scientific accounting of the health impact of road crashes relative to other diseases and health risk factors in sub-Saharan Africa and globally. Our current update, GBD-2010, represents a dramatic improvement over past work in road injury metrics. Several other studies (e.g. Jacobs et al., 2000, Kopits & Cropper, 2005, WHO, 2009a, WHO, 2013) have attempted to estimate the global and regional incidence of deaths from road injuries in isolation from other diseases. Such work is problematic for various reasons. First, one important purpose of such analysis is to highlight the magnitude of the problem of road safety and, hence, to bring attention to it. However, in a world where we grapple with many hazards to our health, the incidence of road injuries needs to be described relative to other health threats as discussed in this report.

Second, other studies often rely primarily on national official statistics of road traffic deaths reported by traffic police. We show that police reports in sub-Saharan African countries often have underreporting that exceeds 500%. More recent studies recognize the problem of underreporting in police data and thus have also attempted to construct estimates using national vital registration statistics. The 2009 and 2013 WHO Global Status Reports are two notable examples of such work. However, since high quality vital registers do not exist in sub-Saharan Africa, these studies have few data sources from the region, relying instead on statistical models to estimate deaths for most countries in the region. In contrast, our work uncovered and incorporated vast amounts of information that have not been used previously in constructing estimates of the burden of road injuries. This required the development of many new tools for analysis that we have described in this report.

Finally, past work has made meager, if any, attempts to estimate the incidence of non-fatal road injuries. This is primarily because such estimations require substantial efforts in acquiring data sources that are difficult to access, and developing analytical models to construct meaningful estimates. Our work is the first attempt at producing estimates of non-fatal injury incidence in sub-Saharan Africa and globally.

Implications for road safety policy in sub-Saharan Africa

The UN Decade of Action for Road Safety calls for a transition to a decade of investments in safer road systems in low- and middle- income countries. Our analysis supports this call by providing evidence of the importance of road safety to population health, which is arguably the most pressing developmental issue for sub-Saharan Africa.

We show that road injury has risen substantially in the health priorities for sub-Saharan Africa over the last two decades and now ranks within the top 10 causes of death and ill health. The current ranking of road injuries in Sub-Saharan African countries is similar to those for other developing countries, which have already begun to prioritize road safety in their development agenda through increased political attention and financial commitments. This is not the case yet in sub-Saharan Africa. Instead, the health agenda in sub-Saharan Africa remains focused primarily on infectious diseases, maternal health, and childhood diseases. However, our findings show that more people die in road crashes in Africa than from tuberculosis and maternal disorders. Among children, road injuries rank in the top 10 causes of death after the first year of life.

In fact, we show that road injury death rates in sub-Saharan Africa are amongst the highest in the world. Six countries from the region rank among the ten least safe countries in the world. Three regions of sub-Saharan Africa (Western, Eastern and Central) have the highest death rates of any regions in the world. In two regions (Western and Southern), the road death toll has more than doubled since 1990.

The UN Decade of Action aims to reverse this trend by focusing on five pillars of safety – road safety management, safer roads and mobility, safer vehicles, safer road users, and post-crash response. The dividends of such an approach are clear from looking at the experience of the high-income regions that have walked this path. Our analysis shows that the road death toll has declined by 43% in Western Europe since 1990. However, a longer historical analysis shows that road safety has steadily improved since the early 1970s in most high-income countries despite increasing vehicle ownership rates and continued expansion of highway infrastructure. The policy history of these countries suggests that starting in the late 1960s, they established national road safety agencies with legislative powers and a mandate to manage safety in the transport system (Wegman et al., 2008). These agencies instituted a long series of interventions that targeted highway infrastructure (e.g., by requiring median barriers, guard rails, and traffic calming designs), vehicle safety (e.g., by requiring airbags, seatbelts, child seats, crashworthiness standards, and crash avoidance technologies), and road users (e.g., by enforcement and campaigns to encourage seat-belt use, helmet use, and drink driving). Countries in sub-Saharan Africa now need to walk on a similar path as they develop their transport systems by building highways that incorporate safety infrastructure, acquiring vehicle fleets that integrate safety technology, and deploying enforcement technologies that encourage safe road use, using a results-oriented safe system approach.

Implications for future research in road injury metrics

We believe that this report presents enough evidence about the burden of road injuries in sub-Saharan Africa for policy makers to begin investing in road safety immediately. Managing these investments will require a road safety measurement framework that can be used to identify cost-effective interventions, define benchmarks, set achievable targets, and monitor progress towards achieving them. Continued improvements and refinements of road safety metrics should be an ongoing process that should evolve as the Decade of Action unfolds. Our work suggests that such work should simultaneously focus on strengthening local information systems and the continued development of analytical methods for generating information that can guide policy.

Our work highlights the availability of a large number of data systems in sub-Saharan Africa that have been underutilized in policy relevant analysis. Strengthening these existing data systems is an efficient way to rapidly improve the availability of road injury statistics in the region (Bhalla et al. 2012). For instance, we relied extensively on mortuary data systems, which can provide valuable information about the distribution of injury deaths in urban settings. The existence of a legal framework for investigating causes of unnatural deaths creates an opportunity to develop mortuary-based surveillance systems especially in sub-Saharan Africa where vital registrations systems are particularly weak. Thus, the widespread implementation of the new WHO mortuary surveillance guidelines (Bartolomeos et al., 2012) coupled with periodic studies to validate data quality could bring vast amounts of reliable data to road injury metrics. In the longer term, such infrastructure can be used for monitoring and evaluation of road safety interventions and programs in the regions.

Similarly, our work relied on data from a vast network of health and demographic surveillance sites in sub-Saharan Africa. These sites typically monitor morbidity (via periodic surveys) and mortality (via continuous verbal autopsy) in selected rural populations. Although many of these sites have been collecting data for decades, the data have rarely been used to monitor trends in road injuries. Partly as a result, the injury data available from these sites was often poorly coded, with injury deaths often being ascribed to nature-of-injuries (e.g., head injury) rather than external causes (e.g., pedestrian crash), which are more relevant for policy analysis. Strengthening this existing infrastructure by improving coding procedures could substantially improve knowledge of injury statistics in these regions.

We also found that many countries conduct periodic national health surveys that often include questions about non-fatal injury involvement and medical care received. Despite the readily available data, such surveys have received little attention from the injury research community. Partly for this reason, the survey instruments (i.e. survey questions) are not standardized and often fail to incorporate well-established advice about measuring injuries (e.g. use of appropriate recall periods, Mock et al. 2012). A shortened version of the WHO guidelines for injury community surveys (WHO, 2006) designed for use as an injury module in national health surveys can provide useful guidance to national agencies conducting such surveys and make the findings directly useful for policy making.

In addition to strengthening data systems, we need continuing and concerted research focused on improving methods that can effectively utilize existing data infrastructure to derive metrics that can help road safety policy makers. Our work makes many simplifying assumptions that need to be addressed in future work. Such work should include the development of methods for assessing and correcting misclassification in surveillance systems, reattribution of injuries coded to partially specified causes, and biases in the population that gets included in incomplete surveillance systems.

While the GBD project is unique in estimating the incidence and burden of non-fatal road injuries, such research is in its infancy leaving substantial room for improving analytical methods and conducting empirical measurements. This includes improving measurement of the incidence of non-fatal injuries from household surveys through the development of better methods for addressing such measurement issues as differential item functioning, telescoping and recall biases. Road injuries typically result in injuries to multiple regions of the body but the implication of multiple injuries on health outcomes remains poorly understood. Finally, the bulk of the burden of non-fatal injuries is a result from long-term disabling outcomes. There are few studies that have followed-up victims to track their recovery over the long-term. At present, such studies are only available from regions with relatively good access to medical care, and they used differing health state measures, which required analytical mappings to GBD health states. Such work will benefit substantially from more and comparable measurements, particularly in low-income regions, and improved analytical methods for characterizing the evolution of disability following road injury.

An important stream of future work emanating from this project should explicitly consider the needs of different policy makers and parse the results appropriately. Thus, for instance, this may require constructing estimates of the economic burden of injuries rather than the public health burden of injuries. A robust literature on health costing (WHO, 2009b; Bloom et al. 2011) provides guidance on converting burden estimates measured in this study into economic losses using fairly simple analytical methods. Similarly, in addition to quantifying the public health burden of road injuries, policy makers need guidance on which risk factors matter most. This can be addressed by attributing the burden of road injuries to the various risk factors that a policy maker could address. Such an approach is also easily extended beyond road injuries to model the multiple health impacts of transport policy, including physical inactivity and vehicular air pollution, in a health impact assessment framework.

Conclusions

Improving access to jobs, health care, and education is an important priority for sub-Saharan Africa. However, unmanaged expansion of the transport sector has resulted in many parts of the region becoming the most dangerous in the world. Road injuries now rank among the leading health concerns in the region. National governments and the international development community need to prioritize road safety in the region and implement the recommendations of the 2004 World Report on Road Traffic Injury Prevention.

References

- Bhalla, K, Adofo, K, Mock, CN, Afukaar, F, Appiah, N, & Ebel, BE, 2012, Non-traditional data sources for injury control: an agenda for action in Ghana. Injury Prevention, 18(4), 277–277.
- Bloom, D, Cafiero, ET, Jane-Llopis, E, Abrahams-Gessel, S, Bloom, L, Fathima, S et al., 2011, The Global Economic Burden of Non-Communicable Diseases. Geneva: World Economic Forum.
- Jacobs, G, Aeron-Thomas, A, & Astrop, A, 2000, Estimating global road fatalities. Transport Research Laboratory, Crawthorne, Berkshire, UK.
- Wegman, F., Commandeur, J., Doveh, E., Eksler, V., Gitelman, V., Hakker, S., et al. (2008). SUNflowerNext: Towards a composite road safety performance index. SWOV Institute for Road Safety Research, www.swov.nl.
- World Health Organization, 2004, World report on road traffic injury prevention. World Health Organization: Geneva.
- World Health Organization, 2009a, Guide to identifying the economic consequences of disease and injury, Geneva: World Health Organization.
- World Health Organization, 2009b, Global status report on road safety: time for action. World Health Organization: Geneva.
- World Health Organization, 2012, Fatal Injury Surveillance in Mortuaries, (K. Bartolomeos, C. C. Kipsaina, N. Grills, J. Ozanne-Smith, & M. Peden, Eds.), Geneva: World Health Organization.
- World Health Organization, 2013, Global status report on road safety - supporting a decade of action, World Health Organization: Geneva.

Appendix A1: Regional Results

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	8		1	3	1	13
	7-27 D	10		1	6	1	18
	28-364 D	182		20	92	13	307
	1-4	2352	69	103	296	45	2865
	5-9	422	26	27	60	11	546
	10-14	251	23	26	46	9	355
	15-19	574	35	118	176	19	922
	20-24	864	39	186	301	25	1415
	25-29	735	33	139	233	24	1164
	30-34	606	25	83	167	17	898
	35-39	491	20	62	128	13	714
	40-44	382	16	35	89	10	532
	45-49	342	15	30	76	9	472
	50-54	302	13	22	61	7	405
	55-59	261	12	17	50	8	348
	60-64	225	10	13	40	7	295
	65-69	187	8	10	31	5	241
	70-74	132	6	6	21	4	169
	75-79	81	4	3	12	2	102
	80+	53	2	2	8	1	66
	All ages	8460	356	904	1896	231	11847
Female	0-6 D	1		1	5		7
	7-27 D	1		1	9	2	13
	28-364 D	22		19	131	16	188
	1-4	384	38	106	733	86	1347
	5-9	66	12	19	118	19	234
	10-14	39	11	18	78	17	163
	15-19	45	14	68	195	24	346
	20-24	34	9	56	172	18	289
	25-29	26	7	37	125	13	208
	30-34	24	6	28	91	12	161
	35-39	25	6	24	84	11	150
	40-44	18	5	16	56	9	104
	45-49	20	5	13	50	9	97
	50-54	22	6	13	55	11	107
	55-59	24	6	11	51	12	104
	60-64	28	6	10	50	13	107
	65-69	28	6	8	49	11	102
	70-74	24	5	6	34	11	80
	75-79	20	3	3	20	7	53
	80+	13	2	2	10	5	32
	All ages	864	147	459	2116	306	3892
Both	**All ages**	**9324**	**503**	**1363**	**4012**	**537**	**15739**

Table A1.1 Road Injury Deaths in Central Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	10		2	4	1	17
	7-27 D	10		2	7	1	20
	28-364 D	205		35	115	22	377
	1-4	1933	68	159	313	59	2532
	5-9	480	37	54	89	20	680
	10-14	280	33	48	65	15	441
	15-19	842	65	299	314	39	1559
	20-24	1336	77	484	557	59	2513
	25-29	1205	67	371	451	60	2154
	30-34	977	49	214	323	42	1605
	35-39	777	35	140	227	28	1207
	40-44	638	26	82	156	20	922
	45-49	580	24	65	133	20	822
	50-54	522	21	46	103	14	706
	55-59	429	19	36	80	15	579
	60-64	356	15	26	60	12	469
	65-69	295	13	22	48	9	387
	70-74	215	9	14	32	9	279
	75-79	137	6	7	21	5	176
	80+	106	3	4	14	3	130
	All ages	11333	567	2110	3112	453	17575
Female	0-6 D	1		1	7		9
	7-27 D	2		1	8	3	14
	28-364 D	29		15	138	24	206
	1-4	331	31	71	604	103	1140
	5-9	93	15	21	143	37	309
	10-14	55	13	18	94	30	210
	15-19	96	21	90	337	47	591
	20-24	89	17	99	370	51	626
	25-29	65	13	62	265	37	442
	30-34	52	9	41	179	27	308
	35-39	48	8	26	131	20	233
	40-44	37	6	16	88	17	164
	45-49	39	6	14	75	14	148
	50-54	40	6	12	68	15	141
	55-59	42	6	11	65	17	141
	60-64	41	6	9	56	18	130
	65-69	43	6	10	62	16	137
	70-74	38	5	6	40	15	104
	75-79	32	4	4	25	11	76
	80+	25	3	3	15	9	55
	All ages	1198	175	530	2770	511	5184
Both	**All ages**	**12531**	**742**	**2640**	**5882**	**964**	**22759**

Table A1.2 Road Injury Deaths in Central Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	29.9		4	12	3.2	49.1
	7-27 D	13.3		1.9	8.3	1.1	24.6
	28-364 D	16		1.8	8.1	1.1	27
	1-4	57.2	1.7	2.5	7.2	1.1	69.7
	5-9	10.5	0.7	0.7	1.5	0.3	13.7
	10-14	7.7	0.7	0.8	1.4	0.3	10.9
	15-19	21.3	1.3	4.4	6.5	0.7	34.2
	20-24	38.4	1.7	8.3	13.4	1.1	62.9
	25-29	39.2	1.7	7.4	12.4	1.3	62
	30-34	39.2	1.6	5.4	10.8	1.1	58.1
	35-39	38.7	1.6	4.8	10.1	1	56.2
	40-44	36.8	1.5	3.4	8.6	0.9	51.2
	45-49	39.7	1.7	3.5	8.8	1.1	54.8
	50-54	43.3	1.9	3.2	8.8	1	58.2
	55-59	47.2	2.2	3.1	9	1.5	63
	60-64	53	2.4	3.2	9.3	1.5	69.4
	65-69	61.5	2.7	3.2	10.2	1.7	79.3
	70-74	67.4	3.2	3.3	10.6	2.3	86.8
	75-79	76.2	3.3	3	11.6	2.3	96.4
	80+	88.3	3.1	3	13	2.3	109.7
	All ages	31.9	1.3	3.4	7.2	0.9	44.7
Female	0-6 D	3.2		3.1	21.4		27.7
	7-27 D	1.9		1.8	11.8	3.2	18.7
	28-364 D	2		1.7	11.8	1.4	16.9
	1-4	9.5	0.9	2.6	18.1	2.1	33.2
	5-9	1.7	0.3	0.5	3	0.5	6
	10-14	1.2	0.3	0.6	2.4	0.5	5
	15-19	1.7	0.5	2.5	7.2	0.9	12.8
	20-24	1.5	0.4	2.5	7.6	0.8	12.8
	25-29	1.4	0.4	2	6.6	0.7	11.1
	30-34	1.5	0.4	1.8	5.8	0.7	10.2
	35-39	1.9	0.4	1.8	6.4	0.8	11.3
	40-44	1.7	0.4	1.4	5.2	0.9	9.6
	45-49	2.1	0.5	1.4	5.4	1	10.4
	50-54	2.9	0.7	1.7	7	1.5	13.8
	55-59	3.7	0.9	1.7	8	1.8	16.1
	60-64	5.5	1.2	2	9.7	2.6	21
	65-69	7.4	1.6	2.1	12.9	2.9	26.9
	70-74	9.4	1.9	2.2	13	4.2	30.7
	75-79	13.3	2.1	2.2	13.2	4.6	35.4
	80+	13.5	2.1	2	10	5.5	33.1
	All ages	3.2	0.5	1.7	7.8	1.1	14.3
Both	**All ages**	**17.4**	**0.9**	**2.5**	**7.5**	**1**	**29.3**

Table A1.3 Road Injury Deaths Rates (per 100,000) in Central Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	25.5		4.6	10.6	3.3	44
	7-27 D	9.2		1.4	5.8	0.9	17.3
	28-364 D	11.6		2	6.5	1.3	21.4
	1-4	27.8	1	2.3	4.5	0.8	36.4
	5-9	6.6	0.5	0.7	1.2	0.3	9.3
	10-14	4.5	0.5	0.8	1.1	0.2	7.1
	15-19	16	1.2	5.7	6	0.7	29.6
	20-24	30.5	1.8	11.1	12.7	1.3	57.4
	25-29	34	1.9	10.5	12.7	1.7	60.8
	30-34	34.2	1.7	7.5	11.3	1.5	56.2
	35-39	33.8	1.5	6.1	9.9	1.2	52.5
	40-44	34.3	1.4	4.4	8.4	1.1	49.6
	45-49	38.7	1.6	4.3	8.9	1.3	54.8
	50-54	44.1	1.8	3.9	8.7	1.1	59.6
	55-59	46.2	2	3.8	8.7	1.7	62.4
	60-64	50.5	2.2	3.7	8.4	1.7	66.5
	65-69	57	2.5	4.2	9.3	1.8	74.8
	70-74	63.1	2.8	4.1	9.5	2.5	82
	75-79	72	3	3.8	10.9	2.4	92.1
	80+	93.1	2.9	3.9	12.7	2.5	115.1
	All ages	23.6	1.2	4.4	6.5	0.9	36.6
Female	0-6 D	3.6		2.3	18.5		24.4
	7-27 D	1.5		0.7	7.3	2.4	11.9
	28-364 D	1.7		0.9	8	1.4	12
	1-4	4.8	0.5	1	8.8	1.5	16.6
	5-9	1.3	0.2	0.3	2	0.5	4.3
	10-14	0.9	0.2	0.3	1.5	0.5	3.4
	15-19	1.8	0.4	1.7	6.4	0.9	11.2
	20-24	2	0.4	2.3	8.4	1.2	14.3
	25-29	1.8	0.4	1.7	7.4	1	12.3
	30-34	1.8	0.3	1.4	6.2	0.9	10.6
	35-39	2.1	0.3	1.1	5.7	0.9	10.1
	40-44	2	0.3	0.9	4.7	0.9	8.8
	45-49	2.5	0.4	0.9	4.8	0.9	9.5
	50-54	3.2	0.5	1	5.4	1.2	11.3
	55-59	4.1	0.6	1.1	6.4	1.7	13.9
	60-64	5	0.7	1.2	6.9	2.2	16
	65-69	7	1	1.5	9.9	2.7	22.1
	70-74	8.8	1.2	1.4	9.4	3.6	24.4
	75-79	12.5	1.4	1.6	9.7	4.2	29.4
	80+	14.3	1.5	1.5	8.4	5	30.7
	All ages	2.5	0.4	1.1	5.7	1.1	10.8
Both	**All ages**	**13**	**0.8**	**2.7**	**6.1**	**1**	**23.6**

Table A1.4 Road Injury Death Rates (per 100,000) in Central Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	51		4	68	14	137
	7-27 D	19		3	58	7	87
	28-364 D	315		22	507	59	903
	1-4	2935	423	120	1567	218	5263
	5-9	1194	252	44	492	72	2054
	10-14	755	206	40	462	53	1516
	15-19	1363	385	97	929	93	2867
	20-24	1446	435	179	1609	116	3785
	25-29	1362	334	240	936	121	2993
	30-34	879	252	154	696	76	2057
	35-39	649	229	138	367	57	1440
	40-44	622	189	101	354	41	1307
	45-49	706	261	81	404	45	1497
	50-54	719	244	59	512	34	1568
	55-59	627	301	45	446	33	1452
	60-64	709	263	62	333	33	1400
	65-69	756	276	96	316	23	1467
	70-74	606	393	102	156	22	1279
	75-79	266	177	57	101	14	615
	80+	236	127	105	82	10	560
	All ages	16215	4747	1749	10395	1141	34247
Female	0-6 D	51		7	33		91
	7-27 D	53		5	20	47	125
	28-364 D	197		40	227	200	664
	1-4	1059	54	181	1049	723	3066
	5-9	535	24	52	276	225	1112
	10-14	466	29	69	224	242	1030
	15-19	339	29	191	262	271	1092
	20-24	274	21	179	195	233	902
	25-29	235	16	107	220	162	740
	30-34	196	12	91	161	139	599
	35-39	228	12	67	147	128	582
	40-44	204	12	57	129	137	539
	45-49	252	13	49	132	134	580
	50-54	315	15	50	160	152	692
	55-59	373	13	35	218	179	818
	60-64	506	16	39	183	185	929
	65-69	359	13	25	321	140	858
	70-74	386	12	21	128	155	702
	75-79	472	9	15	84	114	694
	80+	363	7	11	52	89	522
	All ages	6863	307	1291	4221	3655	16337
Both	**All ages**	**23078**	**5054**	**3040**	**14616**	**4796**	**50584**

Table A1.5 Road Injury Deaths in Eastern Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	57		4	73	10	144
	7-27 D	14		2	43	4	63
	28-364 D	350		17	540	44	951
	1-4	2195	285	65	1171	118	3834
	5-9	1245	245	32	547	53	2122
	10-14	783	202	30	478	38	1531
	15-19	2449	648	148	1664	118	5027
	20-24	3243	916	340	3515	185	8199
	25-29	3520	802	479	2269	210	7280
	30-34	2264	573	280	1645	130	4892
	35-39	1509	439	208	728	79	2963
	40-44	1229	320	136	607	49	2341
	45-49	1343	448	112	701	59	2663
	50-54	1405	426	86	906	43	2866
	55-59	1204	521	65	774	43	2607
	60-64	1427	450	86	576	40	2579
	65-69	1529	478	145	561	29	2742
	70-74	1289	726	162	302	31	2510
	75-79	633	351	97	215	20	1316
	80+	637	292	207	207	18	1361
	All ages	28325	8122	2701	17522	1321	57991
Female	0-6 D	71		5	34		110
	7-27 D	60		3	15	27	105
	28-364 D	319		31	252	166	768
	1-4	1054	32	79	650	384	2199
	5-9	675	21	37	243	179	1155
	10-14	530	24	47	189	194	984
	15-19	828	49	277	512	422	2088
	20-24	967	48	352	530	508	2405
	25-29	760	31	188	583	315	1877
	30-34	536	20	138	357	223	1274
	35-39	468	16	77	241	162	964
	40-44	404	16	66	209	181	876
	45-49	518	18	60	215	177	988
	50-54	569	18	55	216	159	1017
	55-59	763	18	45	335	218	1379
	60-64	968	22	48	271	215	1524
	65-69	845	19	36	583	189	1672
	70-74	871	18	29	211	200	1329
	75-79	1178	14	22	146	140	1500
	80+	1112	14	22	121	142	1411
	All ages	13496	398	1617	5913	4201	25625
Both	**All ages**	**41821**	**8520**	**4318**	**23435**	**5522**	**83616**

Table A1.6 Road Injury Deaths in Eastern Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	57.6		4.8	75.7	15.2	153.3
	7-27 D	7.2		1.1	22.1	2.5	32.9
	28-364 D	7.9		0.5	12.7	1.5	22.6
	1-4	19.6	2.8	0.8	10.5	1.5	35.2
	5-9	7.7	1.6	0.3	3.2	0.5	13.3
	10-14	5.7	1.6	0.3	3.5	0.4	11.5
	15-19	12.3	3.5	0.9	8.4	0.8	25.9
	20-24	15.9	4.8	2	17.7	1.3	41.7
	25-29	18.4	4.5	3.2	12.6	1.6	40.3
	30-34	14.6	4.2	2.5	11.5	1.3	34.1
	35-39	13.1	4.6	2.8	7.4	1.1	29
	40-44	15.2	4.6	2.5	8.6	1	31.9
	45-49	21.6	8	2.5	12.3	1.4	45.8
	50-54	27	9.2	2.2	19.3	1.3	59
	55-59	28.7	13.8	2.1	20.4	1.5	66.5
	60-64	41.9	15.6	3.7	19.7	1.9	82.8
	65-69	62.1	22.7	7.9	25.9	1.9	120.5
	70-74	76.5	49.7	12.9	19.7	2.8	161.6
	75-79	60.3	40.1	12.9	22.8	3.2	139.3
	80+	90.6	48.8	40.5	31.5	3.9	215.3
	All ages	15.7	4.6	1.7	10.1	1.1	33.2
Female	0-6 D	58.3		8.3	37.9		104.5
	7-27 D	20.7		1.9	7.8	18.2	48.6
	28-364 D	5		1	5.8	5.1	16.9
	1-4	7.1	0.4	1.2	7.1	4.9	20.7
	5-9	3.5	0.2	0.3	1.8	1.5	7.3
	10-14	3.5	0.2	0.5	1.7	1.8	7.7
	15-19	3.1	0.3	1.7	2.4	2.5	10
	20-24	3	0.2	2	2.1	2.5	9.8
	25-29	3.1	0.2	1.4	2.9	2.1	9.7
	30-34	3.1	0.2	1.5	2.6	2.2	9.6
	35-39	4.4	0.2	1.3	2.8	2.5	11.2
	40-44	4.7	0.3	1.3	3	3.2	12.5
	45-49	7.2	0.4	1.4	3.8	3.9	16.7
	50-54	11	0.5	1.7	5.6	5.3	24.1
	55-59	15.6	0.6	1.5	9.1	7.5	34.3
	60-64	27	0.8	2.1	9.7	9.9	49.5
	65-69	25.9	0.9	1.8	23.1	10.1	61.8
	70-74	41.5	1.3	2.2	13.8	16.7	75.5
	75-79	86	1.7	2.7	15.3	20.9	126.6
	80+	98	1.8	3	14.1	24	140.9
	All ages	6.5	0.3	1.2	4	3.5	15.5
Both	**All ages**	**11.1**	**2.4**	**1.5**	**7**	**2.3**	**24.3**

Table A1.7 Road Injury Death Rates (per 100,000) in Eastern Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	44.6		2.8	57.1	7.8	112.3
	7-27 D	3.8		0.4	11.4	0.9	16.5
	28-364 D	6		0.3	9.2	0.7	16.2
	1-4	9.3	1.2	0.3	5	0.5	16.3
	5-9	4.9	1	0.1	2.1	0.2	8.3
	10-14	3.5	0.9	0.1	2.1	0.2	6.8
	15-19	12.7	3.4	0.8	8.6	0.6	26.1
	20-24	19.4	5.5	2	21	1.1	49
	25-29	25.3	5.8	3.4	16.3	1.5	52.3
	30-34	19.6	5	2.4	14.3	1.1	42.4
	35-39	16.5	4.8	2.3	8	0.9	32.5
	40-44	17.2	4.5	1.9	8.5	0.7	32.8
	45-49	23.7	7.9	2	12.3	1	46.9
	50-54	30.9	9.4	1.9	19.9	0.9	63
	55-59	32.8	14.2	1.8	21.1	1.2	71.1
	60-64	49.1	15.5	3	19.8	1.4	88.8
	65-69	72.8	22.8	6.9	26.7	1.4	130.6
	70-74	90.1	50.8	11.3	21.2	2.1	175.5
	75-79	73.1	40.5	11.2	24.8	2.3	151.9
	80+	113.7	52.1	37	37	3.2	243
	All ages	16	4.6	1.5	9.9	0.7	32.7
Female	0-6 D	57.1		4	27.1		88.2
	7-27 D	16.4		0.7	4.1	7.2	28.4
	28-364 D	5.6		0.5	4.4	2.9	13.4
	1-4	4.6	0.1	0.3	2.8	1.7	9.5
	5-9	2.7	0.1	0.1	1	0.7	4.6
	10-14	2.4	0.1	0.2	0.9	0.9	4.5
	15-19	4.3	0.3	1.4	2.7	2.2	10.9
	20-24	5.8	0.3	2.1	3.2	3	14.4
	25-29	5.5	0.2	1.4	4.2	2.3	13.6
	30-34	4.7	0.2	1.2	3.1	1.9	11.1
	35-39	5.1	0.2	0.8	2.7	1.8	10.6
	40-44	5.6	0.2	0.9	2.9	2.5	12.1
	45-49	8.8	0.3	1	3.6	3	16.7
	50-54	11.5	0.4	1.1	4.3	3.2	20.5
	55-59	18.5	0.4	1.1	8.1	5.3	33.4
	60-64	29.3	0.7	1.4	8.2	6.5	46.1
	65-69	34.6	0.8	1.5	23.8	7.7	68.4
	70-74	50.8	1	1.7	12.3	11.7	77.5
	75-79	109.2	1.3	2	13.6	13	139.1
	80+	144.4	1.9	2.8	15.7	18.5	183.3
	All ages	7.6	0.2	0.9	3.3	2.4	14.4
Both	**All ages**	**11.8**	**2.4**	**1.2**	**6.6**	**1.6**	**23.6**

Table A1.8 Road Injury Death Rates (per 100,000) in Eastern Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	1		0	4	1	6
	7-27 D	0		0	4	1	5
	28-364 D	8		6	26	8	48
	1-4	71	12	17	67	16	183
	5-9	102	16	23	36	22	199
	10-14	61	22	16	27	17	143
	15-19	81	29	53	75	39	277
	20-24	80	26	76	135	51	368
	25-29	79	34	71	84	64	332
	30-34	84	25	46	84	56	295
	35-39	72	25	51	91	34	273
	40-44	54	14	18	69	26	181
	45-49	48	12	23	75	24	182
	50-54	59	17	23	63	11	173
	55-59	48	25	20	50	19	162
	60-64	41	17	14	45	12	129
	65-69	19	11	11	38	8	87
	70-74	15	7	10	30	8	70
	75-79	8	6	6	21	4	45
	80+	7	4	6	17	4	38
	All ages	938	302	490	1041	425	3196
Female	0-6 D	0		2	4		6
	7-27 D	0		1	3	1	5
	28-364 D	6		6	16	5	33
	1-4	45	6	11	28	16	106
	5-9	63	8	17	34	15	137
	10-14	40	8	11	21	10	90
	15-19	27	9	14	26	13	89
	20-24	16	7	14	17	15	69
	25-29	13	8	14	10	14	59
	30-34	14	7	12	8	14	55
	35-39	18	7	11	15	9	60
	40-44	20	5	6	20	8	59
	45-49	21	4	8	20	6	59
	50-54	13	4	7	28	4	56
	55-59	14	4	6	39	5	68
	60-64	18	6	8	36	5	73
	65-69	14	4	8	31	6	63
	70-74	13	5	9	27	5	59
	75-79	15	3	7	13	4	42
	80+	15	4	6	30	4	59
	All ages	385	99	178	426	159	1247
Both	**All ages**	**1323**	**401**	**668**	**1467**	**584**	**4443**

Table A1.9 Road Injury Deaths in Southern Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	1		0	4	1	6
	7-27 D	0		0	3	1	4
	28-364 D	11		7	21	10	49
	1-4	59	10	22	35	27	153
	5-9	73	7	15	17	17	129
	10-14	53	12	13	14	15	107
	15-19	240	59	125	124	78	626
	20-24	450	74	306	337	173	1340
	25-29	432	105	265	282	214	1298
	30-34	244	51	125	185	138	743
	35-39	138	31	85	112	54	420
	40-44	99	20	38	82	38	277
	45-49	91	14	41	84	30	260
	50-54	106	22	54	75	24	281
	55-59	78	26	50	59	37	250
	60-64	67	20	31	49	25	192
	65-69	42	19	28	53	18	160
	70-74	37	9	22	37	16	121
	75-79	25	7	16	28	9	85
	80+	28	8	13	25	10	84
	All ages	2274	494	1256	1626	935	6585
Female	0-6 D	0		2	3		5
	7-27 D	0		0	2	2	4
	28-364 D	5		4	15	10	34
	1-4	28	5	10	20	32	95
	5-9	44	4	8	22	18	96
	10-14	31	5	7	23	17	83
	15-19	102	19	43	113	59	336
	20-24	105	25	67	131	118	446
	25-29	52	20	42	52	85	251
	30-34	31	10	19	32	45	137
	35-39	30	7	11	22	19	89
	40-44	28	4	6	27	15	80
	45-49	34	4	8	31	13	90
	50-54	16	3	7	21	11	58
	55-59	22	5	8	48	20	103
	60-64	22	6	9	32	17	86
	65-69	47	7	14	70	27	165
	70-74	22	5	9	23	15	74
	75-79	23	4	8	15	12	62
	80+	24	6	8	38	13	89
	All ages	666	139	290	740	548	2383
Both	**All ages**	**2940**	**633**	**1546**	**2366**	**1483**	**8968**

Table A1.10 Road Injury Deaths in Southern Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	3.4		2.5	24.5	4.2	34.6
	7-27 D	0.6		0.8	7.4	1.1	9.9
	28-364 D	1.1		0.8	3.5	1	6.4
	1-4	2.3	0.4	0.5	2.1	0.5	5.8
	5-9	2.8	0.4	0.6	1	0.6	5.4
	10-14	1.9	0.7	0.5	0.8	0.5	4.4
	15-19	2.9	1	1.9	2.6	1.4	9.8
	20-24	3.3	1.1	3.2	5.6	2.1	15.3
	25-29	3.8	1.6	3.5	4.1	3.1	16.1
	30-34	4.7	1.4	2.6	4.7	3.2	16.6
	35-39	4.8	1.7	3.4	6.1	2.3	18.3
	40-44	4.7	1.2	1.5	6.1	2.2	15.7
	45-49	5	1.2	2.4	7.9	2.5	19
	50-54	7.8	2.2	3.1	8.3	1.5	22.9
	55-59	7.8	4.2	3.3	8.1	3.1	26.5
	60-64	8.9	3.6	3.1	9.8	2.6	28
	65-69	6.3	3.7	3.7	12.3	2.5	28.5
	70-74	7.8	3.5	4.9	15.1	3.9	35.2
	75-79	7.8	5.5	6	20.9	3.5	43.7
	80+	11.8	7.1	9.9	26.9	6.7	62.4
	All ages	3.6	1.2	1.9	4	1.6	12.3
Female	0-6 D	2.6		13.3	24.2		40.1
	7-27 D	0.8		1.3	6.5	2.7	11.3
	28-364 D	0.8		0.8	2.2	0.7	4.5
	1-4	1.5	0.2	0.4	0.9	0.5	3.5
	5-9	1.8	0.2	0.5	0.9	0.4	3.8
	10-14	1.2	0.3	0.3	0.6	0.3	2.7
	15-19	0.9	0.3	0.5	0.9	0.4	3
	20-24	0.6	0.3	0.6	0.7	0.6	2.8
	25-29	0.6	0.4	0.7	0.5	0.7	2.9
	30-34	0.8	0.4	0.7	0.5	0.8	3.2
	35-39	1.2	0.5	0.7	1	0.6	4
	40-44	1.7	0.4	0.5	1.7	0.7	5
	45-49	2.1	0.4	0.8	2	0.6	5.9
	50-54	1.7	0.4	0.9	3.4	0.4	6.8
	55-59	2.2	0.6	0.9	5.9	0.8	10.4
	60-64	3.4	1.1	1.5	6.9	1	13.9
	65-69	3.5	1.1	2	7.7	1.6	15.9
	70-74	4.6	1.7	3.3	9.3	1.8	20.7
	75-79	8.6	2	3.8	7.9	2.2	24.5
	80+	11	2.8	4.2	22.1	2.9	43
	All ages	1.5	0.4	0.7	1.6	0.6	4.8
Both	**All ages**	**2.5**	**0.8**	**1.3**	**2.8**	**1.1**	**8.5**

Table A1.11 Road Injury Death Rates (per 100,000) in Southern Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	4		2.9	22.5	6.2	35.6
	7-27 D	0.6		0.9	5.9	1.7	9.1
	28-364 D	1.5		0.9	2.8	1.3	6.5
	1-4	1.9	0.3	0.7	1.1	0.9	4.9
	5-9	1.9	0.2	0.4	0.4	0.4	3.3
	10-14	1.4	0.3	0.3	0.4	0.4	2.8
	15-19	6.4	1.6	3.3	3.3	2.1	16.7
	20-24	12.1	2	8.2	9.1	4.7	36.1
	25-29	12.7	3.1	7.8	8.3	6.3	38.2
	30-34	8.7	1.8	4.4	6.6	4.9	26.4
	35-39	6.2	1.4	3.8	5	2.4	18.8
	40-44	5.7	1.1	2.2	4.8	2.2	16
	45-49	6.3	1	2.9	5.8	2.1	18.1
	50-54	8.4	1.7	4.3	6	1.9	22.3
	55-59	7.5	2.4	4.8	5.6	3.5	23.8
	60-64	8.6	2.5	4	6.3	3.3	24.7
	65-69	7.5	3.4	5	9.4	3.2	28.5
	70-74	10.4	2.6	6.1	10.5	4.4	34
	75-79	12.8	3.8	8.1	14	4.3	43
	80+	21.8	5.8	10.4	19.5	7.7	65.2
	All ages	6.5	1.4	3.6	4.7	2.7	18.9
Female	0-6 D	2.3		9.8	19.4		31.5
	7-27 D	0.7		0.7	4.4	3.8	9.6
	28-364 D	0.7		0.5	2.1	1.4	4.7
	1-4	0.9	0.2	0.3	0.6	1	3
	5-9	1.2	0.1	0.2	0.6	0.5	2.6
	10-14	0.8	0.1	0.2	0.6	0.5	2.2
	15-19	2.7	0.5	1.1	3	1.6	8.9
	20-24	2.8	0.7	1.8	3.6	3.2	12.1
	25-29	1.6	0.6	1.3	1.6	2.6	7.7
	30-34	1.2	0.4	0.7	1.2	1.8	5.3
	35-39	1.5	0.3	0.6	1.1	1	4.5
	40-44	1.6	0.2	0.3	1.5	0.9	4.5
	45-49	2.1	0.2	0.5	1.9	0.8	5.5
	50-54	1	0.2	0.4	1.4	0.7	3.7
	55-59	1.7	0.4	0.7	3.7	1.6	8.1
	60-64	2.2	0.6	0.9	3.3	1.7	8.7
	65-69	6.2	1	1.9	9.3	3.6	22
	70-74	4.2	0.9	1.8	4.4	2.8	14.1
	75-79	6.8	1.2	2.4	4.3	3.7	18.4
	80+	8.7	2.1	2.8	13.8	4.6	32
	All ages	1.9	0.4	0.8	2.1	1.5	6.7
Both	**All ages**	**4.2**	**0.9**	**2.2**	**3.4**	**2.1**	**12.8**

Table A1.12 Road Injury Death Rates (per 100,000) in Southern Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	11		5	20	7	43
	7-27 D	6		6	28	5	45
	28-364 D	266		70	420	130	886
	1-4	4907	212	592	1998	479	8188
	5-9	979	129	249	587	231	2175
	10-14	520	83	176	308	99	1186
	15-19	750	147	714	657	206	2474
	20-24	855	166	1071	1138	278	3508
	25-29	627	129	1081	904	282	3023
	30-34	606	101	798	873	232	2610
	35-39	433	70	625	767	141	2036
	40-44	345	55	490	573	110	1573
	45-49	366	51	539	493	82	1531
	50-54	299	44	419	416	73	1251
	55-59	386	47	364	427	75	1299
	60-64	437	46	285	322	69	1159
	65-69	331	41	207	389	62	1030
	70-74	330	36	170	269	55	860
	75-79	268	24	58	183	33	566
	80+	165	15	39	183	20	422
	All ages	12887	1396	7958	10955	2669	35865
Female	0-6 D	8		2	15		25
	7-27 D	8		3	18	10	39
	28-364 D	200		43	241	94	578
	1-4	2640	107	323	1034	410	4514
	5-9	648	41	82	280	95	1146
	10-14	321	31	54	198	72	676
	15-19	377	55	218	269	205	1124
	20-24	289	43	185	460	146	1123
	25-29	162	39	200	389	147	937
	30-34	181	28	157	250	129	745
	35-39	208	31	140	374	99	852
	40-44	198	22	166	255	116	757
	45-49	265	26	93	400	63	847
	50-54	358	28	93	407	67	953
	55-59	416	32	85	396	85	1014
	60-64	411	28	73	370	74	956
	65-69	472	31	64	293	73	933
	70-74	441	26	48	233	68	816
	75-79	294	19	35	173	47	568
	80+	171	11	20	202	33	437
	All ages	8068	598	2084	6257	2033	19040
Both	**All ages**	**20955**	**1994**	**10042**	**17212**	**4702**	**54905**

Table A1.13 Road Injury Deaths in Western Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	22		8	35	13	78
	7-27 D	12		8	43	10	73
	28-364 D	529		103	720	244	1596
	1-4	9336	336	860	3493	821	14846
	5-9	1805	209	366	1086	428	3894
	10-14	885	125	233	548	150	1941
	15-19	1750	297	1354	1577	371	5349
	20-24	2393	404	2571	3342	621	9331
	25-29	2076	373	3419	3227	764	9859
	30-34	1925	282	2442	3056	622	8327
	35-39	1138	162	1493	2089	292	5174
	40-44	743	103	891	1203	204	3144
	45-49	749	91	849	950	145	2784
	50-54	595	79	654	785	134	2247
	55-59	695	79	513	728	120	2135
	60-64	763	77	390	532	110	1872
	65-69	624	70	324	673	97	1788
	70-74	634	64	267	474	92	1531
	75-79	537	43	97	333	57	1067
	80+	412	34	81	392	44	963
	All ages	27623	2828	16923	25286	5339	77999
Female	0-6 D	19		3	29		51
	7-27 D	17		3	29	14	63
	28-364 D	496		54	468	147	1165
	1-4	5512	174	392	1925	605	8608
	5-9	1404	63	96	529	134	2226
	10-14	637	46	60	327	93	1163
	15-19	1064	117	368	707	401	2657
	20-24	1071	112	410	1749	365	3707
	25-29	563	105	452	1431	383	2934
	30-34	535	61	284	716	261	1857
	35-39	434	47	174	704	137	1496
	40-44	413	34	209	461	157	1274
	45-49	521	37	103	669	75	1405
	50-54	559	34	81	522	72	1268
	55-59	736	42	92	556	99	1525
	60-64	686	35	71	472	78	1342
	65-69	967	47	89	488	90	1681
	70-74	799	34	57	321	78	1289
	75-79	618	30	48	266	64	1026
	80+	455	22	34	376	49	936
	All ages	17506	1040	3080	12745	3302	37673
Both	**All ages**	**45129**	**3868**	**20003**	**38031**	**8641**	**115672**

Table A1.14 Road Injury Deaths in Western Sub-Saharan Africa in 2010

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	12.9		6.3	23.1	8.1	50.4
	7-27 D	2.5		2.3	11.2	2.2	18.2
	28-364 D	7		1.8	11	3.4	23.2
	1-4	34.6	1.5	4.2	14.1	3.4	57.8
	5-9	6.5	0.9	1.6	3.9	1.5	14.4
	10-14	4.1	0.7	1.4	2.4	0.8	9.4
	15-19	7.1	1.4	6.8	6.2	2	23.5
	20-24	10	2	12.6	13.4	3.3	41.3
	25-29	8.8	1.8	15.1	12.6	3.9	42.2
	30-34	10.2	1.7	13.5	14.8	3.9	44.1
	35-39	8.9	1.4	12.8	15.7	2.9	41.7
	40-44	8.3	1.3	11.8	13.8	2.7	37.9
	45-49	10.3	1.4	15.1	13.9	2.3	43
	50-54	10.4	1.5	14.5	14.4	2.5	43.3
	55-59	16.8	2	15.8	18.5	3.2	56.3
	60-64	24.5	2.6	16	18	3.9	65
	65-69	25.6	3.1	16	30	4.8	79.5
	70-74	39.7	4.4	20.4	32.4	6.6	103.5
	75-79	60.9	5.4	13.2	41.5	7.5	128.5
	80+	68.6	6.1	16.3	75.9	8.3	175.2
	All ages	12.8	1.4	7.9	10.9	2.6	35.6
Female	0-6 D	9.2		2.7	17.8		29.7
	7-27 D	3.4		1.3	7.4	4.1	16.2
	28-364 D	5.4		1.2	6.5	2.6	15.7
	1-4	19.2	0.8	2.3	7.5	3	32.8
	5-9	4.4	0.3	0.6	1.9	0.6	7.8
	10-14	2.6	0.2	0.4	1.6	0.6	5.4
	15-19	3.6	0.5	2.1	2.6	2	10.8
	20-24	3.4	0.5	2.2	5.4	1.7	13.2
	25-29	2.3	0.6	2.8	5.5	2.1	13.3
	30-34	3	0.5	2.6	4.2	2.2	12.5
	35-39	4.2	0.6	2.8	7.6	2	17.2
	40-44	4.8	0.5	4	6.1	2.8	18.2
	45-49	7.3	0.7	2.6	11.1	1.8	23.5
	50-54	12	0.9	3.1	13.6	2.2	31.8
	55-59	17	1.3	3.5	16.2	3.5	41.5
	60-64	21.2	1.5	3.8	19.1	3.8	49.4
	65-69	32.6	2.2	4.4	20.2	5.1	64.5
	70-74	45.6	2.7	5	24.1	7.1	84.5
	75-79	54.4	3.5	6.4	31.9	8.7	104.9
	80+	50.7	3.4	5.9	60	9.7	129.7
	All ages	8	0.6	2.1	6.2	2	18.9
Both	**All ages**	**10.4**	**1**	**5**	**8.6**	**2.3**	**27.3**

Table A1.15 Road Injury Death Rates (per 100,000) in Western Sub-Saharan Africa in 1990

Sex	Age Group	Pedestrian	Pedal cyclist	Rider motorcycle	Veh. occup. 3+ wheels	Other	Total
Male	0-6 D	16.9		6.2	27.2	10.1	60.4
	7-27 D	3.1		2	11.6	2.7	19.4
	28-364 D	9.1		1.8	12.4	4.2	27.5
	1-4	41.4	1.5	3.8	15.5	3.6	65.8
	5-9	7.5	0.9	1.5	4.5	1.8	16.2
	10-14	4.3	0.6	1.1	2.7	0.7	9.4
	15-19	9.8	1.7	7.6	8.8	2.1	30
	20-24	15.4	2.6	16.5	21.5	4	60
	25-29	15.5	2.8	25.6	24.2	5.7	73.8
	30-34	17.3	2.5	21.9	27.4	5.6	74.7
	35-39	12.8	1.8	16.8	23.5	3.3	58.2
	40-44	10.7	1.5	12.8	17.3	2.9	45.2
	45-49	13.2	1.6	14.9	16.7	2.5	48.9
	50-54	12.9	1.7	14.2	17.1	2.9	48.8
	55-59	19	2.2	14	19.9	3.3	58.4
	60-64	26.3	2.6	13.4	18.3	3.8	64.4
	65-69	28.4	3.2	14.7	30.6	4.4	81.3
	70-74	43.9	4.4	18.5	32.8	6.4	106
	75-79	66.4	5.3	11.9	41.1	7	131.7
	80+	84	6.9	16.5	79.9	9	196.3
	All ages	16.3	1.7	10	14.9	3.2	46.1
Female	0-6 D	15.7		2.3	24		42
	7-27 D	4.8		0.9	8.1	4	17.8
	28-364 D	8.9		1	8.4	2.6	20.9
	1-4	25.3	0.8	1.8	8.8	2.8	39.5
	5-9	6	0.3	0.4	2.3	0.6	9.6
	10-14	3.2	0.2	0.3	1.6	0.5	5.8
	15-19	6.1	0.7	2.1	4.1	2.3	15.3
	20-24	7	0.7	2.7	11.4	2.4	24.2
	25-29	4.3	0.8	3.4	10.9	2.9	22.3
	30-34	4.9	0.6	2.6	6.6	2.4	17.1
	35-39	5	0.5	2	8.1	1.6	17.2
	40-44	6	0.5	3	6.7	2.3	18.5
	45-49	9.1	0.6	1.8	11.6	1.3	24.4
	50-54	11.6	0.7	1.7	10.8	1.5	26.3
	55-59	18.6	1.1	2.3	14.1	2.5	38.6
	60-64	21.8	1.1	2.3	15	2.5	42.7
	65-69	39.6	1.9	3.6	20	3.7	68.8
	70-74	48.2	2.1	3.5	19.3	4.7	77.8
	75-79	63.8	3.1	5	27.5	6.6	106
	80+	70.2	3.3	5.3	58	7.6	144.4
	All ages	10.5	0.6	1.8	7.6	2	22.5
Both	**All ages**	**13.4**	**1.1**	**6**	**11.3**	**2.6**	**34.4**

Table A1.16 Road Injury Death Rates (per 100,000) in Southern Sub-Saharan Africa in 2010

Appendix A2: Country Results

Country	1990			2000			2010								
											Road Users (%)				
	Road Injury Deaths	Rate per 100k	Cause of Death Rank	Road Injury Deaths	Rate per 100k	Cause of Death Rank	Road Injury Deaths	Uncertainty [95% CI]	Rate per 100k	Cause of Death Rank	Pedestrian	Bicyclist	Motorcycle	Occupants	Other
Angola	6563	69.7	10	6495	52.5	12	9408	[2450-31110]	63.1	7	69	2	4	24	1
Benin	982	24.7	14	1434	27.3	13	1726	[1245-2155]	26.2	12	36	5	16	39	4
Botswana	155	12.7	13	505	27.6	7	283	[191-484]	13.2	9	36	7	14	38	5
Burkina Faso	2844	35.0	10	4004	38.1	8	5585	[4271-7113]	39.4	7	34	3	14	33	15
Burundi	2097	47.0	11	2026	43.5	11	2534	[812-5044]	41.0	10	35	16	12	25	12
Cameroon	4051	43.5	9	5422	42.6	9	6951	[4682-9920]	43.2	7	41	4	13	37	4
Cape Verde	45	16.1	12	50	15.2	11	80	[36-177]	19.1	7	44	7	10	35	4
Central Afr. Rep.	916	36.2	14	1225	38.3	15	1911	[899-3835]	49.7	11	47	4	15	26	9
Chad	954	19.8	20	1628	24.5	17	2765	[2144-3536]	30.6	12	38	4	16	36	7
Comoros	143	46.9	9	164	44.4	9	213	[122-411]	43.8	8	49	18	5	24	4
Congo, Rep.	1005	52.9	10	1742	63.3	8	1916	[633-5519]	56.4	8	65	2	5	27	1
Congo, Dem. Rep.	6497	18.1	18	5169	11.0	22	7733	[5107-11060]	12.4	19	35	5	23	28	8
Cote d'Ivoire	3383	35.8	12	6237	47.7	8	6536	[4232-8893]	40.9	9	37	4	17	39	4
Djibouti	303	72.7	5	268	50.9	7	345	[167-723]	51.3	5	65	8	3	22	2
Eq. Guinea	178	50.8	12	277	55.3	10	524	[109-1855]	83.2	6	68	2	3	26	1
Eritrea	682	31.1	13	954	38.0	11	1202	[898-1673]	34.0	11	41	14	7	31	8
Ethiopia	15103	42.0	13	15513	34.0	12	21520	[16689-27821]	37.3	9	47	11	4	30	9
Gabon	586	72.5	7	872	86.4	6	1267	[340-3485]	99.5	5	68	2	5	25	1
Gambia	223	31.9	13	291	30.8	12	387	[283-519]	30.7	9	37	4	15	38	6
Ghana	2053	18.8	16	3157	21.0	14	4844	[3267-6097]	24.8	10	38	5	7	46	4
Guinea	1019	21.2	18	1572	22.6	16	1869	[1409-2305]	23.5	14	33	5	17	39	6
Guinea-Bissau	309	37.9	13	399	39.4	12	443	[288-600]	36.1	11	30	4	22	38	6
Kenya	3648	21.6	13	7016	26.6	11	7820	[5183-13628]	25.1	10	51	12	4	29	3
Lesotho	76	6.2	36	150	9.4	28	232	[106-405]	12.4	23	26	8	18	37	11
Liberia	428	23.0	17	375	16.1	20	561	[199-983]	16.9	18	23	5	29	35	9
Madagascar	2891	33.6	12	2782	26.1	13	3405	[2631-4846]	24.1	11	48	11	5	30	6
Malawi	2722	34.6	13	4285	47.4	10	4867	[3293-6560]	44.3	9	43	12	7	32	6

Continued next page

Country	1990 Road Injury Deaths	1990 Rate per 100k	1990 Cause of Death Rank	2000 Road Injury Deaths	2000 Rate per 100k	2000 Cause of Death Rank	2010 Road Injury Deaths	2010 Uncertainty [95% CI]	2010 Rate per 100k	2010 Cause of Death Rank	Road Users (%) Pedestrian	Bicyclist	Motorcycle	Occupants	Other
Mali	1813	25.5	18	2561	26.4	16	3133	[2379-3924]	25.7	13	35	4	17	38	5
Mauritania	514	34.0	10	770	36.0	8	1016	[743-1383]	36.2	6	35	5	15	40	5
Mauritius	107	12.0	14	123	11.3	12	123	[79-151]	9.3	13	8	10	13	63	6
Mozambique	2264	23.5	16	3819	30.3	13	7154	[5493-11166]	46.7	9	41	11	8	30	10
Namibia	111	11.1	25	221	15.6	19	222	[157-385]	12.8	19	32	9	11	42	6
Niger	1496	21.3	19	1666	17.4	19	2078	[1412-2821]	16.6	16	30	5	19	39	7
Nigeria	32606	39.9	11	51858	45.7	9	74548	[55477-91154]	52.4	5	41	3	18	30	8
Rwanda	2885	59.8	9	2862	47.5	9	2492	[1431-5488]	34.3	10	53	13	5	23	6
Sao Tome & Prin#							33		20.0	14	38	4	14	40	4
Senegal	392	8.8	30	511	8.8	27	645	[307-1406]	9.4	24	48	5	16	26	5
Seychelles	8	16.2	9	10	19.3	8	12	[8-18]	20.8	9	16	6	17	61	1
Sierra Leone	951	29.9	15	785	24.4	17	1095	[627-1505]	26.1	13	29	5	24	36	6
Somalia	1898	37.8	12	1752	33.2	13	2083	[1509-3255]	32.3	13	43	10	7	29	12
South Africa#							14804		29.5	17	50	5	7	36	1
Sudan	5511	29.9	12	7238	29.8	10	10278	[7877-13730]	33.3	6	65	7	3	22	3
Swaziland	53	9.1	28	137	17.0	18	218	[127-346]	23.2	14	33	7	14	40	5
Tanzania	4857	25.3	12	7048	25.8	11	9404	[6482-14042]	27.7	9	53	7	5	29	6
Togo	835	28.8	12	1089	28.0	13	1401	[966-1733]	27.1	11	28	5	20	38	9
Uganda	3185	22.9	17	5944	33.7	13	7365	[5368-10509]	36.5	10	54	10	7	24	5
Zambia	2276	38.1	11	3207	40.7	11	2798	[2077-3955]	30.8	12	53	8	5	30	4
Zimbabwe	1453	18.4	12	3903	36.3	7	3527	[1375-5853]	33.2	10	11	10	31	11	38

Table A2.1 Road Injury Deaths in Countries in sub-Saharan Africa from 1990 to 2010

#Official government statistics for road deaths and death rates are shown for two countries, South Africa and Sao Tome & Principe, where GBD-2010 estimates were lower than official statistics. However, the cause of death rank and the road-user distribution for these countries are from GBD-2010. See also note about Southern sub-Saharan Africa estimates accompanying Table 4.1 and footnote on Page 72.